UNDERSTANDING WEAPON ACQUISITION PROCESSES:

A STUDY OF NAVAL ANTI-SUBMARINE AIRCRAFT PROCUREMENT IN BRITAIN, 1945 - 1955.

by

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CONTENTS

ABSTRACT

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Few attempts have been made to systematically examine weapon procurement activities within states, and particularly within the United Kingdom, despite the central role they play in determining the outcomes of both inter-state disarmament negotiations and outbreaks of international armed conflict. This thesis seeks to correct that deficiency.

The types of issues and areas of study that have served as a focus for existing work were reviewed, and generated an initial assumption that studies could either be undertaken inductively, as narrative history, or deductively, through the medium of a set of interpretive perspectives or models of the processes involved. Nine propositions were derived from the existing literature on the subject to serve as a framework within which the latter type of study could be conducted. These included a descriptive, phased model of a weapon procurement process: propositions about the impact of internal and external factors upon it and the dominance of specific factors at particular points in its evolution: propositions designed to explore the incidence of rational, purposeful behaviour within and between the governmental and industrial organisations involved, as compared with 'bureaucratic politics': and pro-

positions designed to explore the impact of the variables of time, cost and quality upon the evaluation of a project; to assess the importance of human compared to process factors; and to compare the intra-governmental and public discussion and debate on a project.

A narrative account of the evolution of the British naval anti-submarine aircraft programme between 1945 and 1956 was then constructed, based in part on hitherto inaccessible sources. In parallel, this narrative history was analysed through the medium of the nine deductive propositions generated earlier. These propositions were then reassessed in the light of this analysis, and an attempt made to combine them into a single, coherent model of the processes emcompassed within a weapon project.

PREFACE

Man has manufactured weapons for many centuries. Only during this century, however, has sustained attention been focused upon the relationship between the manufacture of weapons and the phenomena of inter-state war. One consequence of the licensing arrangements that existed between private arms manufacturers prior to the First World War was the development during the inter-war period of 'devil' theories of war, where war was seen as engineered by private arms manufacturers to enhance their profits.[1] In parallel, the first sustained attempts were being made on an inter-state level to reach agreement on arms limitation measures. These sought to impose upper limits on both the type and quality of armaments states could procure,[2] but they did little to prevent either the growth of hostility between the European states, or the outbreak of the Second World War.

The growth of the 'Cold War' after 1947 created a perception that there existed an 'action-reaction' type of arms race between the Western States and the Soviet Union.[3] Attempts were again made, and are still being made, to negotiate arms limitation arrangements between the major states involved.

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1. For an example of this type of writing, see F. Brockway, The Bloody Traffic, Gollancz: London, 1933.
2. A detailed account of some of these discussions is given in J.W. Wheeler-Bennett, Disarmament and Security, Allen and Unwin: London, 1932.
3. For a discussion of this concept, see C. Gray, 'The Arms Race Phenomenon', World Politics, 24, October 1971, pp.71-73.

Those treaties that have been concluded have either been of the inter-war upper limit variety,[1] or have dealt with the deployment of weapon systems in areas of low military value, such as Antarctica and Outer Space.

It has been suggested by some participants in the Peace Research movement, that this type of diplomatic activity only addresses itself to the symptoms of the phenomena of inter-state warfare, and not its root causes. These are claimed to lie within states, rather than in the relations of one state with another. 'As much research on the biography of weapons systems has shown, one can clearly state on the basis of the known evidence that the action-reaction scheme is, if not completely false, at least highly dubious. The main trends of the international arms race between East and West have developed quite differently from what has been asserted in the action-reaction theorem.'[2] This line of argument then goes on to assert that the procurement decisions of the major armaments producers have been 'mainly *inner directed* ... The *self-centred imperatives of national armament* policies have been far stronger than those which have resulted from the reciprocal interaction with the so-called *potential* enemy.'[3]

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1. The SALT treaties have been of this type. For the details of the 1972 treaties see *Survival*, July/August, 1972, pp.192-199.

2. U. Albrecht, J. Galtung, P. Joenniemi, D. Senghaas, S. Verona, 'Is Europe to Demilitarise?' *Instant Research on Peace and Violence*, Tampere Peace Research Institute, Finland. No.4 1972, p. 188.

3. *Ibid.*, words underlined are in italics in original.

Two further propositions are associated with these claims. One is that 'As has been proved by empirical analysis, the research, development, experimenting, production and implementation phases of major weapons systems do follow a very rigid sequential scheme within research and production plants, not affected by the vicissitudes in the development of international politics.'[1] The second is that 'defence administrations and those social forces involved in the security and defence business usually put much effort into the maintenance of keeping once established research and production plants going since an interruption of the work in these institutions is considered intolerable by the political and military due to the long lead time requirements of modern weapon technology.'[2]

The authors of the article quoted above then proceed to argue that two corollaries concerning the control of arms races flow from these propositions. One is that 'the loosening-up of enemy fixations does not presently lead to an inroad into the growth patterns of the defense apparata.'[3] The second is that one cannot regard weapons procurement processes as sequential in character, with certain factors dominant within them. Rather, they must be regarded as simultaneous, and having no consistently predominant factors within them. 'Conventional causal schemes have conceptualised causality in terms of the sequential interaction of independent, intervening

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1. Ibid., p. 191.
2. Ibid.
3. Ibid., p. 194.

and dependent variables. Configurative causality is quite different from that type of one dimensional causality in as much as syncronous and diachronous analyses about total phenomena like the contemporary defense apparata show that all possible causal interactions and causal sequences ... can be observed simultaneously with no clear-cut, one-dimensional rigid sequential patterns prevailing.'[1] This assertion is qualified in relation to individual case-studies, however. 'Naturally, in the biography of individual weapons systems a clear weighting of these factors in terms of conventional bi-and multivariate causal models can nevertheless be determined.'[2] These additional propositions lead to the conclusion that 'Arms Control Policies which are aimed at real decreases of armament efforts can only be successful with respect to such configuratively caused as well as redundantly sustained political and social institutions like the defense apparata if, and only if, they combine a plurality of measures and steps.'[3] These assertions seem to imply that arms procurement is a self-sustaining phenomenon within individual states, and is little affected by changes in the international environment. International agreements to limit arms procurement can only succeed if states are prepared and are able to control their own internal weapon procurement processes. This implies a need

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1. Ibid.
2. Ibid.
3. Ibid.

for more cross-national research into these processes,[1] for only with greater understanding of them will it be possible to devise effective policies to enable states to do this.

One major problem encountered in studying recent Western weapon system procurement processes is the all-pervasive assumption that weapons are necessary to defend against known and projected USSR capabilities. This has tended to obscure any autonomous weapon procurement processes that might exist and makes it difficult to disentangle the two elements. Until March, 1948, however, the British Cabinet refused to name the USSR as the potential enemy for defence planning purposes,[2] although the Chiefs of Staff had asked them to do this in January, 1947.[3] The period 1945-1948 therefore provides a unique opportunity for exploring weapon procurement processes in Britain in the absence of politically acceptable assumptions about a likely enemy, and for gaining insights into the self-sustaining elements of such national processes.

Weapon procurement processes can be of interest to groups other than Peace Researchers. Just as many natural scientists have had to accept that their discoveries can be used for both peaceful and warlike purposes, so investigators examining

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1. An initial attempt at producing such a cross-national comparison is contained in the final section of F.B. Horton, A.C. Rogerson and E.L. Warner, Comparative Defense Policy, John Hopkins University Press, 1974.
2. M. Gowing (assisted by L. Arnold), Independence and Deterrence: Britain and Atomic Energy 1945-52, Vol. 1. Policy Making, Macmillan, 1974, p. 214.
3. Ibid., p. 186.

weapon procurement processes may find their work used not only to identify how such processes can be controlled, but also to indicate how they can be made more efficient. Biographies of weapon systems will inevitably contain material that can be used to highlight inefficiencies and errors of judgment that occurred during these projects. In particular, a study of the period from 1945 to 1957 may uncover basic propositions about the process of developing and producing weapons that the much more complex nature of modern development and production processes may obscure.

The purely national and relatively simple nature of the aircraft projects covered by this study makes it unlikely that anything of great practical value could be learned from it which would be useful to the project director of one of today's trans-national weapon projects. Moreover, any increased understanding of the basic elements of weapon procurement processes is likely to provide little more than useful background information for intending project managers. To pinpoint uncertainty as a major element in the weapon development process, for example, provides no insights into practical methods of dealing with it.

A study of national weapon procurement processes thus appears to be an integral part of any attempts to control organised violence on this planet. This provides part of the justification for the case-study which follows. The rest is provided by intellectual curiosity. There have been very few studies of post-war British defence policy,[1] and none have explored in any detail the development, production and placing into operational service of naval anti-submarine aircraft. Such a study involves consideration not only of the technical difficulties encountered by the relevant projects, but also the evolution of aircraft carrier policy in Britain.

A simple record of events as viewed through contemporary archival materials ignores the problems of communication and interpretation generated by both the length of time since these events occurred and the possibility that forces outside the participants' conscious perceptions determined, wholly or in part, their actions.[2] In order to deal directly with these latter issues, the study has been split up into four inductive narrative chapters (2, 4, 6 and 8), and six chapters (1, 3, 5,

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1. The major general studies of British post-war defence policy have been: W.P. Snyder, The Politics of British Defence Policy 1945-62, Ohio State University Press, 1964; R.N. Rosecrance, Defence of the Realm, Columbia University Press, 1968 and C.J. Bartlett, The Long Retreat, Macmillan , 1972. In addition, there have been a number of studies of specific aspects of defence policy, such as P. Darby, British Defence Policy East of Suez, 1947-68, Oxford, 1973; M. Gowing, op.cit., A.J. Pierre, Nuclear Politics, Oxford, 1972, and W.J. Crowe Jr., The Policy Roots of the Modern Royal Navy 1946-63, Unpublished Ph.D. dissertation, Princeton University, 1965.

2. This issue is one which has generated some discussion in the context to the aims and objectives of the study of international relations. For a paper arguing the case for inductive historical studies, see C. Reynolds: 'The Study of International Politics' in The Analysis of International Politics, D332, Block i, Parts 1-4, Open University Press, Milton Keynes, 1975.

7, 9 and 10) concerned with exploring the problems and possibilities of a more deductive form of analysis.

The inadequacy of published material relevant to the narrative sections of this study made it necessary to both gain access to project records held by the Ministry of Defence, and to any material recording the activities of the principal aircraft firms involved in the production of naval aircraft. The Hawker Siddeley Aircraft Company at Brough, the successor company to the Blackburn Aircraft Company Limited, were unable to locate any relevant material in their records, and the Fairey Company Limited could not provide any information on Board Meetings of the Fairey Aviation Company Limited on the Firefly GR17/45 and Gannet. Fortunately, Westland Helicopters Limited deposited the surviving technical records and correspondence of the Fairey Aviation Company Limited with the RAF Museum at Hendon when they closed their Hayes works in 1973. I am grateful to the Museum's Archivist, Mr. Donald Brech, for allowing me to have access to this material, and for making facilities available for me to examine it and record relevant information from it. I am also grateful to the successive Heads of DS15 in the Ministry of Defence for making the necessary arrangements to enable me to consult project material held in both the Admiralty and Procurement Executive Archives, and to the personnel in these establishments who gave me generous assistance in my work. In addition, I am indebted to Mr. G.W. Hall, Rear-Admiral Sir Mathew Slattery KBE CB and Dr. H.F. Winny for discussing with me those post-war anti-submarine aircraft projects in which they participated;

to Mr. W. Broadbent for corresponding with me on this subject; to Mr. John Fairey for providing me with copies of relevant extracts from among his late father's papers, and to Squadron Leader A.C. Rogerson, RAF, for both supplying me with relevant USAF written material and making it possible for me to discuss conceptual aspects of the study with some of those attending the USAF Academy Conference on Comparative Defense Policy in February 1973.

Finally, I am deeply grateful to my colleagues, Professor Joseph Frankel and Mr. Frank Gregory. Mr. Gregory both reviewed and noted some of the files consulted at the Procurement Executive Archive, and took part in the preliminary listing of the materials contained in the Fairey collection at the RAF Museum: Professor Frankel read the initial draft of this study, and made numerous suggestions for improving the content and presentation of its conceptual sections.

LIST OF ABBREVIATIONS

ADC	Advisory Design Conference.
AD/EngRD	Assistant Director of Engine Research and Development in the Ministry of Supply.
AP	Aircraft Production Directorate of the Ministry of Supply.
AD/RDN	Assistant Director of Naval Aircraft Research and Development in the Ministry of Supply.
CNR	Chief Naval Representative in the Ministry of Supply.
CS(A)	Controller of Supplies (Aircraft) in the Ministry of Supply.
DAE	Director(ate) of Aircraft Equipment in the Admiralty.
DAW	Director(ate) of Air Warfare in the Admiralty.
DCNR	Deputy Chief Naval Representative.
DARD	Director(ate) of Aircraft Research and Development in the Ministry of Supply.
DAP	Director(ate) of Aircraft Production in the Ministry of Supply.
DC(A)	Director(ate) of Contracts in the Ministry of Supply.
DMARD	Director(ate) of Military Aircraft Research and Development in the Ministry of Supply.
DDRD(Perf)	Deputy Director of Research and Development with special responsibility for performance measurement in the Ministry of Supply.
DDMARD	Deputy Director of Military Aircraft Research and Development.
DDTD(A)	Deputy Director of Technical Development (Aircraft) in the Ministry of Supply.
DERD	Director(ate) of Engine Research and Development in the Ministry of Supply.

DDERD	Deputy Director of Engine Research and Development.
DG/TD(A)	Director General of Technical Development (Aircraft) in the Ministry of Supply.
DGRD(A)	Director General of Aircraft Research and Development in the Ministry of Supply.
DNAW	Director(ate) of Naval Air Warfare in the Admiralty.
MAP	Ministry of Aircraft Production.
MoS	Ministry of Supply.
RTO	Resident Technical Officer.
RAE	Royal Aircraft Establishment.

CHAPTER 1

THE STUDY OF WEAPON PROCUREMENT PROCESSES.

i. Introduction.

Considerable controversy surrounds the 'correct' methodology which should be used in historical and social scientific research. Thinking on this can be characterised as polarising around two alternative approaches: one of these is embodied in the argument that the process of academic research should involve the initial collection of data and its later structuring in such a way that it produces understanding; the second is based on the proposition that any process of data collection is underlain and preceded by a conscious or unconscious structuring process, which leads to certain data being selected and other data ignored.[1]

Both approaches present the scholar with practical problems if an attempt is made to apply them consciously to research activities. The first offers no clear criteria for deciding which items of information to examine and which to ignore, or any guide to the type of additional information that should actively be sought. The second offers no authoritative guide to a set of 'correct' assumptions or premises to underpin research, or any independent indicators to determine whether the data and understanding obtained through the use of such assumptions or premises accurately mirrors the 'reality' that was being

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1. For a recent short, but comprehensive, treatment of these issues see A. Ryan, The Philosophy of the Social Sciences, Macmillan: London, 1970.

investigated, or merely reflects those initial assumptions.

The structure of this study was designed to avoid a choice between these two approaches by constructing an inductive narrative account out of the basic data, and parallelling it with a separate, deductively based analysis of that data. No attempt was made to articulate the assumptions underlying the data collection process, or the factors which led to certain items being selected and presented and others ignored. Moreover, it has to be admitted that both the initial choice of subject and the selection of information appropriate to it were heavily conditioned by the accessibility of data. Certain sources were made available after a greater or lesser degree of negotiation, but other material remained unavailable or, in some cases, had been destroyed.

In this initial chapter, existing studies of weapon procurement[1] will be examined to ascertain the sets of premises or analytic frameworks underlying them, and also their purposes and objectives. Common themes and issue areas will be extracted from these studies in order to provide a set of propositions to guide a consciously structured analysis of weapon procurement processes. These will then be confronted with a narrative history of the procurement of British naval anti-submarine aircraft between 1945 and 1956, and an attempt made to both examine the relevance of these propositions to an understanding of this history, and to identify areas where the existing

1. The terms weapon procurement and weapon acquisition are treated as interchangeable throughout this study.

general literature appears to be deficient.

ii. Studies of the United States Weapon Acquisition Process.

Two types of study of United States Weapon Acquisition Processes have been undertaken. One is the production of a number of series of semi-popular technical monographs on specific weapon projects, published by such organisations as the United States Air Force Historical Section at Maxwell Air Force Base. These have concentrated on weapons of the Second World War and consist of narrative histories of the characteristics of new and modified weapons, together with the military reasons for, and effect of, such weapons.[1] Little or no attention is paid to the non-technical issues surrounding these projects.

The second type of study attempts to give a much more balanced presentation of the technical and non-technical issues surrounding the procurement of individual weapons, and is predominantly focused upon the decisions taken as part of such a process. It comprises either a reconstruction of the political, military and technological decision-making processes which sanctioned the development and production of specific weapons, or a more general analysis of the nature and deficiences of United States weapon acquisition processes at a particular point in time.

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One major dimension of the United States Weapon Acquisition Process investigated in these studies has been the political environment in which projects have existed. This covers

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1. e.g. B. Boylan, Development of the Long-Range Escort Fighter USAF Historical Study No. 136, Research Studies Institute, Maxwell Air Force Base, Alabama, 1955.

relationships between Congress and the Services, the Services and Industry and Congress and Industry, as well as the relationship of the Executive to all three. The earliest major work in this field was probably a long article by Paul Hammond on the Super Carrier and B-36 bomber controversy that occurred between 1948 and 1950.[1] This reconstructed the political manoeuvring that occurred on this issue between the Joint Chiefs of Staff; within the Navy Department, and between the Secretary of Defense and the individual Service Secretaries. In addition, the substance and impact of the relevant Congressional Hearings were also discussed. The author demonstrated the way in which the creation of the centralised Defense Department and the consequent uncertainties over the future of individual Services affected the issue. These factors were compounded by the imposition of a fixed budget ceiling for all the Services, which created acute competition for resources and bitter disputes over priorities both within the individual Services and between them. The central focus of the study was the relationship between the high level military bureaucracy and members of Congress. No attempt was made to reconstruct the detailed processes through which the B-36 and super-carriers had evolved, or the original reasons for their design and development. Instead, attention was focused upon the political arguments used later to justify their production. This was illustrated by the

1. P.Y. Hammond, 'Super Carriers and B-36 Bombers: Appropriations, Strategy and Politics' in H. Stein (ed) American Civil-Military Decisions, University of Alabama Press: Birmingham, 1963, pp. 465-554.

questions the author sought to answer in his concluding analytical section. These were:

'(i) What role was played by Congress in the B-36 investigation besides the rather obvious neutral role of providing a forum for the expression of conflicting views?

(ii) What effect, if any, did the experience of the hearings have on Congress, or its Armed Services Committees?

(iii) To what extent, under the circumstances, was the Navy appeal to Congress successful?

(iv) What effect did this appeal have on the problem of service rivalry in general, the roles-and-missions problems, and the Air Force-Navy aviation dispute most particularly?

(v) What was accomplished by this public debate over military strategy sponsored by the House Armed Services Committee?'[1]

A further study focusing upon these issues, though within a slightly broader context, was that undertaken by Michael H. Armacost into the development and production of the Thor and Jupiter IRBM systems for the United States Air Force and Army between 1955 and 1960.[2] The object of the study was 'to contribute to an understanding of how the content of weapons policies is influenced by the character of the political process through which these decisions are made. Specifically, this study presents an analysis of the ways in which interservice

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1. Ibid., p. 552.

2. M.H. Armacost, The Politics of Weapons Innovation: The Thor-Jupiter Controversy, Columbia University Press: New York, 1969.

competition affected the development, production and deployment of the novel weapon system: the intermediate-range ballistic missile.' 'Detailed study of the rival Army and Air Force efforts to design, develop, produce and deploy an IRBM system should shed some light on the political dimensions of the choices between competing weapons systems.'[1]

Armacost focused his attention upon the attempts by each of the two Services to acquire political support for their own programme, and diminish that for their rival's. He also sought to dispute C.P. Snow's contention, based on British experience, that 'the cardinal choices have to be made by a handful of men: in secret: and, at least in legal form, by men who cannot have a first-hand knowledge of what those choices depend upon or what their results may be.'[2] Armacost argued that in this case the need for external support for each Service's programme drove the issue into the wider public forum.

Given these objectives, it is not surprising that Armacost's conclusions were couched in terms of broad generalities. He argued that

> 'the dynamics of interservice politics are not to be understood in terms of the relationships among autonomous groups occasionally co-ordinating their activities as they pursue their independent interests. They rather involve the competitive as well as co-operative relationships among powerful institutionalised interest groups formally subordinate to a civilian defence leadership that although legally empowered to co-ordinate and discipline the activities of the services is sometimes politically incapable of doing so.'[3]

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1. Ibid., p. 8.

2. C.P. Snow, Science and Government, Oxford University Press: London, 1961, p. 1.

3. Armacost, op.cit., p. 251.

He concluded that

> 'the evidence of the Thor-Jupiter case suggests that, at least in those instances where service rivalry is a significant factor in weapons innovation, participation is nowhere so limited, the absence of an attentive public so complete, secrecy so impenetrable or the dichotomy between politicians and experts so stark as Lord Snow has portrayed them.'[1]

A third study of the political processes surrounding a weapon programme was that undertaken by Harvey M. Sapolsky into the Polaris programme.[2] This built upon a previous study of more limited scope by Robert Hunter.[3] The Sapolsky study was based on the polemical theme that 'Government continually fails us .... In this book I am going to describe a government program which worked, a public bureaucracy which was successful.'[4]

The bulk of the study dealt with the nature of the inter and intra-service rivalry surrounding the Polaris project, and the methods that the management group responsible for it, the Special Projects Office, adopted to gain support for its activities. It also contained a brief discussion of the criteria available for evaluating such projects. 'For the partisan, goal attainment is the only appropriate standard by which to measure the success of governmental programs and organisations.'[5] Sapolsky

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1. Ibid., p. 257.
2. H.M. Sapolsky, The Polaris System Development, Harvard University Press: Cambridge, 1972.
3. R. Hunter, Politics and Polaris: the Special Projects Office of the Navy as a Political Phenomenon, unpublished B.A. thesis, Wesleyan University, 1962.
4. Sapolsky, op. cit., p. 1.
5. Ibid., p. 230.

proposed an objective alternative to this: an 'operationalizable surrogate,'[1] in which the 'Absence of criticism ... can be taken as a mark of success, for it means that no-one views the operation of a particular program or organisation as inimical to his own interests or goals and that some may even perceive it as beneficial.'[2]

The further study of weapon project processes was R.J. Art's investigation into the TFX decision.[3] This concentrated on the political pressures and institutional processes that together contributed to a decision to allocate the contract for building the TFX aircraft, better known by its later designation of F 111, to the General Dynamics Aircraft Corporation, rather than to Boeing. It contained a number of interesting points about the relationship between cost, technical uncertainty and Congressional attitudes. The main reason for McNamara reversing the Services recommendations that the Boeing design be developed, was identified as its incorporation of thrust reversal equipment, which served the same function as dive brakes and enabled the latter to be deleted from the design.[4] He felt that the costings for the development of this device were extremely optimistic, and that it meant accepting a very large technical risk for, if the thrust reversal equipment could not be successfully developed, dive brakes would have to be retrospectively built into the

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1. Ibid., p. 231.
2. Ibid., p. 232.
3. R.J. Art, The TFX Decision: McNamara and the Military, Little Brown & Co.: New York, 1968.
4. Ibid., p. 140.

aircraft.[1]

Art also demonstrated that although the Service recommendations appeared to have been arrived at by a very thorough examination at all decision-making levels of the information available, in practice very little high level attention had been given to the matter, and the majority of the judgements and recommendations had been made by people at relatively low levels in the decision-making hierarchy.

> 'Only one person other than Air Force Secretary Zuckert had ever bothered to read the Fourth Evaluation Group Report. Most had not even glanced at it. Instead, they relied on an oral briefing that optimistically described the performance of the Boeing plane, but omitted the Report's critical analysis of the risks and difficulties involved in attempting to achieve such performance.'[2]

The author traces much of the Congressional opposition to McNamara's decision to allocate the TFX contract to General Dynamics to a lack of understanding and appreciation of these two points.

The most detailed and comprehensive study of a United States weapon project is probably that undertaken into the A-7 attack aircraft programme by R.G. Head. This drew heavily upon the three differing analytical perspectives used by G.T. Allison in his study of the Cuban Missile Crisis.[3] The first of these

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1. Ibid., pp. 143-145.

2. Ibid., p. 162.

3. These perspectives were first expanded in G.T. Allison, 'Conceptual Models and the Cuban Missile Crisis,' American Political Science Review, Vol. 63, No. 3, September 1969, pp. 689-718, and in a slightly different form provided the backbone for Allison's book Essence of Decision, Little Brown: New York, 1971. All quotations are taken from the latter book.

was the 'Rational Actor or "Classical Model" (Model I)',[1] which was intended to portray 'governmental behaviour ... (as) ... action chosen by a unitary rational decision-maker: centrally controlled, completely informed and value maximising.'[2] The second was the 'Organisational Process Model (Model II)', which based itself on the assumption that 'governmental behaviour relevant to any important problem reflects the independent output of several organisations partially co-ordinated by governmental leaders.'[3] Allison suggested that organisational actions were heavily conditioned by the existence of 'standard operating procedures' designed to deal with situations that had been encountered previously. The third model was the 'Governmental (or Bureaucratic) Politics Model (Model III)' which regarded 'The "leaders" who sit on top of organisations' as a disunited group, with each "leader" 'in his own right, a player in a central, competitive game.' These "leaders" acted 'in terms of no consistent set of strategic objectives, but rather according to various conceptions of national, organisational and personal goals,' and this led to governmental decisions being made 'not by a single rational choice but by the pulling and hauling that is politics.'[4] The author goes on to observe that 'different groups pulling in different directions may produce a result, or better a resultant ... distinct from what any person or group intended.'[5] The study

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1. *Ibid.*, pp. 4 and 5.
2. *Ibid.*, p. 67.
3. *Ibid.*
4. *Ibid.*, p. 144.
5. *Ibid.*, p. 145.

left the precise delineation between Model II and Model III behaviour obscure, as Model II behaviour could act as an input into Model III as well as producing outputs in its own right. It also blurred any dividing line between politicians and civil servants, it being rather unclear whether 'the leaders' are the former, the latter, or both.

Head's study concentrated on 'The act of decision ... with the sequence of decisions making up the primary elements of a process of decision-making in the field of defense research and development .... One of the theoretical concerns of this effort is to investigate the extent to which contemporary decision-models explain the special world of defense decision-making in the programme under study.'[1] Head then went on to examine the three perspectives developed by Allison, and argued that his Model III, Governmental (or Bureaucratic) Politics, should be more accurately labelled an individual influence model.

In his concluding chapter, Head summarised the six key decision-points in the A-7 programme, and emphasised the impact of individuals upon it at two levels. He argued

> 'One should ask what difference did it make that it was Robert S. McNamara who was Secretary of Defense from 1961 to 1968 instead of (say) Clark Clifford or Thomas S. Gates. From the evidence it seems fair to conclude that it made a great deal of difference that McNamara was the Secretary of Defense, that Dr. Enthoven was heading the Systems Analysis office, and that Dr. Brown was the head of DDR & E.'[2]

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1. R.G. Head, Decision-making on the A-7 Attack Aircraft Programme, unpublished Ph.D. Thesis, Syracuse University, 1971, p. 35.

2. Ibid., pp. 545-6.

Head also identified the project managers as crucial variables in the programme. He stated that

> 'One of the clearest examples of the utility of the Individual Influence Model is indicated by the effect of the project managers on the A-7 .... The evidence indicates that their personal knowledge of the system management business, the intricacies of joint service development and the other individuals in the decision process played an important role in their management of the A-7'.[1]
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> 'A recommendation for further research in this area is that scholars find methods to incorporate more of Allison's Model III into the research methodology and aim at moving to greater precision and refinement in providing for individual personalities.'[2]

Unfortunately, Head made little attempt to indicate how such integration could be obtained. Instead, he generated a new model, the Professional Organisational Model, to partially explain the behaviour of people such as Systems Analysts whose activities did not fall clearly into any of Allison's three models.[3]

Head also emphasised the artificiality of separating out one set of decisions or one weapon project from the totality of the overall weapon procurement process:

> 'The mere selection of a single aircraft program as the subject necessitated the rejection of many other approaches. Implicit in this original rejection was the rejection of much existing data which bore obliquely on the A-7, but led off into other, tangential fields. Specifically, the reader should bear in mind that the decision-makers discussed in this study devoted only a small proportion of their time to the A-7; they were constantly besieged by other matters which cannot be fully appreciated by the casual observer. The effect this may have on the study is to impart a more coherent picture of the events in retrospect than was experienced by the participants in the original decision process.'[4]

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1. Ibid., pp. 546-7.
2. Ibid., p. 568.
3. Ibid., pp. 556-559.
4. Ibid., p. 33.

This caveat is probably applicable to all decision-making processes.

Allison's three perspectives upon decision-making also formed the theoretical basis of M.H. Halperin's study of the ABM development decision.[1] This attempted to describe the processes that led to the decision that the United States would produce and deploy an anti-ballistic missile defence system, rather than merely continue research and development work into one. The analysis was focused upon the political forces acting upon the Defense Secretary before the decision was made, but no conclusions emerged about the utility or limitations of the models as guides to the analysis of weapon procurement decisions.

A rather more general and polemic study of weapon procurement decisions was undertaken by J.R. Kurth, who identified four differing perspectives through which these could be examined: the strategic, bureaucratic, democratic and economic.[2] He also paid extensive attention to the reasons why particular firms were awarded specific contracts. Two types of explanation of governmental action were examined in this context; the 'follow-on imperative' and the 'bail out imperative.'[3] The basic theme of this article was that the procurement of specific weapons is

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1. M.H. Halperin, 'The Decision to deploy the ABM: bureaucratic and democratic politics in the Johnson administration', World Politics, 25 (1), October, 1972, pp. 62-95.
2. J.R. Kurth, 'Why we buy the Weapons we do.' Foreign Policy, No. 11, Summer, 1973, p. 34.
3. Ibid., pp. 38-43.

predominantly due to a perceived need to maintain the industrial structure responsible for arms production in the United States, rather than a response to external threats.

. . . .

A second major dimension central to studies of United States weapon procurement has been the idea that uncertainty is the key characteristic of such a process. A number of attempts have been made to identify the different types of uncertainty involved, and suggest ways that its disruptive impact could be reduced. This latter form of policy orientated discussion usually evolves into arguments about the merits or demerits of a parallel development strategy.

One of the most extensive studies of this type was based on 'a series of development case histories studied by a number of different investigators at RAND.'[1] These have never been published, but abbreviated versions of them appeared in a RAND paper edited by T.A. Marschak on the role of project histories in the study of research and development. This lengthy study set out to investigate whether these project histories supported two hypotheses:

> (1) 'major uncertainty, at least in the earlier phases of development, is a natural and inevitable property of a program that seeks a real technical advance'[2] and
>
> (2) 'when the predictions available at the start of a development program are used as the basis of heavy commitments to a highly specified design, then in the fortunate cases when the predictions turn out to be correct, time and money may be saved if such commitments do not have to be postponed until later in development. If the

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1. T.A. Marschak (ed), <u>The Role of Project Histories in the Study of R & D</u>, RAND Paper P-2850: Santa Monica, 1965.

2. <u>Ibid</u>., p. 3.

> predictions are seriously wrong, however, costly revisions will be required. The initial uncertainties of development are such that the gains due to heavy initial commitments in the fortunate cases are outweighed by the costly revisions of the unfortunate cases.'[1]

After examining the series of case studies of radar, aircraft engine and airframe programmes and one missile project, Marschak concludes that the first hypothesis is proven, but that

> 'in addition to such "technical uncertainties", there are often great "strategic uncertainties", for there typically occur outside the development project during the course of development, events that affect the relative desirability of the design being pursued: the relative value of different missions change, fundamental state-of-the-art advances occur, and other projects turn out to have an unforeseen bearing on the project under study.'[2]

He has to redefine the second hypothesis, however, in terms of two extreme types. The first, an inflexible strategy 'takes very seriously the best predictions available at the start of development as to the effort required to achieve alternative, highly detailed specifications. One such set of specifications is chosen, and large commitments to it are made, that would achieve rapid development if the predictions turned out to be correct.'[3] In contrast, the second, flexible strategy 'avoids all but the broadest specifications to start with and makes no major commitment until a substantial jump in knowledge about the item being developed has been attained.'[4] Despite this elaboration of the original hypothesis, however, its validity

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1. <u>Ibid</u>.
2. <u>Ibid</u>., p. 15.
3. <u>Ibid</u>., p. 16.
4. <u>Ibid</u>.

is judged to have been 'far from settled, one way or the other, by the preceding collection of histories.'[1]

This study was parallelled by a more general investigation into the United States weapon acquisition process conducted by M.J. Peck and F.M. Scherer.[2] This was based on 99 aircraft and missile projects initiated by the United States government between 1945 and 1960.[3] The authors isolated uncertainty as the major feature distinguishing weapon procurement from other types of procurement process. They stated that 'the weapons acquisition process is characterised by a unique set of uncertainties which differentiates it from other economic activity.' They divided this 'unique set of uncertainties' into 'two broad classes:

> internal and external uncertainties. Internal (or technological) uncertainties relate to the possible incidence of unforeseen technical difficulties in the development of a specific weapon system. External uncertainties relate to factors external to an individual project and yet affecting the course and outcome of the project. They originate in the pace of technological change in weaponry, changes in strategic requirements, and shifts in governmental policy.'[4]

In a further section of the study, possible types of development strategy were discussed. Starting from the proposition that for any project 'the minimum possible development time is determined by the longest single chain of necessarily sequential bottleneck tests,'[5] the authors examined methods of

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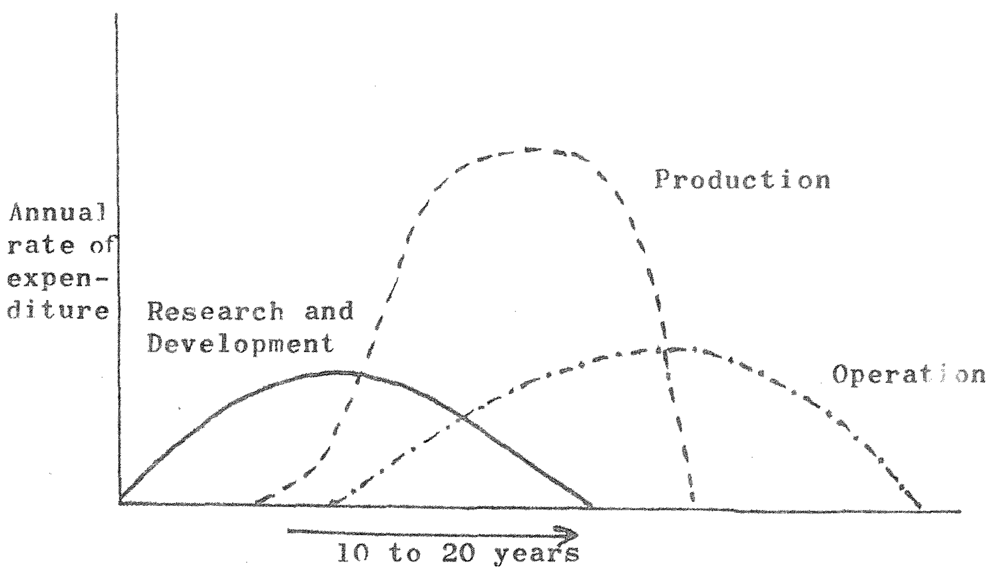
1. Ibid., p. 119.
2. M.J. Peck and F.M. Scherer, The Weapons Acquisition Process: an Economic Analysis, Harvard University Press: Cambridge, 1962.
3. For a full listing of these see Ibid, Appendix 12a pp. 645-667.
4. Ibid., p. 24.
5. Ibid., p. 261

achieving this. These included 'operating simultaneously two or more approaches to the step, test, or problem to insure that at least one approach will hit the mark at the earliest possible moment.[1] Two variations of this approach are suggested. 'In one, completely different conceptual approaches to a given problem are carried forward. Each absorbs its full complement of human resources and test prototypes.'[2] In the other 'essentially similar items of test hardware' are duplicated in order 'to prevent the interruption of testing by unforeseen accidents.'[3]

The authors then examined the relationships between time, cost and uncertainty in weapon programmes. They delimited three principal phases of a programme: (1) research and development, (2) production for the operational inventory, and (3) actual operation. Each phase was characterised by the differing streams of expenditure illustrated in the following graph.[4]



1. Ibid.
2. Ibid.
3. Ibid., p. 362.
4. Ibid., p. 310.

A further general study of the role of uncertainty was produced in 1959 by R.R. Nelson.[1] This examined whether parallel development was the optimal strategy for the early phases of a weapon procurement process. The crux of his argument was that because of the major uncertainties involved at the start of any R & D programme, small sums of money spent at that point were likely to produce very significant reductions in the uncertainty involved.

> 'The possibility of acquiring significantly improved estimates at relatively low cost suggests that it may be economical <u>not</u> to choose one design or contractor for an R & D job on the basis of first estimates ... but rather to initiate parallel-development efforts, cutting down the list of competing projects as estimates improve. The best decision to make on the basis of some information may be to delay a final decision until more information is obtained.'[2]

Nelson pointed out that parallel research and development efforts and duplication are not the same thing. Indeed, he argued that 'Most of the arguments against parallel research and development are arguments against <u>duplication</u>. But parallel efforts need not be duplicate efforts. In the atomic-bomb project the alternatives were far from duplications, they were very different technically.'[3] Unfortunately, he failed to address himself effectively to the question of how and at what point, a choice between parallel research and development efforts should be made and rather lamely concluded that 'It may turn out that neither project will have flown in twenty months, in which case the Air Force will not be in a better position to make up its mind at the end of twenty months than it was initially.'[4]

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1. R.R. Nelson, <u>The Economics of Parallel R & D Efforts: A Sequential-Decision Analysis</u>, Rand: Santa Monica, Nov., 1959.
2. <u>Ibid</u>., pp. 3 and 4.
3. <u>Ibid</u>., p. 6.
4. <u>Ibid</u>., p. 14.

The author identified two separate propositions which underlie the argument that parallel development is the optimal Research and Development strategy. 'First, at the start of a development program, estimates of the cost, time and performance of a proposed weapon system are subject to great uncertainty. Second, these estimates improve and become more reliable as development proceeds.'[1] He related these to an additional proposition that 'parallel development of alternative designs seems called for when the technical advances sought are large, much additional information can be gained by prototype testing, and the cost of a few prototypes is small relative to total systems cost.'[2] His overall conclusion, therefore, was that if major technological uncertainties were involved, and time was a major factor, then parallel development of a number of alternative systems was likely to be the optimum strategy.

A further contribution to the discussion of uncertainty as the key characteristic of the weapon acquisition processes was made by Hitch and McKean in their book The Economics of Defense in the Nuclear Age.[3] This was concerned to demonstrate the use of formal tools of analysis in a number of defence decision-making situations, and included one chapter devoted to Military Research and Development. In this, it was argued that 'the important thing to appreciate in making good decisions with respect to research and development is the dominant role

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1. Ibid., p. 19.
2. Ibid., p. 31.
3. C.J. Hitch & R.N. McKean, The Economics of Defense in the Nuclear Age, Harvard University Press: Cambridge, 1960.

played by uncertainty.'[1]

The need for duplication of research and development was also discussed, it being emphasised that 'Not only does the use of several routes buy time; it also, up to a point, actually saves money!'[2] This argument for duplication is further advanced by listing four situations where duplication is desirable.

'1. There should be more duplication, the greater the expected pay off from the research ...

2. There should be more duplication, the greater the uncertainties ...

3. There should be more duplication, the cheaper it is to duplicate ...

4. There is a stronger case for duplication if the alternatives are qualitatively different.'[3]

The importance of uncertainty was also highlighted in a number of the studies of the development of specific weapons systems. Armacost observed that 'the vagaries of politics and the uncertainties of technology combine to render objectives hazy, evaluation of alternatives tentative, cost, time and performance estimates of advanced systems highly questionable.'[4] This 'suggests the difficulties of equating rational policy with a rigid adherence to a sequential process which begins with the definition of a single statement of strategic policy and proceeds then to deduce material requirements, research and development priorities, and budgetary decisions from it.'[5] In addition,

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1. Ibid., p. 248.
2. Ibid., p. 249.
3. Ibid., pp. 249-250.
4. Armacost op. cit., p. 257.
5. Ibid., p. 259.

'where military problems urgently demand solution, the support of parallel development programs may constitute a defensible method of overcoming technical difficulties efficiently. While postponing a choice as between rival approaches, technical uncertainties may be reduced, cost estimates improved and strategic needs systematically assessed. A broad menu of technological possibilities may be assured even as the high costs of premature commitment to the production of any specific system may be avoided.'[1]

In a similar vein, Sapolsky argued that the ability of the Special Projects Office to write its own specification for the weapon system, was a key factor in the success of the project.

'Control over the performance goals of the FBM system gave Admiral Smith flexibility. A standard technical strategy in priority research and development programs is to run parallel or backup projects where major uncertainties exist .... Backup strategy was, of course, extensively employed in the FBM program .... Having control over the performance goals, however, provided the Admiral with the alternative of curtailing goals as well as trying parallel approaches to building a viable system. Instead of just employing a backup strategy, he could also employ what could be called a fallback strategy .... Performance was a manipulatable variable in the Polaris Program.'[2]

In a later passage, Sapolsky broadens this argument by stating that

'complicating a need or demand determining view of the relationship between technology and society is the fact that the society ... seldom makes clear-cut choices among available policy alternatives .... The consequences of indecision are clearly revealed in the weapons acquisition process. The choice among weapon projects is the choice among defense strategies .... Most weapon projects languish in uncertainty, with no guarantee that funds will actually be appropriated or procurements will actually be made ... where there is strategic disagreement or indecision the usual result is a conscious or unconscious compromise to keep options open.'[3] 'The project gets just enough

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1. Ibid., p. 260.
2. Sapolsky, op. cit., pp. 140-141.
3. Ibid., p. 237.

resources to drag along, but not enough to make much headway .... With the ebb and flow of the strategic debate, the project's opportunities shift.'[1]

The types of uncertainty identified in these studies were systematized in the report on a study aimed at aiding the USAF in evaluating the risks involved in new weapon projects. This argued that four types of uncertainty were inherent in such projects:

i. '*Target Uncertainties*', which 'reflect the incomplete knowledge of the final physical and performance characteristics that will be required to satisfy a military need .... A major source of target uncertainty is the technological change occurring in both the home country (what is available) and in opponent countries (what is required.)'[2]

ii. '*Technical Uncertainty*' which 'surrounds estimates of engineering feasibility and "state of the art cost" projections.'[3]

iii. '*Internal Program Uncertainty*' which 'originates from the manner in which programs are organised, planned and managed. This relates to selection of an acquisition strategy, authority of the program manager, and the administrative details of the program.'[4]

iv. '*Process Uncertainty*' which 'originates in the external environment, primarily in the political process of the country.'[5]

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1. *Ibid.*, p. 238.
2. *Final Report of the USAF Academy Risk Analysis Study Team*, Joint Faculty Project, USAF Academy, Colorado, August 1971, pp. 23-24.
3. *Ibid.*, pp. 26 and 27.
4. *Ibid.*, p. 28.
5. *Ibid.*, p. 30.

A third dimension inherent in studies of the United States weapon procurement process is the attempt to describe that process in terms of a number of sequential phases. Marschak tried to formulate 'an Idealised Division of Engine Development into Stages,'[1] based upon a number of case studies of the development of specific engines. These stages were listed as:

> '(i) Collection of "on-the-shelf" component test data without application to a specified complete engine (this stage may not occur).
> (ii) The general design study stage.
> (iii) The stage of performance orientated development.
> (iv) The stage of weight and durability orientated development.
> (v) The final prototype stage.'[2]

A similar phasing was also put forward by Peck and Scherer. This was adapted from a scheme first prepared by D. Norwick.[3] In it

> 'Step I can be roughly equated with basic science, Step II with applied research, Step III with advanced engineering and Step IV with product engineering.'[4]

> 'Step I activity emphasizes a further understanding of nature through theory and empirical verification; that is, the creation of new knowledge .... Step II activity searches for knowledge about specific means of using the phenomena of nature to practical advantage.'[5]

> 'At Step III, uncertainty centres on whether the cost, time of completion and utility of the activity's outcome will be such as to make the effort worthwhile.'[6]

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1. Marschak, op. cit., p. 25.
2. Ibid.
3. David Norwick, 'What do we mean by Research and Development?', California Management Review, Spring 1960, p. 21.
4. Peck and Scherer, op. cit., p. 27.
5. Ibid., p. 28.
6. Ibid., p. 29.

> 'Step IV has the same character as Step III, only with an even higher degree of predictability and an even more direct relationship between effort and outcome.'[1]

In a later section of their study, Peck and Scherer built up a rather more pragmatic model of the weapon acquisition process. They argued that it was a 'Sequential Process' in which 'program decisions are made repeatedly as various bench marks in the development-production-operation progression are reached and as budgets come up for their periodic reviews.'[2] The first phase in this process was that 'once a new weapon system idea has been conceived, the first real decisions generally have to do with the establishment of military requirements. These are formal documents stating the particular service's need for a new weapon system type, over-all technical characteristics for the weapon system desired, and the time period during which that weapon system is operationally needed.[3] The second is that 'if contractors have not yet been chosen, some kind of selection procedure is carried out .... Occasionally development work is started even before the issuance of military requirements, in which case the contractor proceeds on an informal understanding of the service's needs.'[4] Third, 'at some time during this early period and on subsequent occasions, decisions are made in the program's priority relative to other efforts.'[5] Fourth, 'a

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1. Ibid., p. 30.
2. Peck and Scherer, op. cit., p. 316.
3. Ibid.
4. Ibid., p. 317.
5. Ibid.

development program may be reviewed anywhere from a few to dozens of times to determine whether it should be continued.'[1] The fifth phase was 'detailed design work;'[2] the sixth the decision to invest in 'long lead time production tooling and facilities;'[3] while in the last 'full-scale quantity production must ... be authorised.'[4] Throughout this process 'an alternative at any time to continuing a development and production program is cancellation.'[5] However, 'once a development program is well under way, cancellation decisions are not readily forthcoming unless the arguments for termination are overwhelming.'[6] In addition 'an alternative to terminating a development program in favour of a wholly new challenger is reorienting the existing program around new goals,'[7] because 'additional performance is often obtained at an incremental cost much lower than the full cost of sponsoring a complete new development program.'[8] In addition the study looked at the issue of contractor selection in some depth, and concluded that contractor capability, past performance, spare capacity and industry planning considerations are major factors in this phase.[9]

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1. Ibid., p. 318.
2. Ibid.
3. Ibid.
4. Ibid.
5. Ibid., p. 320.
6. Ibid., p. 322.
7. Ibid., p. 321.
8. Ibid., p. 322.
9. Ibid., pp. 362-382.

A much simpler, but equally pragmatic structuring of the weapon procurement process was put forward by Head. He identified four phases

'1) The Concept Formulation phase ...

2) The Contract Definition phase ...

3) The System Acquisition phase ...

4) The Systems Operation phase ...'[1]

In a later work, however, he reverted to a rather more abstract structure comprising Conceptual, Validation, Full-Scale Development, Production and Operation phases.[2] 'The Conceptual phase combines knowledge developed in basic and applied research with operational needs.'[3] Validation 'is an outgrowth of the Contract Definition phase', for 'the change from Contract Definition to Validation ... was intended to reflect the increased emphasis on hardware development and testing before a decision to begin Full Scale Development.'[4] 'Full Scale Development' involves 'extensive hardware development and testing in addition to certain pre-production costs.'[5] 'Production' and 'Operation' are self-explanatory.

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1. Head, op. cit., pp. 75 and 76.
2. R.G. Head, 'The Weapons Acquisition Process: Alternative National Strategies' in F. B. Horton et al, op. cit., p. 415.
3. Ibid.
4. Ibid.
5. Ibid.

These studies offer two alternative dimensions or perspectives upon United States weapon procurement processes: the idea that they involve a special type of decision-making environment whose major characteristic is a high level of risk or uncertainty, and the idea that they can be described by reference to a sequential set of phases or steps.

iii. Studies of Defence Procurement in Britain.

In contrast to the extensive and detailed accounts of United States programmes, there is a dearth of literature on British weapon procurement. The material that does exist comprises purely descriptive studies of weapon procurement during and immediately following World War II, the most extensive works of this type being those by Gowing[1] and Postan, Hay and Scott.[2] The former describes the development and manufacture of nuclear reactors and atomic bombs by Britain between 1939 and 1952, while the latter attempted to examine Britain's wartime experience of weapon development and production.

Gowing's studies were not intended to provide a systematic, general understanding of weapon procurement processes, though the 1945-52 study highlighted two interesting factors which were central to the evolution of the British nuclear

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1. M. Gowing, Britain and Atomic Energy, 1939-45, Macmillan: London, 1964, (hereafter cited as Gowing 1939-45), and M. Gowing assisted by L. Arnold, Independence and Deterrence: Britain and Atomic Energy, 1945-52, Volume 1: Policy Making and Volume 2: Policy Execution, Macmillan: London, 1974, (hereafter cited as Gowing, 1945-52, Vols. 1 or 2).
2. M.M. Postan, D. Hay and J.D. Scott, Design and Development of Weapons, History of the Second World War, War Production Series, HMSO: London, 1964.

programme. The first was that the programme was dominated by a political desire not to do anything which might hinder a resumption of full nuclear cooperation with the United States.[1] The impact of this decision-making criterion was illustrated by a decision to terminate construction work on a third plutonium pile at Windscale when it was (incorrectly) believed that a resumption of full cooperation might be imminent.[2] The second was the way that effective operational control of the project devolved upon three middle rank scientific civil servants, Hinton, Cockroft and Penney, whose individual personalities and abilities determined whether the first British atomic bomb would be completed within the prescribed time scale.[3]

The Postan, Hay and Scott study was not comprehensive and it contained little material on naval procurement programmes. It concentrated on the procurement of aircraft and equipment for the RAF, and contained an informative section on the British philosophy of aircraft procurement. It was stated that up to 1945, the dominant procurement strategy had been the 'multiplicity of types' approach, in which two or three designs of aircraft were developed in each class in order to 'provide a minimum safeguard against the temporary collapse of any one type putting the whole ... force out of action.'[4] It was believed that this strategy provided 'a valuable insurance against the hazards of development

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1. Gowing 1945-52, Vol. 1, esp., Chs. 4, 5, pp. 87-159 and Chs. 8-10, pp. 241-348.

2. Ibid., pp. 291-293.

3. Ibid., Vol. 2. This theme underpins the whole of the volume.

4. Postan, Hay and Scott, op. cit., p. 19.

and of early operational experience.'[1] Their study also contained details of the seven phase 'normal procedure' used for military aircraft procurement, which comprised:

(1) Inception, 'when the Air Staff compiled the operational requirements for a new type or when the aircraft firms gave birth to preliminary designs in anticipation of a coming operational requirement.'[2]

(2) 'The period when the Air Ministry, or later the MAP formulated the official technical specification embodying the operational requirements of the Air Staff, and possibly also the technical forecasts of the industry.'[3]

(3) 'The competitive tender, ... (which) ... was largely devoted to a discussion, preceding the issue of the prototype orders, of the relative merits of the tender designs.'[4]

(4) 'The construction of prototype aircraft.'[5]

(5) 'Tests and trials of prototypes.'[6]

(6) This phase, sometimes omitted, 'covered the development ... orders.'[7]

(7) 'Production orders.'[8]

This seven-phase process can be seen as a further descriptive model of the weapon acquisition process, while the multiplicity of types philosophy was a variant of the concept of parallel development.

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1. Ibid.
2. Ibid., p. 140 and Appendix 11, pp. 499-500.
3. Ibid., and Appendix 11, pp. 500-501.
4. Ibid., and Appendix 11, pp. 501-502
5. Ibid., and Appendix 11, pp. 502-503.
6. Ibid., and Appendix 11, pp. 503-504.
7. Ibid., and Appendix 11, pp. 504.
8. Ibid.

A number of shorter studies of weapon procurement in the post-war period have also been published, but they have been mainly descriptive or polemical rather than analytical in character. Studies of the Polaris project,[1] of the TSR-2 project,[2] and of joint projects with other European states[3] fall into this category. In addition a number of official Reports and House of Commons papers have been published on various aspects of the British weapon procurement system during the post-war period, but they too have been either purely descriptive in content, or concerned with advocating changes in institutional processes.[4]

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1. J. Simpson, 'The Polaris Executive: A case study of a Unified Hierarchy', Public Administration, Winter 1970, Vol. 48, pp. 379-390, and I. McGeoch, 'The British Polaris Project', unpublished paper presented at a University of Southampton Conference on 'The Evolution of British Defence Policy, 1945-1970,' Wessex Hotel, Winchester, April 29th - May 1st, 1975.

2. G. Williams, F. Gregory and J. Simpson, Crisis in Procurement: A Case Study of the TSR-2, RUSI: London, 1969 and S. Hastings, The Murder of TSR-2, Macdonald: London, 1968.

3. M. Edmonds, 'International Collaboration in Weapons Procurement - the implications of the Anglo-French case,' International Affairs, April, 1967, pp. 252-264, Defence Technology and the Western Alliance, Institute for Strategic Studies: London, 1967, Parts 1-6, and J. Simpson and F. Gregory, 'West European Collaboration in Weapons Procurement,' ORBIS, Vol. XVI, Summer 1972, No. 2, pp. 435-461.

4. Both the House of Commons Select Committee on Estimates and the Public Accounts Committee have investigated defence procurement practices and projects from time to time, and published their minutes of evidence and conclusions. In addition, the following committee reports and parliamentary papers have been produced: 2nd Report of the Select Committee on Science and Technology, 'Defence Research,' House of Commons Paper No. 213, 1968-69, HMSO; The Supply of Military Aircraft, Cmnd 9388, 1955, HMSO; 1st and 2nd Reports of Inquiry into the Pricing of Ministry of Aviation Contracts, Cmnd. 2428, 1964 and Cmnd. 2581, 1965, HMSO; Report of the Committee of Enquiry into the Aircraft Industry, Cmnd. 2853, 1964-65, HMSO; The Reorganisation of Central Government, Cmnd. 4506, 1970, HMSO, Ch. 17; (contd)

There also exist three attempts to examine the bureaucratic politics surrounding defence policy and weapon procurement in Britain. The earliest of these is contained in C.P. Snow's monograph, Science and Government in Britain. In this, the author first defined "closed politics" as any kind of politics 'in which there is no appeal to a larger assembly - larger assembly in the sense of a group of opinion, or an electorate, or on an even bigger scale what we call loosely "social forces"'[1] He then went on to argue that in the 'Tizard-Lindemann story we saw three of the characteristic forms of closed politics .... The first is committee politics ... the archetype of all these is that kind of committee where each member speaks with his individual voice, depends upon his personality alone for his influence, and in the long run votes with an equal vote.'[2] 'The second (is) "hierarchical politics" - the politics of a chain of command, of the services, of a bureaucracy, of a large industry. On the surface these politics seem very simple. Just get hold of the man at the top, and the order will go down the line ... chain of command organisations do not work a bit like

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Government Organisation for Defence Procurement and Civil Aerospace, Cmnd. 4641, HMSO, 1971; Report of the Committee on the Management and Control of Research and Development; Office of the Minister of Science, HMSO, 1961; Report of the Steering Goup on Development Cost Estimating, 2 Volumes, Ministry of Technology, HMSO, 1969; and The Productivity of the National Aircraft Effort, (Report of a Committee appointed by the Minister of Technology and the President of the SBAC), Ministry of Technology, HMSO, 1969.

1. Snow, op. cit., p. 56.

2. Ibid., p. 57.

that .... To get anything done in any highly articulated organisation, you have got to carry people at all sorts of levels. It is their decisions, their acquiescence or enthusiasm (above all, the absence of their passive resistance), which are going to decide whether a strategy goes through in time.'[1] 'The third ... is ... "court politics." By court politics I mean attempts to exert power through a man who possesses a concentration of power.'[2] These propositions suggested that very similar bureaucratic activities to those uncovered by the United States studies existed within the British weapon procurement process, but due to the 'closed politics' involved, they were invisible to public view.

L.W. Martin made a more specific attempt to examine the political relationships and arguments over procurement policy between the three Services in Britain in an article published in 1962[3]. This included two empirical points which illuminated some of the problems of weapon development encountered by Britain in the preceding decade. He pointed out that due to shortages of money, there was 'a temptation to defer developments for fear of precluding later possibilities.'[4] This had produced a situation where there was 'very little weapon development other than that of the Atomic bomb during the "forties"'[5] He also observed

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1. Ibid., p. 60.
2. Ibid., p. 63.
3. L.W. Martin, 'The Market for Strategic Ideas in Britain: The "Sandys Era"', American Political Science Review, Vol. 56, No. 1, March 1962, pp. 23-41.
4. Ibid., p. 24.
5. Ibid.

that 'the Chief Scientist proved particularly useful for settling issues, ostensibly on technical grounds but frequently merely to secure a decision.'[1]

Finally, W.J. Crowe produced a study of British Naval Policy between 1946 and 1963, which included some examination of 'the interaction between governmental decision-makers which resulted in naval policy.'[2] This work was based on an extensive series of unattributable interviews. It concentrated mainly on the debates over the shape of the fleet, and comments on the problems and politics of weapon procurement were sparse, and often rather misleading.[3]

iv. Studies of Weapon Procurement in France, the USSR, and Sweden.

There also exists a very limited literature on weapon procurement in states other than Britain and the United States. Two historical studies of the aircraft procurement system in the USSR have been produced.[4] These emphasised the widespread use of the parallel development strategy by the Russians, despite the abandonment of this technique during the early 1950's by both the United States and Britain. A study of the development methods employed by one of the major aircraft companies in France illustrated the use made of the procedure of producing several differing prototypes of potential military aircraft before any

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1. Ibid., p. 26.
2. Crowe, op. cit., p. 4.
3. See, for example, p. 97 below.
4. A.J. Alexander, R & D in Soviet Aviation, RAND, Santa Monica, 1970, R-589-PR, and J. Simpson, 'The Military Aircraft Procurement Process in the USSR', in The Soviet Union in Europe and the Near East: Her Capabilities and Intentions, RUSI: London, 1970.

production decisions were taken.[1] Finally, a book length study of the Swedish process of military aircraft procurement illustrated the ability of this state to develop modern weapons, despite both a very limited industrial base, and the lack of effective internal competition.[2] It offered few general insights into weapon procurement processes, and concentrated upon investigating the interaction between the weapon procurement process and the Swedish Parliament and political system.

In an earlier study of a Swedish weapon project,[3] the same author attempted to develop a conceptual scheme to guide research into his subject matter. In this, he used Peck and Scherer's concepts of time, quality and cost as a framework for analysis.[4] He equated these with obsolescence or the replacement problem, resources available, and the budgetary system respectively. He then argued that in the Swedish case

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1. R.L. Perry, A Dassault Dossier: Aircraft Acquisition in France, RAND, Santa Monica, 1973, R-1148-PR.

2. I. Dorfer, System 37 Viggen: Arms, Technology and the Domestication of Glory, Universitetsforlaget: Oslo, 1973.

3. Dorfer: 'System 37 Viggen: Science Technology and the Domestication of Glory', in Public Policy, Vol. 17 (1968), pp. 201-229.

4. Peck and Scherer, op. cit., p. 19. It is difficult to believe that the originators of these theoretical concepts expected them to be used in this way. The original intention was to demonstrate that they are three interrelated variables. Their relationship is such that development time can be reduced by increasing the resources devoted to a project or by reducing its quality: reducing the resources available will stretch out development time or lead to a reduction in quality, while a reduction in quality will reduce development time or the resources needed for a project.

time was the most flexible variable, while cost and quality were relatively inflexible.[1] Although this is a useful device for conceptualizing certain of the background conditions within which Swedish weapon procurement operates, it fails to provide a comprehensive model of the Swedish weapon procurement process.

v. Comparative Studies of Weapon Acquisition Processes.

There have been two major attempts to produce cross-national studies of weapon procurement. The first was a comparative study of military aero-engine development in the United States, United Kingdom and France up to 1946.[2] This centred upon the differing contractual relationships between the United States and British governments and their aero-engine firms, and attempted to assess whether one type of relationship was markedly better than the other in developing high quality military engines. Thus 'the only really important incentive leading (United States) private industry to carry out the development of aircraft engines effectively was the prospect of profits on quantity production.'[3] 'The British followed a contrary policy, which amounted in essence to the assumption of all risk by the government. British firms ... before doing any extensive development ... submitted the project to the government and continued with it only if the government awarded a

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1. Dorfer in Public Policy, op. cit., pp. 222-223.
2. R. Schlaifer and S.D. Heron, Development of Aircraft Engines and Fuels, Harvard Business School: Cambridge, 1950.
3. Ibid., p. 9.

development contract.'[1] Schlaifer's conclusions were that there was little to choose between these two methods in terms of the end product for: 'The two systems led to the existence in the two countries at the outbreak of the Second World War of series of engines of about equal over-all technical merit and military utility. Specific points of superiority or inferiority do not seem to be a result of the difference between the systems of financing development.'[2]

The second attempt at comparative analysis is much more comprehensive and wide-ranging than the Schlaifer study. It originated in a set of papers prepared for a USAF Academy conference on Comparative Defence Policies,[3] which were then added to and revised, before being commercially published. One quarter of this conference and the subsequent book was devoted to a comparison of national weapon procurement policies.[4]

In the original conference papers, Sapolsky argued that it was impossible to construct an analytical framework that would be universally applicable to all national weapon procurement processes, because 'the development and procurement of weapons ... are fashioned in "the currency of domestic politics"... (and) once we recognise domestic politics as the coin of our realm, as we must, then we all but concede the futility of a cross-national comparative effort.'[5] He went on to produce two

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1. Ibid.

2. Ibid., pp. 59 and 60.

3. Proceedings of the Conference on Comparative Defense Policy, Dept. of Political Science, USAF Academy, Colorado, 1973, (hereafter cited as Proceedings).

4. F.B. Horton et al., op. cit.

5. H.M.Sapolsky, 'The Military/Industrial State in Comparative Perspective' in Proceedings, op. cit., p. 1.

further arguments in support of this proposition: 'On the one hand, comparative studies of domestic politics can easily generate more information than can be effectively absorbed' and 'on the other hand, there is rarely anything beyond speculation to analyse when one seeks to understand why a government other than the government of the United States made a particular weapons development decision.'[1]

These propositions were explicitly rejected in two of the articles published in the book. One, on the acquisition of military aircraft in Great Britain and West Germany raised 'the fundamental question of whether any meaningful comparison between national weapons acquisition processes is possible.'[2] It went on to argue that weapons acquisition processes could be seen either 'as dependent variables in relation to their parent political system' or 'as comparable sets of national methods of approaching similar weapons acquisition issues.'[3] From 'the first perspective, the starting point for any cross national analysis of weapons acquisition processes must be a comparison of the functioning of their political systems.'[4] From 'the second perspective, one starts by identifying the common problems, decision stages, issue areas and other points of comparison that appear to be relevant to most weapons acquisition processes, and uses these as a framework to guide

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1. Ibid.

2. F.E.C. Gregory and J. Simpson, 'The Acquisition of Military Aircraft in Great Britain and West Germany' in F.B. Horton et al, op. cit., p. 453.

3. Ibid.

4. Ibid.

and structure comparative analyses.'[1] It was then argued 'that one cannot meaningfully compare national weapons acquisition processes as such, but one can compare their components. These are related together through the medium of a set of sequential decision points, each one preceding a movement from one component of the weapons acquisition process into the next one.'[2] The authors tentatively concluded that 'a complete analysis of how a new weapons system progresses is only possible by applying' each of these two perspectives to 'differing decision points in the process.'[3] They hypothesised that 'in routine matters of technical evaluation and decision such as the initial determination of a project's cost, time or performance parameters, the internal operations of the weapons acquisition process are dominant. The action to be taken, should it cross any of these boundaries as it progresses, usually involves the taking of decisions within the mainstream of a state's political system. Such decisions can often only be explained in terms of the workings of that political system at that point in time.[4]

Having stated the case for the validity of comparative analysis, the authors went on to outline an eleven phase model of weapon acquisition processes comprising:

'1. The broad based process of defence research and component development .

2. The process through which the demand for a new weapons project is created .

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1. *Ibid.*
2. *Ibid.*
3. *Ibid.*
4. *Ibid.*, pp 453 and 454.

3. The process of deciding the specification of a new weapons system.

4. The overlapping process of costing the project as it becomes more accurately defined.

5. The process of contractor selection.

6. The process of the contractor producing a definitive design.

7. The process of arriving at a decision to proceed to prototype development.

8. The procurement style.

9. The process of selecting the project management and contracting system.

10. The process of project review and approval/cancellation.

11. The process of initiating production.'[1]

Finally a further hypothesis was advanced that 'the political process only appears to dominate the weapons acquisition process at two key points: the decision to proceed with a project and the decision to cancel it. All other decisions can be seen as occurring within the confines of the weapons acquisition process.'[2]

This set of hypotheses represents the most detailed descriptive model of weapon procurement processes yet developed, but it is not sequential, for some of the steps such as 3, 4, 5, 7, 8 and 9, run parallel to each other, while others such as 8, are not really phases at all, but optional strategies

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1. <u>Ibid.</u>, p. 454.
2. <u>Ibid.</u>, p. 455.

that may be followed during the development process. In addition, the relationship between the wider political process and weapon projects is not integrated into the embryo model.

In his article in the same volume, R.G. Head presented the much simpler, five-phase model already described.[1] He hypothesised that four differing strategies were open to states who wished to acquire weapons: self-sufficiency, co-operation, licence production and off-the-shelf purchase.[2] He then went on to examine the bureaucratic politics of the weapons acquisition process from the standpoint of attempts by project management groups 'to gain organisational autonomy.' These attempts had two specific sub-objectives. The first was to attract a broad base of support for a weapon system both inside and outside government: the second was to prevent the rest of the government from interfering in the management of 'their programs.'[3] Four bureaucratic strategies: differentiation, co-operation, moderation and managerial innovation, were the possible methods of achieving these objectives.[4] In addition, Head emphasised the problem of uncertainty. He argued that two central concepts, innovation and obsolescence, provide the dynamic element in weapon acquisition processes,[5] and that 'military R & D also

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1. See p. 26. below.
2. *Ibid.*, p. 414.
3. *Ibid.*, p. 418.
4. F.B. Horton et al, *op. cit.*, p. 418 - These strategies are described in detail in Sapolsky, *op. cit.*, pp. 43-59.
5. *Ibid.*, p. 412.

has the effect of making one's own weapon obsolete - a kind of unilateral arms race.'[1]

vi. Conclusions.

The preceding review of the literature on defence procurement has illustrated the lack of any universally accepted approach or perspective for such a study. Authors have investigated different aspects of these processes, but no comprehensive model or structure for understanding appears to exist. Before such a structure can be even tentatively constructed, a number of basic issues emanating from this review of the literature need to be resolved. The first of these is the utility of attempting anything other than a narrative of individual weapon projects or programmes. As Head states, 'the major contribution of the case may be in the mere presentation of the data.'[2]

One implication of this argument is that each project is unique, and can only be understood in terms of the factors which surrounded it. This ignores the fact that understanding is essentially a process of mental comparison between existing data and new data, with new data being 'understood' in terms of fitting it into existing categories. Any study of weapon procurement processes must start from some concept of what constitutes such a process, as without this a scholar would be unable to recognise this phenomenon when he was confronted with it. Thus such a process cannot be regarded as unique, as it can only

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1. Ibid., p. 413.
2. Head, op. cit., p. 525.

be understood in terms of either prior conscious or unconscious mental constructs or historical experience.[1]

A second implication of this argument is that the narrative should attempt to recreate the decision-taking environment facing the participants in the weapon procurement process, as their actions can only be understood in terms of that environment. Such a recreation would be a very uncertain and subjective process, for no unambiguous criterion exists against which its congruence can be measured. In addition, the types of data used to build up such a narrative may often be misleading. Documentary evidence such as official files and minutes of meetings may only give a selective account of the range of issues involved and the nature of the filing system may itself be a source of inaccuracies. The filing of material under project titles implies that decisions were taken in the context of the preceding material in such files, but in practice decision-makers are responsible for a large number of projects and their decisions on one specific project may be heavily influenced by current concerns with other projects. It is very difficult to reconstruct such a decision-making environment if the necessary data is contained within many separate project files. It would ideally involve identifying the individuals involved, and

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1. For an extended discussion on this point see K. Deutsch, The Nerves of Government, Free Press: New York, 1963, pp. 3-60, also A. Ryan, op.cit., pp. 80 and 81.

reconstructing their work on each day of the period under review: a task beyond the bounds of practical possibility.

Such a detailed documentary study would not necessarily give a complete picture of the decision-taking environment surrounding a project as many telephone calls, discussions and other verbal communications will not be recorded on file, and neither will information such as the reputation of firms or rumours about the progress of development work. This type of data can in theory be obtained by interviewing participants about their decisions. Unfortunately the detailed circumstances surrounding decisions are soon forgotten and most individuals retain only simple, general ideas of their activities of twenty or thirty years previously, and an incorrect version of the chronology of events.

All of these limitations mean that although a simple narrative is a necessary part of understanding weapon procurement processes, its explanatory power is limited by the nature of the data employed and the lack of a clear criterion of relevance. For a more complete understanding of such processes, other, more conscious, analytical devices must be employed.

The arguments which underlie such a search for a conscious, analytical framework to structure research into weapon procurement processes contain no guide to the sources from which it should be derived. Two alternative basic perspectives are relevant to this issue. One is the determinist assumption or belief that weapon procurement is dominated by non-human elements; the second the contrary assumption or belief that human beings dominate this process, and its outputs are a product of their actions. Acceptance of this first perspective implies initiating a search for regularities which appear to exist in weapon procurement processes irrespective of the individuals or states involved, and integrating any that may be uncovered into a coherent analytical framework. Acceptance of the second perspective implies that an analytical framework may be impossible to construct, for unless some general 'laws' of human behaviour are evolved or discovered, the future attitudes and actions of the individuals involved in a weapon project will be unpredictable, resulting in the processes involved operating in an idiosyncratic manner.

Any choice between these perspectives is governed by existing ideas about human behaviour in general, as well as the nature of weapon procurement. The latter appears to consist of an interaction between man and his physical environment, which is now universally accepted as being governed by much more precise and determinist 'laws' than appear to apply to human relationships. Weapon systems have to comply with the dictates of physical 'laws' if they are to work effectively: if these laws are either ignored, or simply not understood, the weapon may be unable to attain its performance targets. At the same time, its relevance to the contemporary strategic or political situation will be heavily dependent upon human perceptions. This dichotomy appears to imply that some aspects of weapon procurement may conform to fairly rigid 'laws', while others will allow full scope for human idiosyncracies. An understanding of weapon procurement processes may thus involve the delineation of the areas to which these differing types of proposition apply.

The idea that a conscious concept of weapon procurement can be used to guide empirical research also raises the issue of which areas of knowledge ought to be scrutinised in any attempt at its construction. This in turn demands both some conscious criteria of relevance and some prior definition of what constitutes the boundaries and components of a weapon procurement process. It also assumes that weapon procurement is a discrete, independent phenomenon, rather than a dependent variable related to an independent one. If the latter assumption were to be accepted, research would only need to be undertaken into comparisons between governmental operations in different states, or over time. If it is rejected as unproven pending investigation of the original assumption, it becomes necessary to generate an initial definition of the weapon procurement process. This can be based on two alternative premises about weapon procurement. One is that an individual weapon project should be regarded as a coherent, unitary phenomenon: the second that an individual project is a rather artificial entity made up of elements from other discrete phenomena.

There are a number of issues associated with the choice between these alternatives. One is the argument that the only constant element and unifying factor present throughout the life of a weapon project is the configuration of the weapon, or, alternatively, the specification or requirement for it. Yet the configuration of that weapon may, and often does, change in the course of the project and the same applies to the specification or requirement. This raises a major boundary problem if projects are used as the basic unit of analysis, for any delineation between the initial configuration of a weapon and its later adaptions and variants is going to be rather arbitrary.

A second set of issues arises from the fact that certain of the processes or phases inherent in a weapon project appear to be completely different phenomena, yet they are given an apparent coherence by the artefact being produced. The choice lies between accepting this coherence or rejecting it in favour of a non-project based approach. Such an approach is reinforced by the argument that, for example, the development phase of an individual weapon has more in common with the development phases of other weapons than with its own inception, production and operational phases.

No clear guidance appears to be available to influence this choice unless the criterion of the purpose and objectives of a study of weapon procurement is introduced. If the research is directed towards investigating specific weapon projects, then, despite its self-fulfilling nature, an approach centred around the weapon in question seems appropriate. If the desire is to investigate in greater depth weapon procurement processes in general, the comparative phase approach would seem more appropriate.

The use of the objectives and purposes of research as criteria of relevance raises a number of important wider issues. 'Understanding' appears superficially to be a value-free idea and as such implies description of both structures and processes. Unfortunately, processes, being abstract entities, are very difficult to describe in a value-free manner, as reference has frequently to be made to their end-product, or their role relative to some larger process.[1] Whilst this reinforces the argument that a weapon procurement process can only be understood on the basis of individual projects which have the objective of developing, producing or obtaining a weapon capable of meeting its specification, it also creates two further problems.

The first of these is whether weapon projects ought to be evaluated in terms of very wide criteria such as their utility to a state or the international system compared with other types of governmental expenditure; for example whether money allocated to a defence project would be better spent building a new hospital. The second is whether a weapon project should be evaluated against the yardstick of an idealised model of that project. This implies both ideas of maximisation and efficiency, the existence of a critical path specifying the optimal set of activities for a project, and an evaluative technique involving the identification of points at which a project deviated from this path. In the absence of such a fully articulated model of the ideal project, this type of evaluation tends to be highly subjective, for no agreed criteria of comparison exists.

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1. Functional analysis has been the subject of considerable methodological controversy within social science. For a short exposition of the main issues involved see A. Ryan, op. cit., pp. 182-194.

Some of the literature on weapon procurement is written in terms of this type of evaluative procedure, and contains judgments about the inefficiencies and failures of organisation and management in weapon projects. Such judgments are invariably highly subjective, for they are not made through a comparison with any well articulated model of an ideal weapon project. Although it is a common practice to conduct research into weapon projects with the avowed purpose of uncovering deficiencies in order that they may be corrected in future projects, understanding demands a greater component of detailed description than is usual in such prescriptive exercises. The purposive element in understanding cannot be ignored, however, as part of any detailed description of a weapon project will inevitably include some attempt to identify the objectives the human participants in the process sought to achieve in initiating and sustaining it.

Reference may be made to two specific bodies of literature if it is desired to acquire material with which to construct a general concept of weapon procurement. One is studies of past weapon projects, the second studies of non-weapon procurement. The major argument for drawing material exclusively from the former area is that weapon projects can be sharply differentiated from all other types of technological activity. If this argument can be demolished, other types of activity become legitimate sources of data.

The major argument for maintaining that defence projects are clearly distinguishable from all other projects is based on the nature and degree of uncertainty inherent in these projects. This derives from the fact that weapon projects usually involve major technical innovations and advances, and their complexity produces problems of component integration. Any problems in the development of a key component will delay the progress of the whole project. In addition, the lengthy development process common to all advanced technological products poses specific problems for a weapon project. Decisions to produce new types of energy sources, civil airliner or other civil prime movers are mainly based on technical calculations of economic growth and absolute national and international needs, which, until recently, were assumed to be relatively stable over time, despite domestic and international political changes. The demand for new weapons appears to be directly related to contemporary perceptions of the political and strategic environment, and as these perceptions change, support for specific weapon projects will alter in conformity with them. These two major elements of uncertainty or risk appear to sharply differentiate weapon projects from other types of development and manufacturing activity, and justify the proposition that the most relevant source of data for the creation of a general concept of a weapon procurement process resides in the histories of other weapon projects. It has to be admitted, however, that some types of weapon procurement either do not involve major technological advances, or by-pass the need for a lengthy development phase. One can also point to civil projects such as Concorde, or Apollo, which involve major technological innovations

Any concept of weapon procurement exclusively based on the twin characteristics of technological and politico/strategic uncertainty is thus not going to be applicable to all defence projects. Reference can also be made to a previous argument in support of the initial proposition. A major distinguishing component of a weapon project is its objective of producing a defence artefact, and it can only be fully understood in relation to the defence or national security environment which surrounded it and other weapon projects.

The basic issues inherent in defining the boundaries of the weapon procurement process have now been discussed, and it has been demonstrated that there exists a major analytic distinction between the weapon procurement process in a state and individual weapon projects. While the latter only exists in the context of the former, it may be viewed as a number of distinct and separable processes or phases. A weapon project retains its analytical unity by reference to the artefact being produced.

Weapon procurement involves at least three major participant groups or individuals. First, the group of military officers concerned with the initiation and development of a new weapon. Second, those members of the civilian administration and the political process who take decisions which govern a project's progress. Third, those industrial organisations which are allocated the task of transforming the aspirations of officers, civilian administrators and politicians into operational equipment. Any analytical framework which attempts to guide research into weapon procurement and projects must incorporate the activities of these human participants.

It is now possible to outline some initial assumptions of this study. One is that it cannot solely consist of a narrative: it must have an overt framework of analysis associated with it in order to provide criteria of relevance. The second is that this framework must offer scope for identifying both the repetitive and idiosyncratic elements inherent in any individual weapon project: this includes identification of the major actors involved. The third is that this framework must be derived from a comparative study of weapon projects involving both major technical and politico/military uncertainty. The fourth is that genuine doubt exists over whether the correct focus of analysis for understanding weapon procurement is the individual weapon project, or a particular phase in that project. At this stage this problem will be left unresolved, as it is proposed to look at a number of projects in the course of the study.

A framework to guide analysis of the narrative case study can be constructed out of the existing literature on weapon procurement and projects, and will contain two major elements. One is a tentative description of the structure of the phenomena under study, namely weapon projects, which involves listing the sequential phases inherent in a weapon procurement process.

The second comprises a number of propositions concerning the processes or pressures which input into this structure. These should contain fairly precise statements about the point of entry in order to isolate those phases of a process that are affected by a particular input and those that are not. Three types of proposition may be involved:

i) those concerning inputs largely outside the control of human beings

ii) those concerning inputs which depend very heavily upon the idiosyncratic actions of individual men or groups of men and

iii) those concerning inputs which contain major elements of both (i) and (ii).

As the initial review of the weapon procurement literature indicated, a limited number of detailed descriptions of the structure of weapon projects have been formulated in addition to a number of propositions about pressures and processes inputting into it. These propositions include:

i) The all-pervasive effect of uncertainty. The term 'uncertainty' in this context masks a number of quite different phenomena, such as the ability of the proposed technical characteristics of a projected weapon system to fulfil the requirements to which it is to be built; the possibility that these requirements may alter independently of the technical progress of the project due to changes in strategic or tactical thinking, actions by the weapon procurement organisations of other states, or changes in the quantity of state resources allocated to defence; the tentative nature of any military requirement aimed at anticipating military thinking twenty to thirty years into the future, and the ability of individuals to manage a project in such a way that it is completed rapidly and cheaply. An associated issue is the choice between a parallel, single or duplicative Research and Development strategy.

ii) Related to this first issue, but utilising a slightly different perspective is the question of whether the evolution of a weapon project is determined solely or predominantly by inputs from within the defence establishment, or whether inputs from outside of it are dominant. An alternative and possibly more promising formulation of this issue is that at certain points in a weapon project external factors are dominant, while for the remainder of the time an autonomous process is taking place.

iii) An assortment of issues related to the decision-making behaviour of governments, including the assumption that governments are monolithic purposive actors (Allison's Model I). These ideas include propositions which imply that the desire of governments to maintain a research and development base, and the desire not to choose between alternatives, are standard governmental inputs into a weapon project.

iv) The idea that weapon procurement decisions are heavily dependent on bureaucratic political activity (Allison's Model II), which is a major feature of studies of United States weapon procurement and the Military Industrial Complex, but has been little discussed in the British context with the sole exception of the work of C.P. Snow. It encompasses the question of who are the actors or participants in a weapon procurement process.

v) The idea that key individuals can determine the success or failure of a project (Allison's Model III). This is a major theme of Gowing's work on the British nuclear project.
vi) The proposition that weapon procurement processes can be best understood in terms of the inter-relationship between time, quality and cost.

These six perspectives and the attempts to construct a descriptive structural model of a weapon project constitute the closest existing approximation to a general framework for understanding weapon procurement processes and projects. In their existing form they lack precision and cannot be regarded as incisive analytical tools. To remedy this they need to be recast in the form of heuristic propositions capable of generating detailed and precise hypotheses when confronted with a case study. Although the resulting inquiry may have the appearance of a rigorous social science investigation, in practice the propositions are insufficiently well defined to allow this, and the format has been adapted solely for ease of analysis and presentation.

The first proposition concerns the impact of uncertainty upon weapon procurement projects. It is that:
i) Uncertainty is inherent in weapon procurement projects, but the types of uncertainty involved are directly related to the stage that has been reached in the evolution of the project.

The second proposition concerns the sources of inputs into a weapon project. It is that:
ii) External factors dominate a weapon project at certain key

points, specifically decisions on inception, production and cancellation. At other times, the process operates autonomously.

The third proposition is designed to both investigate the existence of certain types of standard governmental behaviour and the utility of Allison's Model I perspective. It is that:

iii) Governments act purposefully and as unified entities both to maintain their defence R & D base, and to avoid having to make conscious choices between conflicting alternatives.

The next three propositions seek to both explore certain aspects of governmental behaviour inherent in Allison's Models II and III and Snow's description of technological decision-making in Britain and to help identify the actors in weapon procurement processes. They are:

iv) The weapon acquisition process is conducted solely through closed politics, and public debate and discussion exercises no influence over it.

v) The weapon procurement process is dominated by civilian direction, and industrial and Service views or problems have no influence upon it.

vi) Governments do not act as unified entities when taking decisions on defence projects because of the conflicting interests and expertise of the bureaucratic organisations involved. This creates a lack of positive direction and control over projects.

The seventh proposition is designed to illuminate Allison's Model III:

vii) Certain individuals may, through their personal or organisational position, determine whether a defence project is sustained or cancelled.

The eighth proposition is drawn from Dörfer's study of Swedish defence projects, and contains his conclusions: viii) Time is the most flexible variable in the weapon procurement process, followed by cost and quality.

No clear guidelines exist to enable an authoritative choice to be made between the Postan, Hay and Scott, Gregory and Simpson, or Head schemes for a descriptive structural model of a weapon project. An arbitrary integration of the first two of these schemes produces the following proposition: A weapon project comprises the following sequential phases:

a) Background research and the production of a military specification.

b) Design study and competitive tender.

c) Prototype construction.

d) Prototype trials and selection of contractors.

e) Production development.

f) Production orders.

g) Military service.

CHAPTER 2

INCEPTION 1945 - 1946.

i. Introduction.

The post-war British naval anti-submarine aircraft programme was initiated in 1945 against a background of major changes in the technology of warfare. The wartime period had acted as a forcing house for new weapons technology; new weapons had been developed and placed in service in amazingly short periods of time. Consequently, no clear yardstick existed to judge the pace of likely technological advance in the post-war era.

Innovations had taken place in three areas of military technology that were to have major effects upon the post-war naval anti-submarine aircraft programme. The most important of these was the development of an entirely new form of motive power for aircraft, the gas turbine engine. The second was the development of airborne radar equipment, which enabled aircraft to detect surface vessels and submarines beyond the visual range of their crew members. The third was the development of new types of attack weapons other than free fall bombs and torpedoes. These ranged from unpowered and uncontrolled glide weapons to remotely guided rocket weapons.

The war time period had also witnessed major changes in the performance characteristics of naval aircraft. The take-off and landing weights and maximum speed of carrier borne fighter aircraft had increased by approximately 50%, while that of torpedo/bomber/reconnaissance aircraft had almost doubled.[1] These increases meant that existing catapults (or as they were known in contemporary British parlance, accelerators) on British operated aircraft carriers were unable to handle heavily laden aircraft, and rocket assisted take-off equipment (RATOG) had to be used where the length of the carrier's deck did not permit a free take-off. This was an inherently unsatisfactory and costly substitute as the rocket installations either remained strapped to the aircraft during flight and degraded its performance, or were jettisoned into the sea and therefore incapable of re-use.

Landing also presented increased problems, as approach speeds had tended to creep upwards, and this, coupled with the increased landing weights, meant that undercarriages, arrester hooks and carrier decks were all being subject to increased stresses. One consequence of this was that the more modern naval aircraft could no longer use all of the existing British carriers, and plans were well advanced at the termination of hostilities in 1945 to build new and heavier aircraft, such as the Sturgeon, Spearfish and Wyvern, which would only be able to operate from the newly designed aircraft carriers of the <u>Audacious</u>, <u>Malta</u> and <u>Hermes</u> classes. The existing carriers would have to be extensively rebuilt if they were to be required to operate these aircraft, or alternatively some new means of

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1. For a detailed listing of these developments see Appendix 1.

take-off and landing used on them.

The termination of hostilities also left the Royal Navy with little experience of the problems of operating modern airborne radar equipment. Early types of Air to Surface Vessel (ASV) radar sets had been carried in anti-submarine Swordfish and Barracuda III aircraft, and some radar-equipped night fighters had been deployed, but these were small, cramped aircraft which had not been originally designed to perform these tasks. Visual search remained the main anti-submarine detection method. By comparison, Coastal Command of the Royal Air Force, the land based anti-submarine force, had used very large twin- and four-engined aircraft to perform anti-submarine patrols. The size and load carrying abilities of these aircraft enabled more effective use to be made of ASV equipment, and they had accumulated a large amount of information on both the technical and human factors relevant to this type of operation. Unfortunately, there had been a long standing conflict between the two services over the control of maritime aircraft and their personnel. One possible result of this friction was that little interchange of information seems to have taken place between the two services on the problems of operating radar-equipped anti-submarine aircraft.

It was against this technical and organisational background that work began in 1945 to produce a requirement for a naval aircraft able to perform anti-submarine duties. This requirement was to be translated by the Ministry of Aircraft Production into specification GR 17/45.[1] When this work began, a major proportion of Britain's aircraft carrier fleet and its aircraft was subject to Lend-Lease arrangements with the United States. A lack of suitable British naval aircraft and the advantages of interoperability with United States carriers had led to the bulk of the Indian Ocean and Pacific Fleets being equipped with United States aircraft.

The termination of hostilities with Japan had four immediate effects upon the Royal Navy's carrier fleet and its aircraft. The remaining 35 Escort carriers out of the original 38 supplied to Britain under Lend/Lease were returned to the United States. Similarly, the Wildcat, Hellcat and Corsair fighters and Avenger strike aircraft were also returned under the same arrangements. Third, the extensive aircraft carrier building programme was drastically curtailed, as the immediate need for it had dis-

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1. The Navy had its own system of numbering their staff requirements, as had the RAF, but these were then incorporated by the Ministry of Aircraft Production, and later the Ministry of Supply into a standard listing for aircraft specifications, which also included civil aircraft being developed at governmental initiative. This listing had three components; a letter code and then two number codes. The second of the number codes was the last two numerals of the year in which the requirement had been received by the Ministry of Aircraft Production, such as /39 for 1939 and /45 for 1945. The letter code corresponded to a standard listing of the role(s) the aircraft was designed to perform. Examples of these were B for bomber, F for fighter and C for transport. In 1945 there does not seem to have existed a letter code for anti-submarine aircraft, and therefore GR, standing for General Reconnaissance, was used for both the naval anti-submarine requirement and the land based RAF requirement, GR 14/45. The first of the number codes merely represented a specific requirement's chronological place in the list of requirements received by the Ministry of Aircraft Production in a given year. Thus GR 17/45 stood for the 17th requirement received by the Ministry in 1945, which had been categorised by them as a General Reconnaissance type.

appeared and the peacetime requirement was to convert shipyards to civilian production as rapidly as possible. Finally, the immediate objective of the naval aircraft building programme of providing new aircraft for the Japanese war had also disappeared, and it was unclear what the future role of the carrier-borne air arm was to be.

ii. The Development of British Gas-Turbine engines 1941-45

The United Kingdom had supported a slowly expanding programme of gas-turbine research, development and production throughout the Second World War. A number of important milestones can be discerned in this programme.[1] On May 15th, 1941, the Whittle W-1 turbojet, produced by Power Jets, had flown in the Gloster E28/39 experimental aircraft. By the Autumn of 1941, the Rover Motor Car Company, managers of the government factory at Barnoldswick built to produce gas-turbine aero-engines, started component production of an engine designed by Power Jets, the W-2B. This engine failed to attain its initial performance objectives, and friction developed between Rover and Power Jets over their respective responsibilities towards it. The Ministry of Aircraft Production[2] resolved this problem by giving Rover complete responsibility for the production engine, and restricting Power Jets to research and development work. As a result of these development delays, the Gloster Meteor fighter

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1. The narrative of events which follows is based on Schlaifer and Heron, op. cit. pp. 358-373. It is also covered in greater detail in Postan, Hay and Scott, op. cit. pp. 194-233, and Sir Frank Whittle, Jet, Frederick Muller Ltd: London, 1953, pp. 104-303.

2. This title was usually shortened to the acronym MAP.

aircraft which had been designed around the W-2B was first flown on March 3, 1943, with two de Havilland (Halford) Goblin engines.

The continued inability of Rover to produce operational W-2B engines resulted in responsibility for it and the Barnoldswick factory being passed to the aero-engine firm of Rolls Royce on April 1st, 1943. The apparent results of this change of management were dramatic. On June 12th 1943, the W-2B, now known as the Welland, was flown in a Meteor. It went into quantity production in October 1943, and production deliveries began in May 1944. Simultaneously Rolls Royce modified an existing Rover design, the B/26, and produced the Derwent I. This was first tested in July 1943, flown in March 1944, and the first production deliveries commenced in November 1944.

Spectacular progress was also demonstrated in the development of the Rolls Royce RB-41 Nene engine, designed to give twice the thrust of the Derwent I. Work on this started on March 17, 1944, the highest priority was assigned to it, and the engine was first tested in October 1944. As this development had far outstripped that of the airframes that were being built for it, it was decided to scale the engine down to fit into the Meteor, and in this form became the Derwent V. This was first test run in June 1945, and production commenced in September 1945.

The resultant British gas-turbine development programme seemed to be evolving swiftly and smoothly by mid-1945 after two years of apparently fruitless effort between 1941 and 1943. The success of Rolls Royce in swiftly developing their first completely new designs, the Nene and the Derwent V, appeared to indicate that equally rapid development of gas-turbine engines could be anticipated in the post 1945 world. This was reinforced by the gradually increasing proportion of resources allocated to gas-turbines, in comparison with reciprocating engines.[1]

On closer examination, however, such optimism, particularly when applied to gas-turbine propeller engines, appears to have been based on very narrow foundations. All of the engines that had been developed were centrifugal gas-turbine engines, yet it was recognized that axial gas-turbines had greater scope for development, and it was on these new types that development was concentrated after 1945.[2] It seemed a technically simple task to harness a gas-turbine engine through reduction gearing to a propeller, but no serious attempt had yet been made to develop such an engine.[3] In addition, the rapid progress experienced in 1944 and early 1945 had largely been a product of one team concentrating on a limited number of engine developments in sequence. After 1945, Rolls Royce resources were to be apread over an increasing number of projects, while the remainder of the gas-

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1. Postan, Hay & Scott, op. cit., p. 227.

2. Both Rolls Royce and Metro-Vickers had the initial designs of what became the Avon and Saphire axial flow turbojets in hand by early 1945. Whittle, op. cit., p. 286.

3. Rolls Royce had experimented with a modified Derwent I engine fitted with reduction gear and a propeller, and known as the Trent. In addition they commenced development of the Clyde propeller-turbine engine in 1945. Ibid.

turbine development programme was to be the responsibility of the existing aero-engine firms, such as Napier, many of which had been brought into the field through ministerial initiative during 1944 and 1945.[1] The Power Jets design team, having seen their organisation nationalised and converted into a government research establishment, had been largely dissolved by March 1946.[2] The effect of this had been stated by Whittle in a letter to the Controller of Research and Development at MAP on 30th January 1946:

> '... if the old Power Jet's team did break up. In my opinion it would be a disaster. With an engineering team, the whole is far greater than the sum of its parts, and the Power Jets team is a national asset, which must not be allowed to go to waste. There seems a quite unjustified belief that there are a number of competent gas-turbine design teams in the United Kingdom, but in fact only three teams have produced successful aircraft gas-turbines so far, namely: Power Jets, Rolls-Royce and de Havilland. The others are floundering in development difficulties.'[3]

In the specific case of the gas turbine engines which were to be assigned to the GR 17/45 aircraft, none were in an advanced state of design in early 1945. Armstrong Siddeley had produced their ASX axial simple jet engine, but there was no suitable airframe for its installation. It had therefore been decided to convert it into the ASXP engine by adding a gearbox and propeller to it. This was the forerunner of the Mamba engine. Rolls Royce had undertaken two design studies of two-stage centrifugal turbo-props and were developing the Clyde turbo-

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1. Postan, Hay & Scott, op. cit., p. 227.
2. Whittle, op. cit., p. 300 and Postan, Hay & Scott, op. cit., p. 233.
3. Ibid., p. 298.

prop, but none of these projects had progressed very far. Napier had yet to start work on what later became their E128 Naiad.[1] Neither Armstrong Siddeley nor Napier had had an outstanding design record during the wartime period. The former had, for a period during the 1920's, been the dominant radial engine manufacturer in Britain, but after that 'the company continued to prosper with the production of the Lynx, and then of the Cheetah trainer engines.'[2] Napier had produced the widely used Lion radial engine at the end of the First World War, but

> 'As it turned out, the Lion marked the highest point of Napier's achievements. For a time indeed the firm rested on its laurels and allowed the development side of its organisation to lapse ... only three engines of any note were produced up to 1945, all being the work of Major Halford ... whose part-time services they acquired in 1927. Of these three engines, the Rapier was too small for service use, the Dagger was not highly successful, while the last and the most promising of all, the Sabre, provided one of the Second World War's most melancholy stories ... Napier's and Armstrong Siddeley had thus become largely ineffective.'[3]

This state of affairs suggested that the development base for the GR 17/45's engines was likely to be rather insubstantial.

iii. The Evolution of Blackburn's and Fairey's Airframe Designs, 1943-45.

Two British airframe companies had traditionally specialised in the design and development of naval aircraft. These were Blackburn Aircraft Ltd., situated at Brough in East Yorkshire,

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1. File A - TRD Foreward Development Engine Programme - Revised version, January 1945.
2. Schlaifer and Heron, op. cit., p. 152.
3. Postan, Hay and Scott, op. cit., pp. 98-99.

and the Fairey Aviation Company Ltd., whose main works were at Hayes in Middlesex. All airframe companies engaged in two distinct types of activity. The first was the design and development of a very limited number of prototype aircraft. The second was the building of production aircraft for operational service, using production line techniques. There was no inherent reason why one firm should not build production versions of another firm's prototype aircraft, though such an event was usually taken to imply that the first firm's design and development teams were weak. This was also a period when the proprietors of aircraft firms wielded considerable power and influence over the activities of their companies, and the progress of a firm was often related to the declining or increasing abilities and prestige of such a man.

Blackburn[1] could not be assessed as a strong company in 1945 using these criteria. Their wartime design activities had been restricted to three types of aircraft. The first was the Skua, a two-seat, monoplane, naval fighter, which was in operational service with the fleet until early 1941.[2] A variant of this, the Roc, was also developed, but it was restricted to land-based training and support duties.[3] These were the only

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1. Blackburn Aircraft Ltd., was usually shortened to Blackburn and the Fairey Aviation Company Ltd., to Fairey. These abbreviations of the names of aircraft firms will be used throughout this study.

2. A.J. Jackson, Blackburn Aircraft Since 1909, Putnam: London, 1968, pp. 399-410.

3. Ibid., pp. 411-420.

Blackburn naval aircraft designs to see wartime service.[1] Development of a production version of the second naval aircraft designed during the wartime period, the Firebrand single-seat, torpedo-armed, strike fighter was delayed due to a decision to change from the Napier Sabre to the Bristol Centaurus engine, and deliveries of a major production batch did not commence until May 1945.[2] Design work on the third aircraft, a Firebrand with a redesigned wing and improved pilots view, known as the B-48, was started in October, 1943, but it did not fly in prototype form until April, 1947.[3] The main value of Blackburn to the war effort lay in their production facilities. These were used to build large numbers of Fairey Swordfish and Barracuda aircraft.[4]

Fairey had a wider spread of aviation activities than Blackburn, and before the war had made attempts to break out of their specialisation in naval aircraft by developing an aero-engine,[5] and also by developing a design for a long-range civil airliner.[6] During the war, it acquired additional production

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1. Blackburn also designed and developed a flying boat and a maritime reconnaissance aircraft for the RAF, but neither saw extensive operational service. Ibid., pp. 394-398 and 421-438.

2. Ibid., p. 445.

3. Ibid., pp. 452-455.

4. Ibid., pp. 535-536.

5. Schlaifer and Heron, op. cit., p. 205.

6. Royal Air Force Museum Archive (hereafter cited as RAFM) AC-73/30 (41/b/1), The Fairey Queen. [The bracketed code letters and numbers (41/b/1) indicate current shelf placings, which will be altered when the Fairey documents and photographs are integrated fully into the rest of the Archive. It should then be possible to retrieve the material on the basis of the access number (AC-73/30) and box file nominal title (The Fairey Queen) only].

facilities at Stockport, and a separate design organisation was set up there. The firm's Chairman, Richard Fairey, had spent a major part of the wartime period in the United States as a representative of MAP, and in his absence the Ministry had felt impelled to intervene in the running of Fairey. At the end of 1942 they had insisted on reorganising the design department at Hayes by creating separate design teams for each project, these teams being co-ordinated and administered at the top by the Chief Engineer.[1]

A number of Fairey naval aircraft were produced in large quantities during the war. These included the Swordfish bi-plane torpedo/bomber/reconnaissance aircraft, the Fulmar fighter, the Firefly strike fighter and the Barracuda torpedo-bomber. Work had also started in mid-1944 on a large torpedo-strike aircraft, the Spearfish, which was intended for operations in the Pacific Theatre from the new classes of very large carriers then under construction.[2]

Once the Spearfish prototype design had been accepted by both the MAP and Admiralty, Fairey initiated a series of privately financed design studies to investigate the possibility of coupling engines together in order to produce a twin-engined aircraft within a single-engined airframe configuration. These studies were based upon a version of the Firefly intended for reconnaissance purposes.

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1. Postan, Hay and Scott, <u>op. cit.</u>, p. 27.

2. RAFM, AC-73/30 (41/a/1), War Records (Record of the Technical Activities of Fairey Aviation being a contribution to the Scientific War Records as Requested in a letter from DGTD (Director General Technical Development) Ministry of Aircraft Production on 22nd June 1945), Pp. 1-27 contains details of these activities.

> 'Through contacting Rolls-Royce on the question of using an extension shaft drive with a single engine, to obtain the best possible view, we conceived the idea of using two highly developed engines in tandem within the fuselage. The engines were to drive a common gear-box with a pair of contra-rotating propellers, each propeller being driven by one of the engines quite independent of the other .... To investigate the possibilities of the use of this twin tandem piston engine arrangement, a long and comprehensive series of design studies was prepared.'[1]

> 'During August 1944 ... we were requested to investigate the possibilities of the tandem twin engine scheme in connection with an entirely new project, viz., The Naval Strike Aircraft.'[2] 'We submitted a full tender specification in October, 1944, using twin tandem Merlin engines as the power plant.'[3]

As a result of this submission, which suggested to MAP the operational requirement and specification that should be written around such an aircraft, 'a contract was placed to supply four twin-engined two-seaters to the general requirements of the original 05/43 specification .... Design work in connection with this project was commenced at the beginning of 1945.'[4] These aircraft were known by their specification number, 021/44.

During the early part of 1945, attention shifted to the possible use of propeller-turbine engines in this type of aircraft. The main thrust of the firm's external activities was still

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1. Ibid., p. 28.

2. Ibid., p. 29.

3. Ibid., p. 30 - Two brochures were involved in this submission, dated 8.9.44 and 3.10.44. The September one, RAFM AC-73/30 (41/C/2) Spearfish (Box 1), was a Spearfish conversion. The October one, RAFM AC-70/30 (41/C/2) Strike 1944, was for either a single-seat, naval long-range fighter or a single-seat fighter-reconnaissance and strike aircraft. Two versions were proposed, one with Rolls Royce Merlin, the other with Rolls Royce Griffon piston engines.

4. Ibid., p. 29. 05/43 was the specification for the Spearfish.

concentrated upon the presentation of the case for this type of configuration to MAP and a further brochure, dated 12.3.45 was prepared to argue this case at length.[1] Fairey then 'suggested ... the use of twin turbines driving contra-rotating propellers.'[2] They 'prepared two design studies for the Naval Strike Aircraft, one having a single RB52 + 50% jet cum propeller engine, and the other two 75% RB52 jet cum propeller engines arranged in tandem, with a separate contra-propeller gearbox, each propeller being driven by its own turbine,'[3] and 'submitted a brief summary of comparisons of the twin piston engine, single turbine and twin turbine schemes to MAP on June 30th 1945.'[4]

The result was that 'upon cessation of hostilities ... Rolls Royce were requested to state their views as to whether the twin tandem piston engined projects should be continued or abandoned in favour of the jet cum propeller arrangement .... In view of their attitude, it was decided to reconsider the Naval Strike Project around the twin jet cum propeller engines.'[5] Fairey appear to have approached the problem of utilising these new power-plants with an open mind despite their previous work,

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1. RAFM AC-73/30 (41/c/2), Strike 16/45.
2. RAFM AC-73/30 (41/a/1), War Records, op. cit., p. 30.
3. Ibid. The percentage figures indicated increased or decreased power compared to the existing RB52 engine.
4. Ibid. - this was contained in a brochure dated 4.7.45. RAFM AC-73/30, (41/c/2), Strike 16/45.
5. RAFM AC-73/30 (41/a/1), op. cit., War Records.

for they 'conceived the idea of abandoning the tandem arrangement in favour of arranging the two turbine engines side-by-side behind the main gearbox and beneath the floor of the pilot's cockpit. A rough draft of the scheme was shown Rolls Royce who were entirely in favour of the arrangement, and the scheme has been adopted in the latest scheme of the "Naval Strike Aircraft", the engines being known as A.P.25.'[1]

This new arrangement resulted in the production of two further brochures dated 13th November and 14th December 1945.[2] These were virtually identical, except that the November brochure contained a section arguing at length the case for the twin-engined layout. The aircraft was stated to be powered by two Rolls Royce A.P.25 Tweed engines. The major external changes over the earlier piston engined designs were the removal of gun blisters and radiators from the inboard sections of the wings, allowing the undercarriage to retract inwards instead of backwards as before.

It is unclear how far this activity by Fairey and Rolls Royce had an impact upon the MAP and Admiralty, for although they had 'submitted a design for a twin-turbine Naval Strike Aircraft to meet the requirements of the draft specification issued in June 1945,'[3] Fairey's brochure of the 14th December stated that 'a draft of specification N16/45 has come to hand which, if complied with fully, would have an important influence

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1. Ibid.
2. RAFM AC-73/30 (41/c/2), Strike 16/45.
3. Ibid., Brochure 14.12.45.

on the design. The functions of the type have now been changed by the elimination of escort fighter/night fighter and extreme range reconnaissance roles, and the introduction of the dive bombing requirement.'[1] Fairey and the Admiralty do not seem to have had particularly close liaison on this project, as it was normal practice for some indication of such a major change to be given to interested companies before the drafting of a specification.[2]

Blackburn's and Fairey's activities between 1943 and 1945 present a very contrasting picture. Blackburn had been mainly concerned with producing Fairey designed aircraft, and their own activities centred around attempts to develop and place in production an aircraft, the Firebrand, which by October 1943 was seen to have major deficiencies which necessitated a substantial redesign. Fairey, had developed and produced four aircraft which had served extensively with the wartime Fleet Air Arm. They were also a firm who preferred to develop new concepts and then try to sell them to the MAP and Admiralty. They had their own ideas of the type of aircraft the Fleet Air Arm should be equipped with, and were prepared to try to persuade the Admiralty that they were right. Whereas it would have been difficult for Blackburn, with their design record, to oppose the MAP and Admiralty's views and activities, Fairey were inclined to take a much more independent stance.

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1. Ibid.
2. Interview with Rear-Admiral Sir Mathew Slattery, KBE., CB., FRAeS., Chief Naval Representative (CNR), MoS, 1945-48.

iv. The Royal Navy's Aircraft Carrier Fleet, 1939-1945.[1]

The start of the Second World War saw Britain operating a number of ageing aircraft carriers, which were mainly conversions from other types of warship, plus one modern carrier, the *Ark Royal*, which had been launched in 1937. Two further carriers of 23,000 tons had been ordered under the 1936 Re-armament programme, and a further four during the years 1937-39.

The pre-war navy regarded the aircraft carrier as a fleet support vessel, whose aircraft were to

> '(a) attack and slow down an enemy fleet so that the final issue could be decided by the heavy guns of the battleships;
>
> (b) provide fighter cover for the fleet; and
>
> (c) to spot for gunfire and general reconnaissance duties.'[2]

In the design of the six new large carriers, it was assumed that

> 'in Home and Mediterranean waters they would be subject to heavy attack from shore based bombers, ... and so the main feature of the design was to provide protection to resist attack on this scale. The procedure in the face of air attack was to recover, strike down, and defuel all aircraft, leaving air defence to a heavy A.A. armament, and this practice continued to be observed until 1940.'[3]

As a result,

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1. This section is based upon information contained in H.T. Lenton, British Battleships and Aircraft Carriers, Macdonald: London, 1972; H.T. Lenton and J.S. Colledge, Warships of World War II, Ian Allen: London 2nd ed., 1973, and Jane's Fighting Ships, Samson Low: London, 1943-44 and 1944-45 editions.

2. Lenton, Ibid., p. 70.

3. Ibid.

> 'the object of the carrier - to carry and operate as many aircraft as possible - was rather lost sight of in providing an armoured hull that could withstand attack by 1,000 lb. bombs.'[1]

The result of this philosophy was that only a single-level hangar could be installed due to the weight of armour protection included in the design. This reduced the hangar storage capacity to 36 aircraft compared with the 72 aircraft which could be accommodated in Ark Royal's two-level structure.

The first three ships of this class, Illustrious, Victorious and Formidable, were launched between April and August 1939. They had a hangar height of 16ft, but criticisms of their limited aircraft capacity led to the remaining three ships, Indomitable, Implacable and Indefatigable, being redesigned in order to incorporate an additional half-length lower hangar. The penalty paid for this was a reduction in the height of the hangars to 14ft., but it enabled aircraft stowage capacity to be increased to 48 aircraft in Indomitable and 54 aircraft in Implacable and Indefatigable. The strength of the armoured decks of this class of carriers enabled them to operate aircraft up to 20,000lbs. providing suitable arrester gear was installed. The first four vessels of this class were operational by the end of 1941, but due to shortages of equipment and materials it was 1944 before Implacable and Indefatigable were able to enter operational service.

The war experiences of these ships served to some extent to justify the emphasis placed upon armoured protection in their design. Illustrious, Formidable and Indomitable were all struck by bombs in the Mediterranean and survived. Hits were also sus-

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1. Ibid.

tained by vessels of this class from Japanese Kamikaze aircraft during 1945, yet the longest period of repair necessary before such a carrier returned to operational service was one month.

One additional aircraft carrier was ordered during the pre-war period. This was the Unicorn, a maintenance carrier, which was included in the 1938 Naval Estimates. She had a displacement of 16,500 tons, and, because she was unarmoured, had hangar space for 36 aircraft. Using standard destroyer propulsion machinery delivering 40,000 s.h.p. she had a maximum speed of 24 knots, compared to the 30 knots maximum of the Illustrious class.

The Unicorn did not enter service until 1943, when she was used for a time as an operational carrier, but she served as a model for a new class of light Fleet carrier ordered in 1942. The decision to build these vessels arose in part from the difficulties being experienced in completing the equipment of the two armoured carriers still under construction. These new carriers were unarmoured, but had the capability of operating aircraft up to 20,000 lbs. in weight. To speed production, their hulls up to the waterline were of mercantile construction. This enabled them to be built by shipyards which did not normally undertake major naval construction work, while the acceptance of a maximum speed of 25 knots enabled similar destroyer machinery to that employed by Unicorn to be used.

Sixteen vessels of this type were laid down, ten being of the Colossus class and six of the Majestic class. The latter differed from the former in detail only. They had a hangar height of 17½ ft., a 690 ft. flight deck, and could carry 48 aircraft on a displacement of 13,190-15,700 tons. By comparison, Indomitable housed the same number of aircraft, had a 751 ft. flight deck, a top speed of 30 knots and a displacement of 25,000 tons. Six of the Colossus class had been completed by the end of the war in the Pacific, and four were ready for operational service. All vessels of the class had been launched by October 1944. The Majestic class vessels had all been launched by September 1945, but none had been completed at the termination of hostilities.

The maximum speed of these light Fleet carriers fell midway between that of the armoured carriers and that of the large number of Escort carriers which entered Royal Naval service from 1942 onwards. The first Escort carrier was a simple conversion of a captured German passenger liner, the Hanover. This was given a 453 ft. flight deck and equipped to carry six aircraft, which were parked on deck. The conversion was completed in June, 1941, and renamed Audacity, she was in service by September of that year. In parallel, the United States Navy had also requisitioned two merchant ships for conversion to Escort carriers. The second of these, the Archer, had a hangar and deck lift, a 442 ft. flight deck; could carry and operate twenty aircraft; and had a maximum speed of 17 knots on a displacement of 12,150 tons. In the second half of 1941, before the United States entered the Second World War, Britain ordered six vessels of this type from United States shipyards. Four of these entered operational service before the end of 1942.

The fifth vessel of this 1941 order, the Tracker, was modified at an early stage in construction to become the lead ship of a new class of 21 conversions. These had larger hangars than their predecessors, two deck lifts and a catapult. They retained the 442 ft. flight deck, and could attain a maximum speed of 18½ knots on a displacement of 10,200 tons. Eleven of these ships were allocated to the R.N., the remainder going to the U.S.N.

The final series of Escort carriers acquired from the United States were the Ruler class. Twenty four new vessels of this class were built for the U.S.N., of which all but one were allocated to the R.N. They were similar in all important respects to the Tracker class, and all were launched before November 1943 and were in service by 1944.

Five Escort carrier conversions were also undertaken in Britain in addition to the Audacity. Four of these were originally fast refrigerated ships, and the resultant carriers were larger than the United States built vessels, with flight decks ranging from 498 to 515 feet; a maximum speed of 17 knots; displacements from 11,800 to 13,825 tons; and the capacity to operate 15-18 aircraft. These vessels were named Activity, Campania, Nairana and Vindex. The fifth was a conversion of the passenger liner Pretoria Castle of 17,392 tons displacement. This was given a flight deck of 560 ft. and could operate 15 aircraft, but was regarded as too vulnerable for convoy work, and was only used for training.

In addition to these fully equipped Escort carriers, a number of simpler merchant ship conversions were also undertaken. These Merchant Aircraft Carriers (MAC ships) were either grain carriers or tankers, which carried a reduced cargo, and were fitted with a flight deck. The grain ships were provided with a hangar, but the tankers merely had an extended flight deck in order to provide adequate deck parking space. Six grain ships were converted in this way, and given flight decks ranging from 413¾ ft. to 424½ ft. They could carry four aircraft, had a top speed of 12½ knots and an empty weight of 7,950 to 8,250 tons. Eleven tanker conversions were also completed with flight decks of 460 ft. They too could operate four aircraft, and had maximum speeds ranging from 11 to 12 knots.

v. British Carrier Aircraft, 1939-45.[1]

The Fleet Air Arm started the Second World War with two main types of aircraft, the Blackburn Skua two seat fighter and the Fairey Swordfish three-seat bi-plane torpedo-bomber/spotter/reconnaissance aircraft. As the war progressed, the Skua was replaced by the Fairey Fulmar two-seat fighter on board British carriers, which in turn was superseded by the Sea Hurricane and Seafire and, especially from 1944 onwards, by the United States produced Wildcat and Corsair. The Swordfish was superseded in the torpedo bomber role by the Fairey Albacore bi-plane, and then by the Fairey Barracuda, which was also equipped as a dive-bomber.

1. This section is based upon Owen Thetford, British Naval Aircraft, 1912-58, Putnam; London, 1968, and Jane's All the Worlds Aircraft, Samson Low; London, 1944-45 and 1945-46.

By the end of the war, the latter was being extensively supplemented by the United States produced Avenger. In addition, the Fulmar tradition of two-seat fighter/reconnaissance aircraft had been continued by the advent of the Fairey Firefly, which by 1944 had also been adapted for night fighting and rocket attacks against ground targets.

These developments created three major problems for the Admiralty. The first was that the limited flight deck length and restricted maximum speed of the Escort carriers made it difficult to operate the more modern aircraft from them as the weight and landing speed of the latter increased. In addition, the emphasis during the war had been on increasing the top speed of fighters and torpedo bombers, often to the detriment of their slow speed handling characteristics.[1] Initially, the Admiralty had not found it difficult to equip their Escort carriers and the MAC ships. The Swordfish aircraft displaced from the Fleet carriers from 1942 onwards were capable of being operated from these carriers in an anti-submarine role, as they combined good slow speed handling characteristics with an adequate short take-off and landing performance. Equipped with radar sets and either rocket projectiles or depth charges, and despite their open cockpits, they served as the Navy's standard anti-submarine aircraft until the end of 1944. During 1944 they were increasingly supplanted by United States manufactured Avenger and British produced Fairey Barracuda III aircraft, the latter being

1. For a comparative analysis supporting this point see Appendix I.

equipped for the anti-submarine role by the fitment of ASV Mk.IX radar sets in the rear fuselage. The Barracuda had to be equipped with Rocket Assisted Take-Off Gear (RATOG) to operate from Escort carriers, but the Avenger needed no such assistance. During the early part of 1945, Barracuda III anti-submarine squadrons started re-equipping with Avengers, and the type looked like becoming the standard British naval anti-submarine aircraft. The Swordfish operated from the MAC ships were not replaced by either of these two types of aircraft, these ships and their aircraft being phased out of active service from early 1945 onwards.

The increasing use of the United States manufactured Avenger and Corsair aircraft by the Fleet Air Arm created a second problem for the Admiralty, for these aircraft had not been designed to British specifications, which would have included a maximum height figure related to the hangar dimensions of the existing carriers. The Avenger stood 15ft. 8 inches high and the Corsair 15 ft. 1 inch high. This meant that although these aircraft could operate from Escort carriers, light Fleet carriers and the first three vessels of the Illustrious class, they were unable to enter the hangars of the three most modern armoured carriers.

The final problem only emerged with the conclusion of hostilities with Japan. All the United States' aircraft and Escort carriers had been supplied under the terms of their Lend-Lease legislation, and in accordance with this, they were either scrapped or returned to the United States during the latter half of 1945 and the early part of 1946. This left the Fleet Air Arm in a difficult equipment position, for the ability of the United States to supply the Navy with the majority of its aircraft had reduced the wartime pressures to develop and produce new types of British naval aircraft. Those designs which did exist did not cover the total spectrum of naval air requirements. The Seafire was still operational in the single-seat short-range fighter role, but the Barracuda had been largely withdrawn from service by the end of the war. The Firefly was in production, as was the Firebrand torpedo/strike fighter. Prototype production work was taking place on a number of new naval aircraft. These included the Fairey Spearfish and Short Sturgeon multi seat torpedo/bomber/reconnaissance aircraft and the Westland Wyvern single-seat torpedo/strike fighter. All these designs had loaded weights of over 22,000 lbs., and were intended for operations from the Audacious and Hermes classes of carriers then under construction. The Barracuda V bomber/reconnaissance aircraft was at the prototype trials stage. This was a re-engined and redesigned version of the Barracuda III, and had been intended for use as an interim aircraft pending the production of the Sturgeon and Spearfish.

Plans also existed to convert a number of existing land-based designs into naval aircraft. Trials had been conducted with a number of these aircraft in a semi-naval configuration, prior to the production of fully equipped versions with folding wings and other naval equipment. Aircraft in this category included the Hawker Sea Fury, the De Havilland Sea Mosquito and the De Havilland Sea Hornet.

These aircraft gave the Navy the capability of re-equipping itself with adequate fighter and strike aircraft, but it lacked a specialised anti-submarine aircraft. Such an aircraft was neither immediately available or at an advanced stage of development. All that existed were those Barracuda III aircraft which had been produced during the war, and which, by late 1945, were either stored in reserve or used by training squadrons.

vi. The Royal Navy's Aircraft Carrier Fleet, 1945-1946.[1]

The Navy's carrier policy in the immediate post-war era can be divided into five separate components. The first was that prior to the termination of hostilities in the Pacific, steps had been taken to de-activate the Merchant Aircraft Carriers, and by 1947 they had all been converted back into their original configurations as grain carriers or oil tankers. The Escort carrier fleet suffered a similar rapid decline. By the end of 1946 all the United States built Escort carriers had been returned to North America, and by 1948 had either been scrapped or converted into merchant vessels. Only those Escort carriers used by the United States Navy during the war were retained in reserve in that country. The majority of the British built Escort carriers were rapidly civilianised. Activity returned to the civilian register in 1946, Pretoria Castle and Vindex in 1947, and Nairana, after a period in 1946 on loan to the Royal Netherlands Navy, in 1948. The Campania was retained by the Navy, as its sole remaining Escort

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1. This section is based upon information contained in H.T. Lenton, op. cit., H.T. Lenton and J.S. Colledge op. cit., and Jane's Fighting Ships op. cit., 1945-46 edition.

carrier.

The original intention had been that the light Fleet carriers would undergo a similar process of conversion into passenger liners at the end of hostilities. Their ability to operate almost as many aircraft as the larger armoured carriers on one third of the latters installed power, with consequent savings in peacetime fuel costs, plus their modernity soon led to this plan being abandoned. Five were retained for service with the Royal Navy, while the rest were transferred to common-wealth Navies, sold abroad or their completion was suspended pending a decision on how best to dispose of them. In consequence, when the six armoured carriers of the Illustrious class returned to the United Kingdom from the Pacific during 1946, they were either assigned to accommodation and training duties, or were used as trials vessels.

Three further classes of aircraft carrier were under construction in the United Kingdom in 1945. The first of these was an improved and enlarged version of the Illustrious class armoured carrier. It had twin-level hangars, each level being $17\frac{1}{2}$ ft. high. These enabled it to accommodate 100 United States built aircraft, and it was capable of being equipped to operate aircraft up to 30,000 lbs. in weight. Four vessels of this Audacious class were designed during 1942-43, but little priority was given to their construction, and in consequence in mid-1945 work on Africa had not been started and little work had been done on Eagle. These two contracts were terminated soon after the end of hostilities, but Audacious, which was in an advanced state of construction, was allowed to proceed, being launched in March 1946. In the interim, the decision was taken to rename her Eagle. Construction of the last vessel of this class, originally known as Irresistible, but later renamed Ark Royal, was halted at the termination of hostilities to incorporate wartime experience into the design and it was May, 1950 before she was launched.

In July 1943, a second, and even larger, Fleet carrier design had been ordered into production. This was the Malta class, which differed from its predecessors in having many features found in contemporary United States Navy carriers, such as a thinly armoured flight deck, the ability to operate aircraft up to 30,000 lbs., and deck-edge lifts. Only the lead ship Malta, had been started by the completion of hostilities, and she and her sister ships Gibraltar and New Zealand were cancelled during November and December 1945.

The Colossus/Majestic class of light Fleet carriers had originally been regarded as stop-gap designs. Although they could carry as many aircraft as the much heavier and larger fleet carriers, their 25 knots maximum speed was seen as a major drawback to fleet operations. A new class of lightly armoured small carriers was evolved to repair this deficiency. This was achieved by doubling the installed engine power of the Colossus class design. They were also to have a single hangar, capable of accommodating 50 aircraft, and flight decks strong enough to accept 30,000 lbs. aircraft. Eight vessels of this Hermes class were included in the 1943 Naval Estimates, and all had been started by the termination of hostilities. Four of them, Arrogant, Monmouth, Hermes and Polyphemus were cancelled in October 1945, the name Hermes being transferred to Elephant. Work continued on the remaining four ships at a much reduced rate, with Centaur and Albion being launched in April and May 1947, Bulwark in June 1948, and Hermes, in February 1953.

The 18 months from mid-1945 witnessed a drastic change in the composition of the Royal Navy's carrier fleet. The Escort carriers and MAC ships had all been de-commissioned and converted into merchant ships, with the sole exception of the Campania. Five light Fleet carriers were in service, together with the six armoured carriers, but none of these was capable in their existing form of operating aircraft designed to take full advantage of the capabilities of the Audacious, Malta and Hermes classes of carriers. In addition, three of the armoured carriers had no internal storage space for aircraft over 14 ft. high. Some units of the Audacious and Hermes classes remained under construction, but their future was uncertain. The Navy was faced with major problems in planning its future aircraft programme, for in the absence of a clear picture of the types of carrier it would be operating in five years time, it was difficult to specify the dimensions, performance and weights of its future aircraft with any confidence.

vii. The British Airframe Development Programme, 1945-46.

It was recognised, as the Second World War drew to a close, that Britain's wartime policy of concentrating upon those new and modified aircraft designs which could be placed into service rapidly had produced a need for the complete re-equipment of both the RAF and Naval Aviation. This was reinforced by the return to the United States of those aircraft supplied under Lend-Lease. As a result a comprehensive three year programme of new aircraft projects was initiated within MAP in early 1945.

This process started at the end of January 1945, with the compiling of a list of potential new airframe projects, and the assignment of main and alternative design firms to each of them. Although this listing only included civil and RAF aircraft, it was clear that neither Fairey nor Blackburn was likely to gain much design work from it. Blackburn was listed as the alternative design firm for both a 'Utility Freighter' and an 'advanced trainer' project, while Fairey was named as the alternative design firm for a 'Coastal Command Strike Type (Brigand Replacement).'[1] None of these projects was given a high priority. A meeting of the Aircraft Development Programme Committee was held at the end of August 1945, to discuss this list, and agree on the projects to be started during the financial year 1945-46.[2] As a result of this discussion, Fairey was nominated to design a new single-seat naval strike aircraft, with Blackburn as the alternative design firm, while Blackburn was nominated to design a naval night fighter. Fairey was also nominated as the alter-

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1. File A - Notes of Controller of Research and Development 27.1.45, Director of Technical Development 6.2.45 and Assistant Chief of the Air Staff, 30.1.45.

2. Programmes ran for the duration of the Government's financial year, e.g. April 1945 - March 1946.

native design firm to Bristol for an Army Air Observation Post helicopter.[1]

The Admiralty's proposed additions to the existing MAP 1945-46 programme were also discussed at this meeting. No alternative design firms were nominated in their programme, and out of ten items four were to go to Westland, three to Short, and one each to Supermarine, Fairey and Blackburn. The Westland and Short nominations were for variations of two existing designs, the Wyvern and Sturgeon. In this listing, Fairey was given responsibility for a two seat strike aircraft with gas turbines, while Blackburn was assigned to design an 'Anti-submarine and replacement two seat strike aircraft in the "Illustrious Class" of aircraft carriers.'[2] This requirement was presumably motivated by a desire to provide a modern strike aircraft for operations from the Illustrious and Colossus classes of carrier, which appeared likely to comprise the bulk of the carrier fleet for the remainder of the decade. In their existing form, these classes of carrier were unable to operate the Spearfish, Wyvern, Sturgeon or the Fairey N 16/45 two-seat strike aircraft, all of which had a maximum take-off weight of over 20,000 lbs. If such a new design were equipped with a search radar, which had become standard equipment for such projected strike aircraft, it could also serve as an anti-submarine aircraft.

The next phase in this planning process was a further

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1. File A. Deputy Director of Technical Development (DDTD), Notes of Meeting 30.10.45.

2. Ibid.

meeting of the Aircraft Development Programme Committee on the 3rd October 1945. This reviewed the existing 1945-46 programme, and noted the action taken since it had been laid down. No action appeared to have been taken over Fairey's 'Brigand Replacement' aircraft, but the 'advanced trainer project' had been awarded to Boulton Paul and the Utility Freighter to General Aircraft, thus disposing of the only two non-naval projects assigned to Blackburn.[1]

An attempt had already been made within MAP to identify those firms which the Ministry wished to sustain, and those which could be regarded as dispensable. Fairey had been placed in the first category, as it was regarded as a vigorous, forward looking firm with good all round ability. Blackburn was in the second category. However, when the Admiralty realised that MAP did not plan to give Blackburn any further design work, and were prepared to see them be eliminated from the aircraft development field, they made positive efforts to find immediate naval design work for them. As a result, it was agreed at the meeting on the 3rd October that Blackburn was to be asked to design an aircraft to meet both the Naval requirement for an 'anti-submarine (Swordfish Replacement) aircraft' and the RAF requirement for a 'frontier aircraft and advanced National Service Trainer.'[2] Fairey was to be nominated as the alternative design firm for these two requirements.

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1. File A. Minutes of the Aircraft Development Programme Committee, 3.10.45.

2. Ibid.

Projections of spending based on the existing aircraft development programme had been made for the period up to the end of the financial year 1949-50, and these formed the basis of the discussions at the next Aircraft Development Programme Committee meeting. It was reported that development work on the Blackburn B-48 Firebrand was being curtailed, and no expenditure was planned on this project after the financial year 1945-46. It had been intended to order four prototypes of the Fairey Naval Strike fighter, but Treasury sanction had not been obtained for this. The total estimated cost of this project was £402,000, and the intention was to complete the prototype programme during 1948-49. In its place, the Treasury had agreed to allow the much cheaper competitive conversion of three Westland Wyvern prototypes to take gas-turbine engines. It was also reported that it was intended to order three prototypes of the 'Naval anti-submarine Escort Carrier aircraft (Swordfish replacement) and RAF Frontier Aircraft' from Blackburn for £150,000, expenditure on this to be completed during 1947-48.[1] This cost estimate seemed to imply that the Naval and RAF requirements had been successfully amalgamated resulting in a cheap, rugged and simple aircraft. There appears to have been some confusion over the timing of this project, for although it was planned to sign a prototype contract during the 1945-46 financial year, this aircraft was also included in the 1946-47 programme with Fairey and Miles as alternative design firms.

The projected 1947-48 airframe programme discussed at this meeting, contained further design work for both Fairey and Blackburn. Fairey was nominated to start work during this period on a single-seat strike aircraft which was to have night fighter and long-range escort derivatives. Blackburn was to be the alternative design firm for these types. It was noted that the specifications for these aircraft were to be completed and given to the firms between Autumn 1946 and mid-1947. In addition, Blackburn was assigned to the task of producing an armed communications derivative of their anti-submarine type for both the Navy and RAF, and was also nominated as the alternative design team to Vickers (Weybridge) for work on winged projectiles.

Four conclusions can be drawn from the information presented to these meetings during 1945. One is that much of the planning process was proceeding in the absence of any firm military requirements or detailed specifications. These were expected to be drawn up once decisions had been made on the types to be developed. Second, the nomination of Blackburn as designer of the naval anti-submarine aircraft occurred for purely industrial reasons, and at a time when considerable confusion existed about the alternative roles this aircraft was to perform. Third, there may have been some internal opposition to the decision to nominate Blackburn as the designer of the naval anti-submarine aircraft, in view of the decision to allow either Fairey or Miles to produce a competitive design after Blackburn had commenced work. Fourth, it seems to have been expected that development work on this aircraft would be completed by early 1948, giving an in service date for possible production aircraft of 1949. This, together with the prototype cost estimates, suggests that at this time what was envisaged was a simple, light, uncomplicated aircraft, using existing engines and accessories. This view is reinforced by the contract to Fairey for development of their strike aircraft. This involved a much greater expenditure than that envisaged for the anti-submarine aircraft, and implied that it would be a larger and more complex aircraft than the latter.

Although Blackburn started work on their anti-submarine aircraft in the Autumn of 1945, their initial proposals do not seem to have been acceptable to the Ministry of Supply.[1] Fairey had been encouraged by Naval personnel to go ahead with their own design,[2] and at the next meeting of the Aircraft Development Programme Committee in December 1945, Blackburn or Fairey were listed as the possible builders.[3] In addition, by early 1946, the RAF frontier strike aircraft requirement had ceased to be associated with the naval anti-submarine project.

During January and February 1946, there was little recorded activity in connection with the naval aircraft programme, but in March 1946 it was reported that the anti-submarine aircraft project had been postponed to the 1946-47 financial year. In

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1. The Ministry of Supply took over the aircraft procurement functions previously performed by MAP during October, 1945. Its title is usually abbreviated to MoS.

2. See below pp. 95 and 102-104.

3. File B. Minutes of Meeting 4.12.45.

addition, the RAF frontier strike requirement was now firmly associated with the advanced national service trainer project, and these two had been divorced from the naval anti-submarine aircraft. Design studies for the RAF aircraft were to be requested from Blackburn, Fairey and Miles as part of the 1946-47 programme, and it was noted that the order for three prototypes for the anti-submarine aircraft was likely to go to Fairey.[1]

The Admiralty's long term aircraft requirements were reviewed by the Aircraft Development Programme Committee in late March, 1946. It was reported that Fairey Firefly IV's were still being manufactured and no plans existed to close the production line.[2] It was hoped that this aircraft would eventually be replaced in operational squadrons by the N 16/45 strike aircraft, though some would have to be retained for operations from the <u>Illustrious</u> and <u>Colossus</u> classes of carriers. It was noted that an order was being contemplated for a small initial production batch of an anti-submarine conversion of the Firefly. Orders for the Blackburn Firebrand had been reduced to 139 aircraft, and the consequent threat to the future of Blackburn was to be investigated.[3] No mention was made of the Fairey N16/45

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1. File A. Minute from TD (Plans) to DARD, 11.3.46.
2. This aircraft was a modified version of the original FR 1 which had been fitted with a supercharged Griffon engine to improve its performance at high altitudes. It also carried an ASH radar scanner under the starboard wing.
3. File B. Minutes of Meeting, 27.3.46.

strike aircraft among aircraft listed as not yet in production, although the anti-submarine GR17/45 was placed in this category. It was stated that this aircraft was required in service as soon as possible to replace the Fairey Barracuda III.

The next significant event in the planning process was that in May 1946, the financial forecast for the GR17/45 project was altered to cover a four-year period up to 1949/50, rather than the three-year period envisaged by the Aircraft Programme Development Committee in October 1945. Total planned expenditure remained unchanged at £150,000.[1] This change may have been related to the slippage of the estimate date for the first flight of the Blackburn GR17/45 to mid-1948.[2] In addition, the only engine listed for the GR17/45 in a summary of the Engine Development Programme prepared in May, 1946, was the Napier E128, an alternative to the Bristol Centaurus in the Blackburn design.[3]

In June 1946 a decision was taken to proceed with both the Fairey and Blackburn versions of the GR17/45 aircraft. It was anticipated that contracts would be let in July 1946, for 3 prototypes of the Blackburn aircraft at an estimated technical cost of £150,000 and for 2 prototypes of the Fairey aircraft at an estimated technical cost of £250,000. Expenditure on both contracts was to continue through to 1949-50.[4]

These Airframe Programme planning activities during 1945

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1. Ibid. Financial Summary of Airframe Development Programme, May, 1946.
2. Ibid. Minute from Air 2 (MoS) to CNR, 10.5.46.
3. Ibid.
4. Ibid. Minute from Air 2 (MoS) to CNR, 4.7.46.

and 1946 represent the formal outputs of a number of important processes that occurred within the Admiralty and the MoS during this period. Four different groups can be identified who interacted together to produce this programme. First, within the Admiralty organisation, two groups existed who did not necessarily share the same view of future naval aircraft needs. One group, the Directorate of Air Warfare (DAW) was responsible under its Director for drawing up new operational requirements. It formed part of the Naval Staff and was under the control of the Fifth Sea Lord. The second group were those Naval officers operating within the Ministry of Supply under the Chief Naval Representative (CNR) who also held the posts of Vice Controller (Air) and Chief of Naval Air Equipment. He was responsible to the Chief of Naval Equipment who came under the Third Sea Lord. Thus although DAW and CNR were theoretically within the same organisation, and the CNR appointment was held by a Rear-Admiral in contrast to the Captain who was Director of Air Warfare, in practice they were situated within different administrative hierarchies, and their relationship was ambiguous. Any dispute between them had to be settled by reference to the Admiralty Board itself.[1] This division of responsibility meant that there was no direct machinery to prevent DAW producing over-ambitious requirements.

The major interest of CNR was to see that the Navy obtained suitable aircraft, and to this end extensive direct contacts were maintained with people at Board level in the relevant air-

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1. Interview with Slattery, <u>op. cit.</u>

craft companies. CNR had also on occasions co-operated with firms to produce proposals for new aircraft, which had then had requirements written around them by DAW. Although extensive liaison existed with members of the Fairey Board, at least one of whom had been a naval aviator, this did not exist to the same extent with Blackburn.[1] Out of these liaison activities arose judgments on the capabilities of aircraft firms and a desire that the firm judged best able to do a job should be given the contract. This formed the background to the encouragement given to Fairey in the Autumn of 1945 to do preliminary design work on the GR 17/45 aircraft although no formal design contract was forthcoming until early 1946.

The MoS was the third bureaucratic structure involved in naval aircraft procurement. Within this organisation there seems to have been a division of opinion between those who wanted to use the post-war period to rationalise the structure and size of the aircraft industry, and those who believed they should spread design work thinly around the industry in order to keep as many design teams as possible in being. The final component was the firms within the industry who had relations with both the MoS and CNR. Each had its own distinctive style of relationship, with Fairey pursuing a very active policy of liaison in this area.

viii. The Military Requirement - GR17/45.

The Admiralty's draft requirement for a naval anti-submarine

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1. CNR and one of the Fairey Directors had served together as naval aviators in the same aircraft-carrier in the immediate pre-war period.

aircraft was circulated to relevant aircraft firms for the first time in October 1945. The preamble to this document stated that the Admiralty required a single-engined aircraft capable of world-wide operations from the decks of the smaller carriers, particularly for use in converted liners, for anti-submarine duties. The aircraft had to be capable of performing by day and night

(a) anti-submarine duties including level or glide bombing;

(b) reconnaissance in areas where enemy fighters were unlikely to be met.[1]

The qualities required of such an aircraft were then enumerated. The normal all-up-weight for take-off had to be less than 16,000 lbs. although a weight of 17,000 lbs. was acceptable in exceptional circumstances. The aircraft was to have a wing span of less than 55 ft., and a height in the tail down position of 13 ft. 9 inches. It was stated that any suitable British engine could be installed. Top speed of the aircraft was to exceed 300 m.p.h., and it had to be capable of patrolling at 150 knots. It was to have an endurance of 4 hours and its flying characteristics were to be such that it would need less than $\frac{2}{3}$ engine power during a deck landing approach at 80 knots, while the take-off run at full normal load from the deck of an aircraft carrier against a 25 knot wind was not to exceed 450 ft. Two crew, pilot and observer, were to be carried, and the aircraft was to be capable of carrying a 2,000 lbs. bomb load plus eight

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1. File C. Draft Staff Requirement for an anti-submarine aircraft. Placed in file at October, 1945.

sonobuoys, or an alternative offensive load of rocket projectiles or packaged guns under the wings.[1]

One of the puzzling elements in this requirement is the reference to the use of the GR17/45 aircraft in converted liners, for the only vessel fitting this description used during the war was the training carrier Pretoria Castle. Alternatively it could refer to the Colossus and Majestic classes of light Fleet carriers, which had been built on mercantile hulls, and which it had been believed would be suitable for conversion into passenger liners after the war. The requirement for a top speed in excess of 300 m.p.h. seems to have been dictated by a desire to use the aircraft in an attack role, while the 13 ft. 9 inch height limit would allow the aircraft to be accommodated in all the carriers of the Illustrious class. At this stage, therefore, the requirement conformed closely to the description applied to the aircraft at the end of August 1945,[2] namely an anti-submarine and replacement two-seat strike aircraft in the Illustrious class of aircraft carriers.

This requirement could be characterised as an attempt to force all the equipment and bomb-load necessary to produce an ideal naval anti-submarine aircraft into an airframe and engine

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1. It should be emphasised that this requirement was from its inception intended to produce a specialised anti-submarine aircraft for the Navy. Due perhaps to confusion over the origins of the GR designation, the scant literature on the origins of the GR17/45 project states that the aircraft was converted to this role in the late 1940's. See for example, W.J. Crowe Jr., The Policy Roots of the Modern Royal Navy, 1946-63, Unpublished Ph.D. thesis, Princeton University, 1965, pp. 75 and 117.

2. See p.87 above.

combination capable of operating from small Escort carriers. The only compromise made by DAW in respect of their ideal specification was to allow an increase in take-off weight from the initial idea of 15,000 lbs. to 16,000 lbs., and the deletion of the normal third seat in the interests of saving weight. It had until then been standard practice to have a pilot, navigator and observer in ship-board reconnaissance aircraft if at all possible.[1] In this case it had been argued that given the weight problems, only two crew were acceptable in the absence of definitive evidence to the contrary.[2] Given Coastal Command and Naval Aviation experience with the fatigue problems encountered by airborne radar operators, this was a very peculiar omission: no thought appears to have been given to possible trade-offs between the third crew member and bomb-load or other equipment.

The emphasis laid on differing elements in the requirement changed substantially during the latter part of 1945, attention being shifted from its possible attack role towards its ability to operate from Escort carriers. The military rationale behind the specification was discussed at a meeting on the 17th April 1946, which reviewed both Fairey's and Blackburn's submissions to the GR17/45 requirements. At this meeting CNR explained that whereas no foreign power could build up a surface fleet which might menace the United Kingdom, they might well build up a substantial submarine fleet against which the anti-submarine

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1. Interview with Slattery, op. cit.
2. File D. Introduction by DAW to meeting 19.7.48 to 'Review the position of the GR17/45 in the light of recent staff proposals to include a third crew member.'

aircraft would be available. Submarines with schnorkel[1] had taken on a new lease of life and detection beneath the surface was a very difficult problem. All that could be done was to provide the best radar equipment possible and that was planned for the present. Radar was capable of detection of the schnorkel itself when the submarine was not below the surface and the sea was not very rough.[2] He then went on to say that the GR17/45 aircraft should be considered as a Swordfish replacement, and would be required to operate from Merchant carriers. These were small and slow. It was important that the aircraft should take-off without the necessity of turning the ship into wind, and this dictated the desirable 440 ft. take-off distance into a 17 knot wind, a slow approach speed, twin-engined reliability and a tricycle undercarriage. It was later revealed that the idea of a twin-engined turbine-propeller design had been accepted because it offered twin-engined reliability, and because the Admiralty wanted to introduce the best and most modern type of aircraft into service in about five years time.[3]

During June 1946, the decision was taken to proceed with both the Fairey and Blackburn designs, and on 27th July the definitive Naval Staff Requirement for an anti-submarine aircraft, No. NR/A9 was issued. This contained one major change from the draft requirement, together with a number of detailed amendments.

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1. A schnorkel is an air tube which diesel electric submarines can extend above the surface of the water to enable them to use their main propulsion engines while the submarine itself remains submerged.

2. File C. Minutes of Meeting held 17.4.46.

3. File D. Introduction by DAW to meeting 19.7.48.

These included the deletion of the clause specifying a single-engined aircraft; the reduction of the top speed requirement to 260 knots; the addition of a statement that a high cruising speed was unimportant; the reduction in the figure for the slow flying speed from 150 to 100 knots, and the specification of the radar set as ASV Mk 15 Series II, with a 36 inch scanner being allowed for, though a 22 inch one was to be fitted initially. The major change, was that the take-off requirement from an aircraft carrier into a 17 knot wind was now stated to be 400 ft. a reduction of 50 ft. over the draft specification and 40 ft. over the figure mentioned by CNR as the April meeting.[1] Whatever desires may have existed in October 1945, for the aircraft to have a secondary strike role had been firmly abandoned, and the type was not unambiguously optimised on the anti-submarine role.

ix. <u>The Initial Proposals from Industry</u>.

During the Autumn of 1945, Blackburn had been formally approached to investigate the possibility of producing an anti-submarine aircraft to the draft Naval Staff Requirement. In parallel Fairey were unofficially engaged in the same task.

Before tracing their subsequent activities in detail, it is relevant to note the major problem of designing such an aircraft, as seen by Fairey:

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1. File C. Naval Staff Requirement for an anti-submarine aircraft - July 1946, and RAFM AC-73/30 (41/b/1), Gannet Box 5.

'The design of Fleet Air Arm aircraft is hedged about by numerous and onerous limitations which together constitute a far more difficult problem than the land based aircraft. The first limitation is overall size .... This limitation ... bears adversely against the successful solution of the main problem of this class of aircraft, namely short take-off run, and consequently special attention has to be paid to the development of efficient lift increasing devices.'[1]

These propositions were reinforced in the GR17/45 requirement by the need to produce an aircraft which could be effectively handled on small Escort carriers.

Little direct information is available on the evolution of Blackburn's thinking about the anti-submarine aircraft, but it is possible to reconstruct a little of what may have happened. Given the original take-off weight limit of 15,000 lbs., their initial reaction was to try to convert the redesigned Firebrand strike aircraft, which weighed approximately 15,000 lbs., into a two seat anti-submarine aircraft. This would have been in line with the original planning description of the aircraft as an anti-submarine and replacement two seat strike aircraft in the "Illustrious" class of aircraft carriers.[2] A model of such an aircraft appeared in the 1948 SBAC show, equipped with a chin radome[3] and either Armstrong Siddeley Python or Napier Double Naiad engines.[4] Blackburn appear to have submitted such a design study by December 1945, but it was regarded as unsatisfactory. The main grounds for this were that the project as it was then formulated did not satisfy the take-off requirements.

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1. RAFM AC-73/30 (41/a/1), War Records, op. cit., p. 12.
2. See p. 87 above.
3. A chin radome is one situated underneath the nose of the aircraft.
4. Jackson, op. cit., p. 457.

It was then suggested that the 1,000 horsepower propeller-turbine engine around which the Double Naiad was designed should be replaced by a 1,500 horsepower unit.[1] This gives ground for speculation that the failure to start the Blackburn project in the 1945-46 financial year may have been a result of the unsatisfactory nature of the design offered by Blackburn. Blackburn then redesigned their aircraft around either a single Rolls Royce AP 25 turboprop or a coupled Napier E 128 Naiad, the design being such that either engine could be fitted with the minimum of structural alteration. In this form it was submitted for MoS and Admiralty scrutiny early in 1946.[2]

While Blackburn concentrated on the anti-submarine aircraft, Fairey's attention was divided between their N16/45 and GR17/45 designs. The commonality of ideas that underlay the two types is illustrated by the manner in which they described the anti-submarine project in their technical war records.

> 'At the present time, we are engaged in completing three alternative design studies to meet staff requirements for a Naval Anti-Submarine aircraft:-
>
> (a) With single Rolls-Royce AP25 jet and propeller engine and contra prop and normal chassis.
>
> (b) With twin Armstrong-Siddeley "Mamba" engines, arranged to drive contra-props, using the same principles as apply to the "Naval Strike Aircraft" project. In this case a normal chasis and tailwheel are used.

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1. For details of the design see Jackson, op. cit., p. 461.
2. File A. Minute from DDRD (Perf) to DGTD 1.12.45.

(c) Similar in all respects to (b) except that a tricycle undercarriage arrangement is used.'[1]

Unfortunately, this document was undated, though the nature of the references to the Naval Strike Aircraft project suggest that it was submitted in late November 1945.

Fairey submitted their ideas to the Admiralty and the Ministry of Supply in the form of a Brochure dated 31.12.1945.[2] The three alternative designs mentioned in the War Records were retained. Again, considerable space was devoted to explaining why the twin engine arrangement had been chosen.

> 'The twin engines, driving a single pair of contra-rotating propellers at the nose of the fuselage by means of a special gear box used in our (b) and (c) projects, is a similar arrangement to that which we have proposed for our "Naval Strike Aircraft". A considerable saving in weight is possible as compared with that obtained if a single engine of similar power is employed, due mainly to the reduction in fuel used during cruising, when one engine only of the pair is used.
>
> Our reason for including the single engined version is almost entirely the fact that the engine is interchangeable with that used in our Naval Strike Aircraft, since in all other respects the twin engined projects appear to be more attractive.'[3]

The aircraft design submitted had a two-seat, tandem 'bubble' type cockpit, forward of the wing, jet pipes exhausting behind the radome at the bottom of the fuselage, rearward retracting main wheels and rearward folding wings.[4] Normal take-off weights for the three versions were 16,700, 16,000 and

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1. RAFM AC-73/30 (41/a/1) War Records, op. cit., p. 31.
2. RAFM AC-73/30 (41/b/1), Gannet Box 5, Brochure in Fairey Naval Anti-Submarine Aircraft 31.12.45.
3. Ibid., p. 2.
4. For a 3 view drawing of the aircraft see Ibid., Drawing No. A 78736.

16,500 lbs. respectively, while take-off run into a 27 knot wind was calculated as 330,395 and 430 ft. respectively.[1] One of the major technical points of note concerning this data was that a significant performance penalty was incurred through using a tricycle under-carriage, though Fairey argued that 'in the present case the absence of bounce and lack of precision in landing technique necessary with this type of under-carriage makes it eminently suitable for use in aircraft intended to operate from the smaller types of carriers under all weather conditions.'[2]

These privately financed project studies, and the activities of the Admiralty representatives in the Ministry of Supply led to official recognition being given to the project in February, 1946, when a contract for £1,000 was given to Fairey 'to carry out design studies to explore the possibilities of general purpose anti-submarine aircraft to meet the requirements of specification GR17/45.'[3] Fairey appear to have submitted a further brochure when they received this contract. At a meeting within the Ministry of Supply in March, 1946, reference was made to their submission containing two tricycle projects, and also to the aircraft having differing wing spans, one of 52 ft. and one of 55 ft.[4]

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1. Ibid., pp. 12 and 13.
2. Ibid. p. 2.
3. File C. Statement at meeting on GR17/45 at Fairey Factory at Hayes, 31.1.47.
4. File C. Minutes of meeting to discuss Fairey and Blackburn GR17/45 designs. 17.4.46.

x. <u>The Prototype Contract Decisions.</u>

The decisive meeting to determine which of the two competing firms were to be awarded a prototype contract took place on the 17th April 1946.[1] At this meeting CNR elaborated on the Naval requirement, and indicated that the Admiralty considered the main attributes of a successful design to be a 440 ft. take-off run into a 17 knot wind, a reasonable approach speed, twin-engined reliability and a tricycle undercarriage. These criteria were used by the meeting to try to systematically eliminate those designs which did not have these characteristics.

It was first pointed out that the Performance Section of the Directorate of Engine Research had calculated that neither of the Fairey Tricycle projects could meet the take-off requirement. Were these designs to be powered by Coupled Napier E128 Naiad engines, this requirement could be met, though the cost would be a take-off weight of approximately 18,000 lbs. Consideration was then given to the question of approach speeds, and it was noted that Fairey's designs had slightly lower estimated speeds than the Blackburn designs. At this stage it was decided that the Fairey 55 ft. wing span project should be eliminated from consideration, as it offered no appreciable gain in take-off distance or approach speed over the 52 ft. wing span design.

A discussion then ensued concerning the arbitrary elimination of the tail wheel designs. It was argued that no conclusive evidence existed to prove that tricycle undercarriages were superior

1. <u>Ibid</u>.

to tail wheel ones for propeller driven aircraft. Moreover, they involved a clear performance penalty. CNR terminated this discussion by stating that the Navy strongly approved of tricycle undercarriages because a pilot making a high approach could always find the deck by pushing the nose of the aircraft down, thereby staying on the deck, whereas with a tail wheel aircraft the tendency would be to bounce over the arrester wires into the barrier.[1] This was an early indication of the importance attached by the Navy to landing and take-off qualities in comparison to other aspects of aircraft performance.

The pilot's view in both sets of designs was then discussed and each was agreed to be equally good. The restricted view from the observer's cockpit in the Blackburn design was adversely commented upon, but CNR stated that the Navy regarded this as unimportant as Radar, rather than visual, detection was to be used in the aircraft. The general conclusion reached by the

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1. The normal method of landing aircraft onto carriers at this time was for the aircraft to engage arrester wires strung across the rear part of the flight deck with its arrester hook. This hook was fitted to the rear fuselage of the aircraft. If a number of aircraft had to be recovered in a short period of time, there would be no opportunity to remove to the hangar the aircraft which had just landed. These aircraft had to be parked on the forward part of the flight deck, where they would prevent aircraft which had failed to engage the arrester wires being able to take off again and make a fresh approach. To stop aircraft attempting to land from crashing into these parked aircraft, a collapsible barrier, which looked rather like a tennis net, was positioned mid-way down the flight deck to protect the parked aircraft, and catch aircraft which overshot the arrester wires. Aircraft which crashed into this barrier usually suffered considerable structural damage, and this was the source of the relatively high attrition rate for aircraft that the naval planners used when calculating the total numbers of aircraft they required for specific roles.

meeting was that there was little to choose between the Blackburn and Fairey designs. The adverse comments on the take-off capabilities of the Fairey designs appear to have been discounted as a result of the Admiralty representatives placing greater faith in figures generated by Fairey than in those produced by the Ministry of Supply.[1]

The Controller of Supplies (Air) (CS (A)) then drew the attention of the meeting to the engine delivery position, noting that difficulties were being experienced with the design of turbine reduction gears for the Double Mamba and Twin Naiad engines. It was also anticipated that there would be difficulties coupling the attendant clutches and gearbox. This made it probable that the single RR AP 25 engine would be available for installation in airframes some time before the coupled Napier E128. The engine position would thus be a dominant factor to be taken into account when arriving at final decisions on the project if the Admiralty wanted the aircraft as soon as possible. A second Ministry of Supply representative then pointed out that the Blackburn designs could take either single-engined or coupled twin-engined power-plants without change of dimensions aft of the engine bulkhead. The implication of these assertions was that certain sections of the Ministry of Supply were strongly in favour of the Blackburn design being chosen for prototype development, for the AP25 powered Fairey design had been excluded from consideration as it had a tail wheel undercarriage.

Despite these pressures, CNR chose to adhere to the traditional

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1. Interview with Slattery, op. cit.

technique of asking for as many differing designs as possible, in the belief that one at least would prove to be successful.[1] The lack of a consensus on the winner of the design competition reinforced this position. He requested, and CS (A) agreed, that both Blackburn and Fairey be awarded prototype contracts. Blackburn's contract was for the building of three prototypes to take either the Rolls Royce AP25 or coupled twin Napier E128 powerplants: Fairey's contract to build two prototypes to take the coupled twin Mamba engine. The reason for ordering more Blackburn prototypes than Fairey ones appears to have been because two different engines were to be used in the former.

There is little evidence to suggest that financial considerations played any part in these decisions. It was accepted that the Navy needed aircraft as rapidly as possible, and pursuing three alternative configurations seemed the best way of attaining this goal. Those sections of the MoS which were in favour of selecting only the Blackburn design for further development found it very difficult to sustain their case in face of the admitted uncertainties over engine development times.

The decision to proceed with two sets of prototypes was reinforced by a later technical assessment of the two design studies by the MoS. This argued that the fundamental problem with the design was to obtain the required take-off distance while keeping the weight within the 17,000 lbs. overload weight limitation. The two designs submitted represented alternative

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1. Ibid.

methods of tackling this problem. Fairey had chosen an approach involving a small power-plant and a large wing span and wing area. Blackburn had chosen a larger and less economic engine, coupled with a smaller wing span and wing area. The success of these approaches would ultimately depend on their airframe design efficiency and weight control, and this could not be judged until prototypes had been manufactured and flown. It was argued that due to these technical uncertainties in the airframe area, there was no alternative to developing both types in prototype form.[1]

CNR's request that both designs be ordered had to acquire the necessary high level approval in both the MoS and Admiralty, and the Treasury also had to be consulted. As a result it was June 1946, before further substantive action occurred on the project, and in the meantime the airframe and engine development programme planning work proceeded on the assumption that no decision had been made, that only one design would be ordered, and that the total cost would not exceed £150,000. By the end of June the necessary clearances had been received for the project, and both firms were given instructions to proceed with prototype development. Fresh estimates of the costs involved were drawn up. The estimated cost of producing the two Fairey prototypes was £320,000[2] exclusive of the engine and other government supplied equipment, while the three Blackburn prototypes were costed at £480,000.[3] These figures seem to have been

1. File E. Report dated 28.6.46.
2. File C. Requisition to purchase 2 Fairey GR17/45 aircraft.
3. File D. Requisition to purchase 3 Blackburn GR17/45 prototype aircraft.

derived from a relatively arbitrary unit cost figure of £160,000 and were not a product of a detailed cost estimating exercise.

Fairey's contract for developing their GR17/45 design was signed on the 12th August 1946, and was to cover both the materials involved, and design and drawing office labour and overhead charges. It stated that on satisfactory completion of the contract the Ministry would contribute the sum of £250,000 if the cost exceeded £250,000. If the cost was less than £250,000, the Ministry would pay the approved costs plus such sum for profit as would bring the Department's total liability up to £250,000, with the proviso that the sum paid as profit was not to exceed £7,000.[1] This was a fixed price, incentive contract, where the maximum profit could be obtained by keeping costs below the £250,000 mark. It is unclear why this type of contract was offered to Fairey. The only explanation that has ever been offered was that 'the Fairey tender to specification GR17/45 had ... been a private venture, and placing of the prototype order for two aeroplanes on August 12th 1946 was conditional upon part of the expenses being met by the company.'[2] If this was true, the MoS appear to have penalised Fairey for allowing themselves to be used by the Admiralty to produce a situation which conflicted with certain of their own long-term policies.

Blackburn were rather more dilatory than Fairey in their contract negotiations with the Ministry. A tender was invited from them on 30th September 1946, but it was not until the

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1. File C. Contract with Fairey Aviation 12.8.46.
2. <u>The Aeroplane</u> - July 13, 1956, p. 48.

20th November 1946 that they tendered for their three prototypes, the tender being accepted and a contract issued on the 25th of that month. This contract was for £420,000, split into £120,000 for design of the aircraft, £250,000 for the production of the three prototypes and £50,000 for components. This contrasts with the official cost estimate of £480,000.[1] A comparison between these contracts and the information given to members of the Aircraft Development Programme Committee reveals a further unexplained discrepancy. CNR had been informed in July 1946[2] that the Blackburn contract would be for £115,000 and the Fairey one for £250,000. In fact, however, the Blackburn contract was for £420,000.

The decision to develop competing prototypes had therefore been taken and contracts let. The decision had in part been based upon the content of the design studies, but the desire of the MoS to direct work to Blackburn, and the counter-pressure from the Admiralty to have an alternative design from Fairey were also of crucial importance. The value of the design study contracts in relation to the prototype contracts meant that these studies were little more than rough design ideas,[3] and this increased the importance of personal assessments of the capabilities of the firms involved.

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1. File D. Contract with Blackburn Aircraft 25.11.46
2. File B. Minute from Air 2 (MoS) to CNR 4.7.46.
3. The Fairey Brochure contained outline proposals for three different designs, yet only consisted of 20 quarto pages. See RAFM AC-73/30 (4/b/1), Gannet Box 5.

xi. The Blackburn GR17/45 Advisory Design Conferences.

The holding of an Advisory Design Conference (ADC) was the first step in the process of producing a prototype aircraft. 'At this meeting representatives of the designing firm were brought together round a table with representatives of the Director of Operational Requirements. Each requirement was worked through in detail, and the firm which was responsible for the design was given an opportunity to raise any points upon which for legitimate design reasons they wished to have concessions or a more detailed statement of requirements. Naturally a concession allowed to one firm would be communicated to the other firm engaged. Thus the projects were set on the way towards the detailed design.'[1] In the case of naval aircraft the Director of Air Warfare served the same function as the Director of Operational Requirements. The Advisory Design Conferences on the GR17/45 aircraft were intended both to uncover any lack of clarity in the requirement, and to resolve it.

The Blackburn airframe A.D.C. was held on the 2nd September 1946.[2] This confirmed that three prototype airframes were to be built, to take either a single Rolls Royce AP25 engine or the Napier twin coupled E128 power-plant. The development programme for the aircraft was discussed, and Blackburn stressed that the date for the first flight of the prototype was dependent upon delivery of the engines. Mock-ups of these would be required by July, 1947, and they hoped that the flight engines could be

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1. Postan, Hay & Scott, op. cit., Appendix 11, p. 502.
2. File D. Minute of Advisory Design Conference held 2.9.46.

delivered by the end of 1947. Blackburn would have the first prototype ready for flight within six weeks of receipt of the engine if this schedule was adhered to, with the other two prototypes following at four to six week intervals. This gave an approximate date for first flight of the end of January 1948.

The meeting was then informed that the performance forecasts for the Rolls Royce AP25 engine had recently been downgraded. The engine would have a much higher fuel consumption than previously calculated, and this, and other changes, had resulted in a reduction in the take-off performance of the AP25 powered Blackburn design. Take-off run was now estimated at 500 ft., 30 ft. more than the Napier E128 version. A Blackburn representative then protested that the definitive Staff Requirement, which had been issued at the end of July, specified a take-off run of 400 ft., 50 ft. less than the Draft Requirement against which the existing design had been devised. He stated that if this was insisted on, Blackburn would have to drastically re-design their aircraft. The Chairman suggested that DAW re-examine this part of the requirement, and this was agreed to.

A further ADC was held on 7th November 1946, to discuss the armament for the Blackburn aircraft. It was stated that its main weapon was to be Zeta, an air dropped anti-submarine homing torpedo. This had two wings which normally folded along the body of the torpedo, but when it was to be used the wings extended to produce an airframe structure which allowed it to glide into the sea at the correct angle from any height. It was necessary for a launching arm to be provided to hold the weapon clear of the bomb-bay while the wings deployed, and for the bomb-bay to be sufficiently large to accommodate both it and the weapon. No detailed dimensions of Zeta were available, but it was stated that it would not exceed 14 ft. in length; 30 inches in vertical diameter; 17 ft. 8½ inches over the wings when ready for launch or 2,000 lbs. in weight. No detailed sighting or launching information was available.[1] The weapon was not being designed and developed by an aircraft firm, but by the Royal Naval Torpedo Factory at Alexandria in Scotland.

Attempts were made during the remainder of 1946 to resolve a number of the issues raised at the Blackburn airframe ADC in September. On the 12th November, it was officially decided that the target date for the first flight of the Blackburn aircraft should be March 1948. Blackburn confirmed on the 29th of that month that they could meet this target date if the power-plants were supplied on time, and if more detailed specifications of Zeta could be rapidly supplied to them.[2]

Consultations had also been proceeding on the acceptable take-off weight of the aircraft, which was now estimated at 16,950 lbs., 950 lbs. above the Staff Requirement. DAW accepted this increase early in December, and on the 20th also accepted that the take-off distances in the Staff Requirement were impractical, and reverted to the 450 ft. distance stated originally in the Draft Requirement.[3] These changes made it appear that the

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1. File D. Minutes of Armament Advisory Design Conference 7.11.46.
2. Ibid. Letter from Blackburn, 29.11.46.
3. Ibid. Staff Requirement for an anti-submarine aircraft. Amendments No. 1. 20.12.46.

Blackburn GR17/45 design was evolving smoothly and satisfactorily at the end of 1946.

xii. <u>The Fairey GR17/45 Advisory Design Conferences</u>.

The April conference, which decided that work should proceed on both the Fairey and Blackburn designs, had been presented with evidence indicating that the take-off performance of the Fairey design was inadequate. Some thought was given within the MoS to the implications of this, and it was accepted that an anticipated take-off run of 525 ft. into a 17 knot wind was very high in relation to the Staff Requirement. The possibility of replacing the Double Mamba engine with the Napier E128 was examined but this produced an aircraft weighing 18,100 lbs. It was felt that a better approach would be to fit one or two rockets to the tail of the existing design until the Mamba engine had been developed to provide more power to meet the take-off requirement.[1] It was pointed out in early July that 2,400 h.p. could only be obtained from the existing Double Mamba design by an 8% overspeed and overload, and if more power was needed to decrease the take-off run, a major redesign of the engine would be necessary.[2]

The first Fairey ADC was held on the 26th September 1946. This discussed the power-plant, which was at the preliminary drawing stage, and the major point at issue was whether it should be built so that it could be removed from the aircraft as one unit,

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1. File C. Minute 14.6.46.
2. File E. Minute from Director of Engine Research and Development (DERD) 4.7.46.

or as two separate engines.[1] The airframe ADC was held a fortnight later on the 9th October. The first issue discussed was the priority to be given to Fairey's GR17/45 work in comparison to the rest of their aircraft programme.[2] Fairey's Chief Engineer indicated that the firm had planned to complete design work on the N16/45 strike aircraft before concentrating their attention on the anti-submarine aircraft. A second draft of the N16/45 requirement had been issued on the 28th May 1946, which envisaged a two-seat twin-engined strike aircraft with two Rolls Royce AP25 turbines driving independently one half of a co-axial propeller, and with a maximum weight of 24,000 lbs.[3] DAW, on behalf of the Naval Staff, indicated that he regarded the two types as having equal importance, but he would consult members of the Admiralty Board on the issue and report the results directly to Fairey. The latter's representative indicated that they would accept any priorities decided by the Naval Staff, but until this issue was resolved, they were unable to offer any target dates for completion of the prototype anti-submarine aircraft. He also queried the relative importance attached by the Naval Staff to the anti-submarine and reconnaissance roles. DAW stated that in the event of any conflict at the design stage, the anti-submarine role would definitely take precedence over the reconnaissance one.

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1. File F. Minutes of Meeting 26.9.46.
2. File C. Minutes of Advisory Design Conference on Fairey General Purposes Anti-Submarine aircraft, 9.10.46.
3. RAFM AC-73/30 (41/c/2) Strike 16/45. Spec. N16/45 2nd draft 28th May, 1946 and RAFM AC-73/30 (41/b/3), Misc. Specs. 1940-46.

Representatives of Armstrong Siddeley, who were present at the meeting, predicted that the gearbox for the Double Mamba coupled engine would be ready for bench testing in September 1947 and the first flight engine available in Spring, 1948. Fairey's original scheme of two engines driving independently one-half of a co-axial propeller had been ignored in the Armstrong Siddeley power-plant design. It was stated that the existing standard single Mamba engine would be used in the power-plant, though a number of the accessories would have to be changed.

DAW than articulated the Naval Staff's misgivings about the weight position of the Fairey aircraft. He pointed out that the firm's estimates of 17,000 lbs. for normal take-off weight and 18,000 lbs. overload weight exceeded the requirement by 1,000 lbs. The 16,000 lbs. requirement had been based on war-time experience of operating aircraft from small, converted merchant ships, which suggested that this was the heaviest air-craft that could be handled under such conditions. He then indicated that before making any decisive decision on the issue, the Naval Staff were prepared to investigate whether weight could be saved through alterations to other aspects of the Requirement. One such alteration was that it had now been agreed to accept a take-off distance of 450 ft. rather than 400 ft. into a 17 knot wind, though he emphasised that it was most important to achieve a shorter distance if at all possible.

The Fairey representatives were given similar dimensions to Blackburn for the Zeta anti-submarine torpedo, and they impressed upon DAW the necessity of ensuring that this weapon did not exceed these dimensions as development progressed. The issue of the radar was then raised. It appeared that little information was available on the current state of development of the ASV 15, Series II, intended for the aircraft, and DAW stated that the Naval Staff felt a 36 inch scanner would be necessary for the aircraft. The Deputy Chief Naval Representative (DCNR) in the MoS was therefore deputed to investigate this issue.

Following this ADC more detailed information became available to the MoS on equipment weights. This further increased the estimated take-off weight of the aircraft, and Fairey were asked to put forward weight reducing ideas. They responded by suggesting that the aircraft should be designed down to a weight of 16,000 lbs. by accepting lower structural specifications, but this approach proved unacceptable to the Admiralty. This left the Naval Staff with the choice of accepting the aircraft at a normal take-off weight of 17,400 lbs. or asking the MoS to cancel Fairey's contract.

The Fairey airframe ADC was followed by an armament ADC on the 18th October.[1] In the course of this the full extent of the uncertainties surrounding the aircraft's equipment and armament became apparent. It was stipulated that British manufactured sonobuoys were to be fitted to the aircraft. Although these were still under development, Fairey's representatives were assured that they would be interchangeable with the existing United States produced ones. The Zeta anti-submarine homing torpedo was discussed, but from the absence of information on

1. File E. Armament Advisory Design Conference, 9.10.46.

sighting and launching techniques it was apparent that little technical information existed about this weapon. An alternative, smaller, anti-submarine homing weapon, the Dealer, was in a rather more advanced design stage, but not yet in service, and the anti-submarine bombs were in much the same state. Finally, the packaged guns for the aircraft were the subject of a design competition, and two separate prototype installations were under development.

The ADCs thus raised four major issues: the priorities to be assigned to the Fairey GR17/45 over the N16/45, the acceptable take-off weight of the design, the technical characteristics of Zeta and the state of development of the radar to be carried by the aircraft. Much official activity during the remainder of 1946 focused upon clarifying these issues.

The issue of priorities was simplified by the problems Fairey had experienced in producing a satisfactory N16/45 design. Their original design had produced an aircraft of 28,000 lbs., take-off weight, and an attempt had then been made to reduce it to the Staff Requirement weight of 24,000 lbs. This unsatisfactory state of affairs led to a decision being taken on the 29th October 1946 to instruct Fairey to give priority to their GR17/45 design work in preference to that on the N16/45.[1]

The issue of the take-off weight of the Fairey GR17/45 design soon became a problem in search of somebody to resolve it. A memorandum was circulated within the MoS towards the end of October pointing out that whereas the take-off weight for the

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1. Ibid. Minute 29.10.46.

Blackburn aircraft had been accepted by their assessors as 16,413 lbs., a dispute existed over the estimated weight of Fairey's design, the Ministry's figure being 17,565 lbs. compared with the firm's estimate of 16,636 lbs. It also stated that there was little doubt that the Fairey aircraft would go into operational service at a weight of about 18,000 lbs. This meant that if DAW insisted that the maximum acceptable take-off weight was 16,000 lbs., the Fairey design would be incapable of meeting the requirement.[1]

This proposition was reinforced by a memorandum from DCNR at the end of the month, in which he expressed gave disquiet at the progress of the GR17/45 designs. He felt that the situation was getting out of hand, and that the aircraft would proceed along the wrong lines unless some early rectification, implying hard decisions, occurred. He suggested that there should be an early meeting with the Naval Staff to try to resolve the issue.[2] This meeting occurred on the 10th December. In the course of it, it was reluctantly accepted that it was impossible to design an effective anti-submarine aircraft within the weights specified in the Requirement, and that the Navy would have to evolve ways of manhandling heavier aircraft in converted merchant ships. It was concluded that the Fifth Sea Lord should be asked to amend the take-off weight figures contained in the existing Requirement.[3] This decision was reinforced by a technical memorandum written four days later, which confirmed that it was

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1. Ibid. Minute 20.11.46.
2. Ibid. Memorandum 29.11.46.
3. Ibid. Minutes of Meeting 10.12.46.

impossible to achieve the 16,000 lbs. figure, and that the minimum weights that could theoretically be obtained were 16,950 lbs. for Blackburn's aircraft and 17,400 lbs. for Fairey's.[1]

This argument continued to drag on through the first half of 1947, despite the positive recommendation which had emerged from the December meeting. In early February, the MoS produced a further memorandum, which confronted the Naval Staff with the stark choice of either accepting the increased weights, or cancelling the project.[2] Despite these urgings, it was June 1947 before the Staff Requirement was amended to cover the increased take-off weight. The amendment stated that the normal weight was to be 17,500 lbs. with an acceptable overload weight of 18,500 lbs. but stress was placed on the importance of reducing these weights.[3]

The technical characteristics of Zeta remained shrouded in mystery despite a number of attempts to obtain further information about it. In a memorandum late in October 1946, the Director of Technical Development confirmed that it was to be the primary weapon of the GR17/45, and that every effort would be made to keep it within the existing specifications of 2,000 lbs. weight, 36" diameter and 14 ft. length. The only other information about Zeta was in the form of unconfirmed rumours. These indicated that it would take three seconds to get the engine running

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1. File D. Minute 14.12.46.
2. File E. Memorandum 11.2.47.
3. File C. Naval Staff Requirement NR/A9 for an anti-submarine aircraft, June 1947.

and 0.7 seconds to spread the wings, which had a span of approximately 16 ft. Fairey were reputed to be in the process of devising a launching mechanism for the weapon. It was also believed that when the torpedo was in the launching position it would obscure the radar scanner. This might interfere with the aiming of the torpedo at a critical moment, and mean that the weapon could only be used successfully if the scanner was re-positioned foreward of the bomb doors.[1]

Information on the radar set was more plentiful, but revealed a confused state of affairs. The ASV 15 radar set had originally been developed with an 18 inch scanner. ASV 15 series II, the set specified for the GR17/45 aircraft, was this set coupled to a 36 inch scanner. In 1945 this was under discussion, but no formal staff requirement existed for it, and no action had been taken to initiate development. The alternative radar set was the ASV 13, which had been developed during the war, had a 36 inch scanner and was immediately available, but it weighed 150-200 lbs. more than the ASV 15. In addition, Fairey and Blackburn had each been given different information about the scanner size of the ASV 15. This had resulted in the Blackburn aircraft being designed around a 36 inch scanner while the Fairey aircraft only had provision for an 18 inch one.

The Admiralty was perceived to have three options to resolve this confused situation. The first was to accept the existing ASV 15 with the 18 inch scanner as the standard equipment for the GR17/45. The Blackburn design would have to be

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1. File E. Minute 23.10.46.

altered to accommodate it, and the effectiveness of the set would be less than if it were fitted with a 36 inch scanner. On the credit side however, it would result in a reduction in the anticipated weight of the equipment. The second option was to insist on the 36 inch scanner for the ASV 15, even though this meant redesigning the Fairey aircraft to take it. This would give the best performance at the lowest weight. The third alternative was to install the existing ASV 13 with its 36 inch scanner. This would give a comparable performance to the ASV 15 with similar scanner, but the increased equipment weight would necessitate a radical redesign of both firms' aircraft if they were to meet the take-off weight limitations contained in the Requirement.

These options were discussed at a meeting called to resolve the problem on the 10th December. It was stated that no scanner size for the equipment had been officially supplied to either firm. Fairey had assumed it would be 18 inches, but Blackburn, after extensive inquiries, had concluded it would be 36 inches. The ASV 13 equipment was rejected on weight grounds, leaving little option but a compromise solution on the ASV 15. This was to develop the 18 inch scanner version first, as this was needed for other aircraft including the N16/45. Resources would then be transferred to a 36 inch scanner version.[1]

On the 14th December, instructions were issued to implement these decisions. The radar for the GR 17/45 was to be stated in the Requirement as the ASV 15 with 36 inch scanner, and DAW

1. Ibid. Minutes of Meeting 10.12.46.

was to issue a Staff Requirement for this equipment. Pending its development, planning was to proceed on the assumption that the initial prototype aircraft would be equipped with ASV 15 radar sets with 18 inch scanners.[1]

xiii. Public and Parliamentary Aspects of Naval Anti-submarine Aircraft Policy, 1945-46.

The first eighteen months after the end of the Second World War were a period during which the Royal Navy concentrated on contracting from its wartime peak in equipment and men, bringing back its major fleet units from the Pacific where it had concentrated its efforts during 1945, and trying to evolve a coherent approach towards its future roles and the shape of its fleet. The Admiralty examined the impact of the newly developed atomic bomb upon its traditional roles, and reached the conclusion that its effect would be minimal. Vigorous attempts were made to publicise this view, and re-affirm the pre-war doctrine that the major role of the future Navy was the protection of Britain's trade routes.

The first major post-war pronouncement on the role of the Navy came in mid-December, 1945, when the First Sea Lord, speaking at Manchester, affirmed that as long as Britain's 'existence depended on the safe arrival of merchant ships' the need for a British navy would remain, 'atom or no atom.'[2] This idea was expanded upon during the First Lord of the Admiralty's speech

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1. Ibid. Memorandum 14.12.46.
2. As reported in the Times, 19.12.45, p. 2.

in the 1946 Debate on the Navy Estimates, when he argued that 'Our experience in the last war demonstrated once more that if we neglected the security of our communications we shall be at the mercy of any aggressor. He would have no need to incur the hazards of using the atomic bomb. He would simply, surely and swiftly destroy us by cutting our arteries at sea.'[1]

The forces necessary to support this future role had been drastically weakened by the end of 1946. With one exception, the fleet no longer had any Escort carriers or MAC ships. Unlike the United States Navy, it had not attempted to retain a stock of these in its Reserve Fleet. These types of vessel had made an important contribution to convoy protection in the last two years of hostilities and were generally regarded as indispensable for the trade protection role. Yet only one remained available for operational use. During the wartime period, aircraft from these carriers had performed three main trade-route protection tasks: anti-submarine patrol, air defence and defence against enemy surface raiders. Only on the Mediterranean and the Russian convoy routes had air and surface ship attacks been major threats. Elsewhere, and especially in the North Atlantic, the submarine had been the main opponent.

In the post-war world the absence of potential enemy fleets or long range air forces served to reinforce the emphasis placed on anti-submarine forces. The Navy's public adoption of the trade protection role as the core of their post-war policy implied that its major future task would be anti-submarine warfare.

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1. Speech by Mr. A.V.Alexander, 7th March, 1946. 420 H.C.Debates Col. 552.

Aircraft carriers suitable for this role and well equipped anti-submarine aircraft capable of operating from them were logically going to be of prime importance in the future. By early 1946, it was apparent that the shape and development of the post-war Royal Navy would be intimately bound up with the availability of such equipment. The GR17/45 aircraft, its radar set and its weapons thus seemed destined to play a key part in the future evolution of the Royal Navy.

CHAPTER 3

ANALYSIS, 1945-1946.

In Chapter 1, nine propositions were constructed to assist understanding of the weapon acquisition process. This Chapter will examine the degree to which they can be applied to the history of the GR17/45 project during 1945 and 1946.

Proposition i: Uncertainty is inherent in weapon procurement projects, but the types of uncertainty involved are directly related to the stage that has been reached in the evolution of the project.

The most detailed classification of the uncertainties found in weapon projects was that produced by the USAF Academy Risk Analysis Study Team. This enumerated four types of uncertainty: target, technical, internal programme and process. It suggested that target uncertainty was the type most likely to be found at the start of a weapon project, and hypothesised that it arose from four different sources:

'Uncertainty concerning the nature of the need or desired operational capability

Uncertainty introduced through the formal process of generating requirements

Uncertainty concerning the physical and performance characteristics which the system must possess if it is to satisfy the stated requirements

Uncertainty of cost and schedule estimates'[1]

1. Final Report of the USAF Academy Risk Analysis Study Team, op. cit. pp. 23 and 24.

If these hypotheses are applied in turn to the early history of the GR17/45, a number of fruitful conclusions emerge.

There seems to have been little doubt that the Navy needed an anti-submarine aircraft at this time, and this generated no uncertainty. The formal process of generating requirements by contrast produced two distinct elements of uncertainty. The first involved the formal requirement, and was concentrated upon the take-off weight and take-off distance figures. The latter was reduced to 400 ft. after the design studies had been completed, but then reverted to the original 450 ft. figure, while the issue of the acceptable take-off weight figure remained unresolved throughout the period. The second element was the emphasis that was to be placed upon the distinct anti-submarine and reconnaissance roles, and the question of whether these roles should be combined with that of either a strike aircraft, or an RAF frontier aircraft. It was eventually decided that the anti-submarine role was to have priority over the reconnaissance one, and the idea of combining the anti-submarine role with a strike role was also abandoned. The latter probably had a significant impact on the initial Draft Naval Requirement, and led to the specification of a higher maximum speed and cruising speed than in later versions. The RAF frontier strike role seems to have had no overt impact upon the situation at all. The decision to accept a two-seat aircraft was also a latent element of uncertainty, but this did not emerge fully until early in 1948.

This source of uncertainty overlaps to some extent with the third one listed in the USAF Study, as one of the elements that produced the reassessment of the two-seater designs in 1948 was whether a two-seat aircraft could effectively perform anti-submarine tasks. Two conflicting views were in existence on this issue, though they were not articulated fully until 1948. They related to two differing areas of controversy. The first was the question of the type of equipment an anti-submarine aircraft needed to carry. The disagreements here reflected a more basic conflict over the correct use of this type of aircraft. One view which was reflected in the Requirement, saw the aircraft as an independent unit patrolling considerable distances from a convoy, and detecting targets with its radar, attacking them with its weapons and, if necessary, searching for them after they had submerged with the aid of sonobuoys. The other, reputedly held by CNR and others, regarded the 'correct use of the aircraft' as attack, with searching 'to be done from the surface, the carrier-borne aircraft being merely the long range artillery.'[1]

This disagreement was paralleled by a second area of uncertainty surrounding the Requirement, namely the inherent ability of the designs to meet their weight and performance specifications. These were ideal specifications which it appeared technically impossible to meet at that stage of engine and airframe development. The MoS personnel consistently tried to communicate this point to the Naval Staff, though they do not seem to have been prepared to recognise its logical corollary. This was that the Naval Staff had either to accept a lighter

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1. Letter from Sir Richard Fairey to Mr. Chichester Smith, 7th May, 1948, p. 1. Copy supplied by Mr. John Fairey.

aircraft with less equipment for operations from Escort carriers or they had to accept that the existing designs were unsuited to operations from them. The implication was that two new requirements should be drawn up, one for a lighter, simpler aircraft to operate from Escort and Merchant Aircraft Carriers, the second for a much heavier and better equipped aircraft for operations from the Fleet carriers.

This choice was recognised at the time, and was forcibly articulated in a letter written by Sir Richard Fairey to a fellow Fairey Aviation director about the GR17/45 in June, 1948:

> 'Do we really feel that this machine will be a success? I insist that we are still ringing the changes on the variables between a 15,000 and 20,000 lb. aircraft, at which the "Firefly" is at the lower end of the scale, the "Spearfish" at the top, with the "Barracuda" and other alternatives in the middle, and they will never get the quart they are seeking out of that particular pint pot.
>
> I think I am right in saying that the aircraft we should ultimately turn out to the specification would operate on nothing smaller than a Light Fleet-Carrier, of which we have eight or nine, or a Fleet Carrier of which there are only two that are operational. What equipment will they have for the Escort and Merchant Carriers?
>
> The "Firefly" can do nearly everything the new aircraft is expected to, and a hundred times more cheaply. The "Spearfish" could do the rest if they needed it, and if they built a dozen intermediaries they would still be in the same trouble.
>
> ... There seems to be little or no technical control on the requirements of the staff and I am fed up with making these overloaded failures ...
>
> I still consider that a light bi-plane is the real answer for the smaller ships ... I did not intend that the bi-plane should carry the full load of the anti-submarine, but ... suggested that the take-off and landing requirements should be settled first and then as much load as possible put into it.'[1]

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1. Ibid., pp. 1 and 2.

This passage suggests that at least one industrialist close to the project believed that the requirement was ill-conceived, and was an attempt to obtain an unrealistically large set of capabilities from too small an aircraft. He may not have been alone in this view.

The fourth source of target uncertainty was listed as cost and schedule estimates. The nature of the cost estimating process for the GR17/45 seems to have been very arbitrary indeed, as little attempt was made to obtain information on likely costs from the industrial firms themselves. The cost figures used appear to have been little more than inspired guesses. Similarly, time estimates were based on arbitrary guesses about engine development times, with no attempt to map out the development processes involved and identify possible bottlenecks.

The GR17/45 project history appears to confirm the proposition that target uncertainty is inherent in the early stages of a weapon project. The only qualification to this conclusion is that there was little doubt at this time about the need for an anti-submarine aircraft.

The second category of uncertainty specified in the USAF study was technical uncertainty. No simple definition is given of this term, but it seems to cover technical problems uncovered as development progresses and about which no information existed when development was initiated.[1] Although the GR17/45 project was later plagued by such uncertainties, at the outset it seems to have been believed that it was almost entirely within the 'state of the art', particularly in comparison with the high

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1. USAF Study, op. cit., pp. 26 and 27.

speed, high altitude military aircraft being developed concurrently for other purposes. It must be admitted, however, that a number of the technical decisions made in the selection of appropriate designs were based on judgment rather than certain knowledge. One of these was the decision to concentrate on designs with a tricycle undercarriage, despite the performance penalties produced by this arrangement, while another was the decision to fit gas turbine engines to the design. Sir Richard Fairey recognised the disadvantages inherent in the latter decision when he stated that he had 'the gravest doubts as to the suitability of the turbine, practically the sole advantage of which is the use of heavy fuel, otherwise it does not fit into a specification involving low cruising speeds and rapid take-off, and the expense is unbelievable.'[1] Despite the latent existence of these problems, technical uncertainty was not a characteristic of the initial phases of the GR17/45 project.

The third category of uncertainty employed in the USAF Study, internal program uncertainty, relates particularly to the weapon acquisition strategy to be used for the project.[2] Although an initial attempt was made to nominate one firm only to undertake the task, pressures built up for a multiple type approach on both airframes and engines, and this was eventually adopted. Parallel development was used for the engines of the Blackburn design, and also the packaged guns, but in other essential areas of equipment such as radar, sonobuoys and anti-

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1. Letter from Sir Richard Fairey, 19th June, 1948, op. cit., p.2.
2. USAF Study, op. cit., p. 28.

submarine weapons this was not attempted, although the differing types of anti-submarine weapon under development did provide some insurance in the latter area. At this stage in the project the consequences of these decisions were unknown.

The final category employed in the Study is process uncertainty. 'The uncertainties here are much broader in scope than in any of the other categories and concern service priorities, other weapons programs, roles and missions debates, DOD policy, the President's budget and congressional political considerations.'[1] Two sets of events during 1945 and 1946 seem to fall into this category. One was the question of the priorities to be given to the GR17/45 and N16/45 aircraft within the Fairey organisation, which was finally resolved by the Admiralty in favour of the GR17/45. The second was the postponement of the initiation of prototype development from the 1945/46 programme to the 1946/47 one. Two possible explanations are available for this, one relating to the need to fit the project into the overall Research and Development budget, the other to the initial inability of Blackburn to produce an acceptable design. On balance, the latter appears to have been the most likely reason for the delay. One may conclude that this type of uncertainty was only a minor element during the initial stages of the GR17/45 project.

A large element of uncertainty can therefore be seen to have been inherent in the project from its initiation. To use

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1. Ibid., p. 30.

Sir Richard Fairey's words, the Naval Staffs were trying to get a 'quart' out of a 'pint pot', and were asking the firms 'to design for undeveloped weapons and for a rather incoherently stated tactical problem.'[1] Moreover, it was accepted that the aircraft was not being designed to combat the equipment of any particular state, but rather was being developed to incorporate newly available equipment and to cope with a particular type of warfare which might be mounted by any state. This reinforces the hypothesis that 'military R & D ... has the effect of making one's own weapons obsolete - a kind of unilateral arms race.'[2] The available evidence also indicates that the predominant type of overt uncertainty present during these initial stages of the GR17/45 project was target uncertainty. Although other types of uncertainty existed, they had little impact and their potential importance was not recognised at this time.

Proposition ii: External factors dominate a weapon project at certain key points, specifically decisions on inception, production and cancellation. At other times the process operates autonomously.

There is little evidence to suggest that external factors such as 'the pace of technological change in weaponry, changes in strategic requirements and shifts in governmental policy'[3] affected the GR17/45 programme during this period. Its initiation seems

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1. Letter from Sir Richard Fairey, 19th June, 1946, op.cit., p. 1.
2. R.G. Head in F.B. Horten et al, op.cit., p. 413.
3. Peck and Scherer, op.cit., p. 24.

to have been solely a product of a desire to replace existing equipment, such as the Swordfish and Barracuda III, and this seems to have been unrelated to any external stimulus. Despite this predominantly internal impetus, the general external context in which this decision was taken was relevant in that it contained no countervailing forces to oppose the inception decision. The expectation was that other states would soon rearm, and the easiest way of developing a potent navy was to develop submarines. Giving priority to the development of anti-submarine aircraft, rather than designs capable only of surface shipping strikes, conformed to this scenario.

There is thus scant evidence to support any proposition that external factors dominated the GR17/45 project at its inception. Indeed this seems to have been a clear case of weapon development being initiated in response to internal factors.

Proposition iii: Governments act purposefully and as unified entities both to maintain their defence R & D base, and to avoid having to make conscious choices between conflicting alternatives.

This proposition contains two rather different hypotheses: that governments act with a single voice to maximise specified objectives, and that they respond in a uniform way to certain types of stimulus. It is proposed to examine the substantive issues raised by the proposition first, and then examine their implications for governmental behaviour.

There is little doubt that during this period a major objective of policy was to maintain the United Kingdom's defence R & D base: those conflicts which arose over this issue were confined to disagreements over the size and composition of that base and specifically whether the Blackburn design team was worth preserving. Indeed, at one stage the GR17/45 requirement was being dominated by industrial policy rather than a desire to obtain the best aircraft for the job irrespective of the industrial implications. The decision to allocate a design contract to Blackburn for the GR17/45 aircraft long before one was given to Fairey was clearly motivated by the desire to maintain the Blackburn design team in existence. This seems to have created some alarm among serving officers who were fearful of the quality of the product that might emerge from this decision. Their response was to encourage Fairey to initiate work on a suitable design, in the belief that they were the better firm, and thus more likely to produce an acceptable product.

One notable omission from the discussions surrounding these decisions was a recognition that the R & D base and the mobilisation base were not necessarily the same thing. Little attempt was made to distinguish between the creative ability of a firm's design team and its production capacity. Blackburn's major claim to remain in the military aircraft field lay in the latter area, for they had been a substantial producer of airframes during the Second World War, and had the strategic advantage of being situated outside the main centres of both the aircraft industry and population, both of which could be expected to suffer from heavy air attacks during any future hostilities.

Three major governmental decisions took place during this period, as well as a number of minor ones. The major ones were the decision to award a design contract to Blackburn, the much later decision to offer Fairey a similar contract, and the decision to allow designs from both firms to move forward to the prototype development stage. The minor decisions were concerned with the type of undercarriage to be used, the type of radar to be carried, the need to alter the Naval Staff's take-off distance requirements and finally, the need to alter their take-off weight requirements.

The decision to award a design contract to Blackburn was presented as a choice between that action or allowing Blackburn's design team to be disbanded. The matter was urgent, and therefore a positive decision had to be made. Refusal to decide would have been tantamount to closing the Blackburn design office. The consequences of not awarding a contract were clear; the consequences of awarding it remained uncertain, for it did not appear that any other part of the aircraft industry would be damaged by this action. As there was no pressing and clear reason why a contract should not be given to Blackburn, it was almost inevitable that such an award would be made.

The decision to award a contract to Fairey constituted official recognition of activities which had already occurred. With Naval encouragement, Fairey had undertaken a design study, and the award of a design contract merely formalised this position. No clear choices were involved.

Such choices did seem to be involved when a decision had to be made on which design study to select for prototype development. The MoS's aircraft planning programme had been based on the assumption that two firms would be given design contracts, and the nominated firm, provided it offered a satisfactory design, would then receive a prototype development contract. This implied that Blackburn's design, if satisfactory, would receive such a contract, while the Fairey design would not proceed further.

The meeting in April 1946, established that the two designs represented radically different methods of resolving the technical problems inherent in the requirement. Technical opinion within the MoS appeared to favour the Blackburn over the Fairey design, because of its estimated take-off performance and take-off weight advantages. This was counter-balanced by three elements that favoured the continued development of the Fairey design. One was that Fairey was perceived to have had a better design reputation and wartime production record than Blackburn. The second was that CNR regarded a multiplicity of types approach as the normal type of development strategy,[1] and this preference was reinforced by the many items of equipment intended for incorporation in GR17/45 which were still under development. The third, was that Fairey was prepared to accept a fixed price contract for the work.

The existence of two factions at the April meeting, each supporting one of the two designs meant that any decision taken at that point would have been controversial. The decision to

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1. Interview with Slattery, <u>op. cit</u>.

allow both projects to proceed was a decision to postpone a decision and avoid an overt conflict. It resulted in each firm being given the same amount of work as it would have obtained had it alone gained the contract, and friction between the MoS and the Naval Staff was avoided. The decision could be rationalised as an attempt to gain further information on both types preparatory to making a better informed decision on which one to put into production. This was therefore a situation where two clear alternatives existed, and a conscious decision was taken to postpone a choice between them.

The minor decisions taken during this period were presented in such a way that no alternatives to the one chosen appeared to exist. The elimination of all the tail wheel undercarriage designs submitted to GR17/45 was an arbitrary decision based upon limited empirical evidence. It was taken rapidly and no sustained challenge was made to it, despite the doubts articulated by some interested parties about its technical correctness. Similarly, the decision to develop the ASV 15 with 36 inch scanner was agreed with little argument as there appeared to be no alternative to this decision if the Staff Requirement were to be met. The reason for the Naval Staff reducing the take-off requirement from 450 ft. to 400 ft. is unclear but was probably based on the flight deck dimensions and maximum speed of certain of the wartime Merchant Aircraft Carriers. The original Staff Requirement for these had specified a speed of 14-15 knots and a flight deck length of 490 feet. A dearth of merchant ships with these characteristics led to a revision of the Staff Requirement with speed being reduced to 11 knots and flight deck length to 390 ft.[1] A 400 ft. take-off requirement would have allowed the GR17/45 aircraft to operate from such ships, whereas the 450 ft. requirement meant that some form of assisted take-off would be necessary. The Naval Staffs thus had a sound practical reason for specifying this distance, though why it was not included in the draft requirement is unclear. Once the technical difficulties of meeting the new requirement were pointed out, a decision to revert to the original take-off distance figure was taken very rapidly.

The take-off weight problem proved much more difficult to resolve. Existing carrier decks were only stressed to take a certain weight, as were the lifts, and this precluded the operation of aircraft exceeding these weights. In addition, aircraft had to be manhandled on a carrier deck, and it was felt there was an upper weight limit beyond which this became impossible. Little information is available on the Naval Staff's discussions in late 1946 and early 1947 on the highest take-off weight that was acceptable, but it is clear that both the MoS personnel and CNR and his deputies were concerned that the Naval Staff did not seem prepared to face up to this problem. The choice was either to accept the increases and limit the aircraft's operations to the larger carriers, thus negating part of the requirement, or start work

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1. I am grateful to my colleague Frank Gregory for drawing my attention to this information. It is contained in J.Lenaghan, "Merchant Aircraft Carrier Ships" (MAC ships) Transactions of the Institute of Naval Architects, Vol. 89, 1947, p. 97.

again through a new design competition. Eventually, the former course was chosen, though its implications were not overtly recognised. This proved to be a very protracted decision process, despite the alternatives having been accurately identified, perhaps because neither choice was particularly palatable to the Naval Staffs.

The evidence accumulated from the initial stages of the GR17/45 project is rather contradictory when applied to Proposition iii. There clearly was a sustained attempt to retain Blackburn as a design team, and thus maintain the size of the R & D base. There also were two decisions which seem to have been consciously deferred or avoided. The apparent reason for this is instructive, for it seems to have arisen from a desire to achieve a consensus on the correct decision to take. This type of governmental behaviour arose from a lack of unity and purpose within the governmental organisation, rather than as a result of its presence Similarly, the activity which superficially appeared to be designed to reinforce a policy of maintaining the R & D base, was in practice a product of conservatism and inertia, and the lack of any vigorous governmental policy aimed at reducing the R & D base to an agreed size. In short, the types of behaviour posited in the proposition could be observed during this period, but they were a product not of the existence of purposive and unified governmental actions, but of their absence.

Proposition iv: The weapon acquisition process is conducted solely through closed politics, and public debate and discussion exercises no influence over it.

Snow's term 'closed politics' implied a situation where there was no appeal to a larger assembly by members of a decision-making group should a decision be taken with which they disagreed. In the period under review, three separate governmental organisations were involved in GR17/45 decision-making: the MoS, the newly created Fifth Sea Lord's Staff Department responsible for Naval Aviation matters, and the Third Sea Lord's Department concerned with all types of naval equipment. As a result, it was possible for issues to rise to an interdepartmental level fairly quickly if they could not be resolved at the lower levels. This implied resort to ad hoc interdepartmental committees, to the Admiralty Board and, if necessary, the Ministry of Defence and its committees. During the period under review solutions, or friction avoiding strategies, enjoying support from the parties involved existed for all the outstanding problems. No resort appears to have been made to parties other than those involved at the working level.

Snow's term can also be seen as involving appeal to an audience outside the Civil Service and Ministerial structure. Evidence is lacking to suggest that there was any knowledge of the GR17/45 or its related projects outside of the relevant industrial and governmental circles during this period. The proposition cannot therefore be falsified from either perspective.

Proposition v: The weapon procurement process is dominated by civilian direction, and industrial and service views or problems have no influence upon it.

This proposition is concerned with the relationship between civil servants, and either serving officers or representatives of industry. Two distinct conflicts were taking place between the civilians in the MoS and the serving officers in CNR's department during this period. The first was that CNR was unhappy at the number of civilians occupying executive positions in relation to naval aircraft, and wished to replace them with serving officers. This was a process which took time and was made more difficult by the semi-permanence of the civil servants compared with the short time serving officers were in such staff jobs before moving back to operational duties.[1] The second was a product of the MoS having drawn up a blueprint for the future shape of the aircraft industry, which did not necessarily coincide with the opinions held by certain serving officers about which firms should be retained and which dispensed with. In the case of the decision to award prototype contracts to either Fairey or Blackburn, this division was further complicated by clear differences of opinion within the MoS on this issue.

The structure of the weapon procurement process made it difficult for serving officers to be dominated by civilian direction at this stage, for the major issue was to define the type of aircraft which was acceptable to the Navy, and only naval officers could do this. The relationship was one of

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1. Interview with Slattery, op. cit.

customer and purchasing agent. All the MoS could do was to point to the relationship between the estimated performance of designs, and the requirement, and indicate areas where it was necessary for the Navy to take decisions. In addition, the key decisions were taken in an interdepartmental committee chaired by CNR, a serving officer, and were heavily influenced by his guidance. This picture of service dominance is reinforced by the methods the Navy used to undermine the MoS policy of assigning only Blackburn to the GR17/45 projects. Their apparent unofficial and later official support for the Fairey design ensured that it would be proceeded with, despite MoS misgivings.

This picture of service dominance explains why Fairey's efforts at exerting industrial influence upon the weapon acquisition process were directed at serving officers and not MoS officials. They took a very positive and independent attitude towards the Navy's aircraft requirements, and seem to have seen this as a perfectly normal and legitimate stance. Their strike aircraft project, with its tandem-engine arrangement, was evolved by them independently of any governmental stimulus, and they appear to have succeeded in interesting the Admiralty in the idea by persistent advocacy, despite the fact that prototype designs for a number of closely comparable aircraft already existed. Similarly, they acted independently in starting design work on the GR17/45, admittedly with some service support. Their attitude towards and relationship with high-ranking officers in the Admiralty is well illustrated by Sir Richard Fairey's thoughts on the GR17/45 situation in mid-1948:

> 'What I have in mind to put before them on top level is that they should face the facts and consider whether they should not withdraw and reissue the specification anew after full consideration of all the factors that would arise from discussion with us. To start modifying and overloading a machine before it is even built is the same old trouble that has wrecked countless designs in the past, and against which I have fought not unsuccessfully with types like the "Fox" and "Swordfish".'

Both the serving officers and civilians may have resented Fairey's very independent and critical attitude towards the direction and management of the Navy's aircraft programmes, but it clearly had some impact upon them. By contrast, Blackburn seem to have made no positive attempts to influence thinking in either the Admiralty or the MoS. They merely accepted unquestioningly the requirements given to them, and did their best to meet them.

Activities surrounding the GR17/45 project during this period suggest that Proposition v was far from correct. Not only were serving officers clearly dominant over MoS officials in their inputs into the project, but also one of the aircraft firms involved, Fairey, was pursuing a very active policy of attempting to exert influence upon naval officers to change the direction of procurement policy.

Proposition vi: Governments do not act as unified entities when taking decisions on defence projects because of the conflicting interests and expertise of the bureaucratic organisations involved. This creates a lack of positive direction and control over projects.

Discussion on this proposition will inevitably overlap with

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1. Letter from Sir Richard Fairey, 19th June 1948, *op.cit.*, p. 1.

that on Proposition iii, as one is the obverse of the other. The conclusion reached on Proposition iii was that the government did not act as a unified entity because of the activities of the three major bureaucratic organisations involved, namely the MoS, the CNR's section in the MoS and the Naval Staff. This led to a lack of positive policy making, and thus the proposition is substantiated for this period.

Proposition vii: Certain individuals may, through their personal qualities or organisational position, determine whether a defence project is sustained orcancelled.

Individuals may influence the course of a defence project in one of two ways. First, by their creative and organisational abilities they may contribute to the production of an artefact capable of meeting the specified requirements. Secondly, by their direct impact upon decisions taken as part of the defence procurement process they may aid in the initiation, continuation or termination of projects. There is little evidence available from this period of the first type of influence being particularly important. The design studies to GR17/45 were of a rudimentary nature, and their content appeared to have only a marginal impact on the decision-making process. In addition, Fairey's experience in the design and development of twin-engined co-axial power-plants was totally ignored by the firms which were commissioned to produce similar engine arrangements for the GR17/45 aircraft. During these initial stages of the project, the creative and organisational abilities of individuals were largely irrelevant to those departmental interests and influences which dominated it.

It is difficult to analyse the impact of individuals upon influence processes occurring within a bureaucratic environment, both because official minutes often give no indication of whose ideas or contributions were crucial, and because of the near-impossibility of distinguishing between the impact of the personal attributes of an individual and his position within an organisation. The available evidence suggests that CNR and DCNR played dominant roles in the major meetings on the GR17/45 during this period. Whether this was for institutional or personal reasons is difficult to determine. CNR occupied a key institutional position, as the MoS depended upon him to explain its technical problems to the Naval Staff, while the Naval Staff used him to pressurise the MoS to do all they could to obtain equipment from industry which met the Admiralty's requirements. At the GR17/45 Prototype Production meeting, he both explained the background to the Navy's interest in an anti-submarine aircraft and formally proposed the line of action which was eventually agreed upon. Although there was opposition from certain parties in the MoS to these proposals, this seems to have been effectively over-ruled by him. It was DCNR who organised clarification of the radar position and the stating of a naval requirement for the 36 inch scanner and it was through CNR that the Ministry of Supply persuaded the naval staffs to both alter their 400 ft. take-off requirement, and, with rather greater difficulty, to recognise the practical implications in terms of take-off weight of all the equipment and weapons they wished to include in the aircraft. The weakness of these institutional arrangements was that nobody seemed to be in a position to evaluate the impact of the increases in take-off weight upon the basic aims of the staff requirement, in the way that Sir Richard Fairey, observing the situation from an interested position within the aircraft industry, was able to do. He lacked direct access to the decision-making process, however, and despite his reputation found it difficult to make any personal impact upon the situation. It is thus difficult to identify points at which an individual per se made a major impact upon the GR17/45 programme during this early period, with the possible exception of CNR. In short, organisational processes, rather than personal qualities were dominant.

Proposition viii: Time is the most flexible variable in the weapon procurement process, followed by cost and quality.

The development of the GR17/45 aircraft flowed from the statement of a naval requirement. Amendments were made to this during 1946, in the light of contemporary technical possibilities. Quality was thus a very inflexible variable up to 1947, and no attention seems to have been given to trade-offs between it and other variables. Cost was not really a variable as it did not seem to enter the picture: although long term costings existed, they were extremely arbitrary, and the costings used for planning purposes did not correspond to the value of the contracts actually let to firms. Similarly, there was an expectation that the aircraft would fly by 1948 and be in production as soon as possible, but this belief was based on scant empirical evidence. Since no comparable aircraft or a clearly identifiable enemy existed, there seems to have been little overt time pressure on the project, other than the idea that it should replace the Barracuda III as soon as possible. Since this aircraft had ceased to be in operational service by the end of 1945, the normal pressures resulting from the cost of maintaining ageing aircraft in operational service were absent. Quality thus seems to have been an inflexible variable, whilst cost and time were for all practical purposes infinitely variable.

Proposition ix: A weapon project comprises the following sequential phases:

a. Background research and the production of a military specification.

b. Design study and competitive tender.

c. Prototype construction.

The GR17/45 case study contains two elements excluded from this sequential list. The first was the recycling process that occurred between the military specification and the design study, particularly through the medium of the ADC. This meeting enabled the firm, the MoS and the Admiralty to identify the omissions, mistakes, and technical impossibilities involved in the specification. It was then the responsibility of DAW and the Naval Staff to either alter the specification in accordance with the ADC recommendations, or cancel it if the revised evaluation of its likely technical characteristics proved unacceptable.

The second element was the initial intention to nominate a single firm to produce the aircraft rather than initiate a process of competitive tender. Multiple prototypes of RAF and naval aircraft were usually ordered only if the project was regarded as sufficiently important to warrant the additional expense of being insured against failure of the nominated firm to produce an acceptable aircraft. A competitive tender situation only occurred in this case because Fairey produced a design study of the aircraft at their own expense. The resultant discussions on the qualities of the two designs can hardly be considered a decision-making process of the type implied by the concept of competitive tender. The decision to proceed with both designs meant that the situation could best be characterised as parallel design and development rather than competitive tender. The sequential phasing suggested in Proposition ix should therefore be amended to include these two elements.

Conclusions

The history of the GR17/45 project during this period appears, with hindsight, to demonstrate that few of the participants in the decision-making process really appreciated the difficulties likely to be encountered in developing an aircraft to such an ambitious specification. This proposition is reinforced by the way equipment which had progressed little beyond the concept stage was written into the design, ignoring possible differences in development timescales. The theory seemed to have been to cram in as much new equipment and weaponry as possible, allow the carrier limitations of the previous war to determine the physical characteristics of the aircraft, and hope something useful would result. Although Sir Richard Fairey seems to have had a reasonable grasp of the dangers of this situation, it proved impossible to communicate these ideas to the Naval Staff. Such retrospective judgments may be too harsh, however, for this was the most complicated aircraft project the Navy had ever embarked upon, and today it would be thought of not as an aircraft but a weapon system, and managed accordingly.

CHAPTER 4

GESTATION, 1947-49.

i. Introduction.

Six sets of factors can be identified as being central to the progress of the naval anti-submarine aircraft programme during this period. First, there were the difficulties experienced with turbine engine development. Second, the large numbers of aircraft projects started in 1945-46 were now moving into the more expensive prototype development phase and generating pressure upon the military aircraft Research and Development budget. Third, there was the slowly crystallising international situation, with the Berlin Crisis in the Summer of 1948 serving as a temporary catalyst for action. Fourth, there was the slow realisation of the tactical complexity of anti-submarine warfare, and the consequent necessity to amend the Staff Requirement to deal with it. Fifth, there were pressures to rapidly place a modern anti-submarine aircraft into operational service, culminating in the search for an interim aircraft. Finally, there was continuing uncertainty over the composition of the British aircraft carrier fleet, and consequent doubt about the performance characteristics required by naval anti-submarine aircraft. To clarify the sequence of events during this period a flow chart of activities relevant to the GR17/45 programme is presented in Figure 1 below.

FLOW CHART OF GR 17/45 ACTIVITIES
1947
March
April
May
June
July
August
September
October
November
December
1948
February
March
May
June
July
August
September
October
November
December
1949
February
April
May
June
July
September
November
December
Fairey N16/45 Tweed (AP25) cancelled
Blackburn GR17/45 Tweed (AP25) cancelled
Proposal to fit Griffon engine to first Blackburn GR17/45 prototype. Cancellation of one of Blackburn's prototypes threatened
MoS agree that Griffon can be fitted to first Blackburn GR17/45 prototype
Blackburn propose to operationalise first Griffon prototype
Drive to try to reduce cost of proto-type programmes
Proposals to cancel one of the Blackburn prototypes
Counter suggestion that Mamba be fitted to 2nd prototype
Notification of Slippage of 3 months in Naiad development programme
Notification of substantial increases in equipment weight. Take-Off Weight of Fairey GR17 with full strike and search load estimated at 19,000 lbs. Fairey reports Take-Off Weight as 17,250 lbs.
Notification of delivery dates for flight engines Naiad - June 1948 Mamba - December 1948
Coupling of Mamba engines abandoned. New type engine now available Feb. 1949 Future of engine in doubt
Forecast that Naiad will be available 6 months before Mamba
Notification that Naiad delayed 12 months. Delivery dates now Sept/Oct 1949 Mamba - Feb. 1949
Brochure on Fairey GR17 with Griffon engine
Revised Staff Requirement published. Normal Take-Off Weight 17,500 lbs. Overload 18,500 lbs.
Brochure on further Griffon version. Discussion with DMARD on these versions
Rejection of Fairey Griffon proposal
Decision changed. Fairey GR17 with Griffon to be allowed to proceed as private venture
Fairey decides not to proceed with GR17 Griffon version
Fairey make provision only for Zeta
Zeta still included in Blackburn design
Zeta removed from Blackburn's design
Fairey asked to tender for N40/46 night fighter
Fairey submit N40/46 design study
Blackburn submit N40/46 design study
MoS realise weight of Fairey a/c now above Staff Requirement at 17,800 lbs. Blackburn a/c 17,400 lbs.
Fairey suggests split role
Thorney Island trials of Barracuda III as interim aircraft
815 Squadron reformed at Eglinton using Barracuda III a/c taken over from 744 Training Squadron
Further drive to try to reduce cost of prototype programmes
Berlin Blockade commences
Berlin Blockade ends
Decision that Mamba will not be fitted to 2nd Blackburn prototype
Notification that Naiad moving ahead rapidly. Slippage in Mamba programme. Both types liable to be ready at same time
Blackburn reports to MoS that they have a scheme for a 3 seater GR17/45
Fairey asked to produce a scheme for a 3 seater GR17/45
Fairey produces proposals for 3-seater. Brochure and memo argue for split role and review of Require-ment
DAW expresses interest in alter-native a/s aircraft at review meeting on GR17/45
Staff Require-ment reviewed and relaxed to include:
1. 3 hrs. endurance
2. 2,000 lbs. max. weapon load
3. RATOG standard above this weight
Postponement of decision on whether 2nd Blackburn proto-type should have operational Griffon installation
Further slippage to Naiad programme. Sept. 1949 earliest possible date for delivery
Agreed that Griffon engine should power second Blackburn prototype
Further slippage to Naiad programme. March/April 1950 earliest date for delivery. Agreed this elimi-nated Naiad from programme. Final decision to be taken in early 1949
Blackburn told to stop work on Blackburn Naiad version. 3rd prototype to have Double Mamba engine
24th meeting of Cttee for Naval a/c design - investigation requested of landing on weights of GR17/45 to see if it could operate from unmodified light fleet carriers
GR17/45 landing weight investigations completed. Satisfactory
3-seater Fairey fuselage agreed
3-seat Fairey prototype agreed to
2nd issue of GR17/45
Contract let for Fairey 3-seat prototype
CNR meeting. Need for 2 different a/s a/c recognised; 1 large, 1 small. Alternative a/s a/c discussed. Redesigned Fire-fly rejected. Sturgeon to be exam-ined further. Fire-fly with ASH seen as only alternative.
24th Meeting of Cttee for Naval a/c design asked for further investigation of Sturgeon
CNR meeting on Sturgeon. No decision. Firms capacity to be investigated
Meeting of Cttee for Naval a/c design - 1st Sea Lord not prepared to place production order for Sturgeon. To go ahead as prototype for R & D purposes only
Fairey produce Brochure on 3-seat Firefly - one prototype by Nov. 1949 and 25 production a/c by July 1950 proposed
Firefly VII 3-seater Staff Requirement published
Meeting on Firefly VII. Judged acceptable for production. No production order
Pound devalued
Suggestion that either Blackburn or Fairey GR17/45 be cancelled
Brochure on Fairey Turbo Griffon GR17/45 produced
Second Brochure on Fairey Turbo Griffon GR17/45

FIGURE 1

ii. The GR17/45 Gas-Turbine Engine Development Programme, 1947-1949.

In January 1947 three engines were under development for the GR17/45 aircraft: the coupled Napier E128 Naiad, the coupled Armstrong Siddeley Double Mamba and Rolls Royce AP 25 Tweed. At the meeting of the Engine Programme Review Committee on 20th February 1947, it was reported that good progress was being made with the Twin Naiad. The initial design of its gearbox had been completed, a mock-up of the engine had been sent to Blackburn, and the firm anticipated that the first coupled engine would be ready for test by January 1948. They were confident that their target date of April 1948 for delivery of a flight engine to Blackburn would be met.[1] By late March 1947, this target date had receded to June/August 1948, though it was hoped to fly the engine in a Spearfish test-bed aircraft in June 1947.[2]

Progress with the alternative engine for the Blackburn design, the Rolls Royce Tweed, was much less promising. Compressor problems were being experienced with it, and it was estimated that this would delay the completion of initial development by six months. A flight engine would not be available before August 1948, and the Tweed powered Blackburn prototype was unlikely to fly before November 1948. Blackburn had investigated the possibility of substituting the Rolls Royce Clyde for the Tweed in their airframe, but this was a larger and heavier engine, and would cause the aircraft to exceed the

1. File D. Minutes of Engine Programme Review Committee 20.2.1947.

2. *Ibid.* Minute 21.2.47.

weight limitations specified in the Requirement.[1]

The prospects for the successful development of the Tweed decreased still further a month later when it was learned that Fairey's N16/45 strike aircraft, which was also to have been powered by this engine, had been cancelled, leaving it assigned to only two airframe designs, the Blackburn GR17/45 and the Saunders Roe Princess transatlantic flying boat.[2]

No delays were anticipated with the Mamba development programme, though some fears were being expressed about the lack of power of the engine, given Fairey's weight and take-off distance problems. It was noted that 2,400 eshp[3] would be available by overspeeding the engines, and that a new compressor design could offer greater power than this. In view of the estimated 430 ft. take-off distance of the Fairey aircraft in comparison with the 450 ft. of the Staff Requirement, little performance margin was seen to exist with this design, and the MoS viewed any increase in power from the engine as very desirable.[4]

The rapid deterioration in the Blackburn engine supply position between January and April 1947, led to CNR visiting the firm to discuss the situation. Following this visit, the MoS wrote to Blackburn instructing them to abandon work on their Tweed engined GR17/45 first prototype and to draw up plans to power this airframe with a Rolls Royce Griffon 57 piston engine.[5]

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1. Ibid.
2. Ibid. Minute 24.3.47.
3. Equivalent shaft horse power (Eshp) for turbine propeller engines is a measure of the power transmitted to the propeller plus the residual thrust from the jet exhaust pipes.
4. File C. Minute 7.2.47.
5. Ibid. Letter from MoS to Blackburn Aircraft 24.4.47.

The decision to terminate development of the Tweed engine appears to have been based upon the overloaded state of the Rolls Royce engine development programme.[1] The MoS also suggested that Blackburn produce a design study of a Naiad powered version of their S28/43 Developed Firebrand, known to the firm as the B.48[2], in order to strengthen the Naiad position.

Information on the evolution of the Mamba programme was sparse, but what did exist was discouraging. The Director of Engine Research and Development (DERD) believed that it was unlikely that the engine in its original form would produce its target 2,400 eshp, while the redesigned version was likely to suffer from a 6% increase in fuel consumption. He believed that Blackburn had adopted the correct approach by using the higher powered Twin Naiad, and that Fairey's choice was consistent with their habit of under-engining an aircraft and then demanding more power before the first flight.[3] It had not been possible to hold a Fairey GR17/45 engine mock up conference in March 1947, as no mock up of the Double Mamba engine had been received by Fairey.[4] During May, the basic Mamba engine ran into major technical problems over blade root fixing. This meant that a coupled flight engine was unlikely to be available before December 1948. The Naiad engine had also run, but given no

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1. File D. Summary of Blackburn GR17/45 programme 11.11.1948.
2. Although a number of project studies were made of this aircraft powered by airscrew turbines, none appear to have been made with the Naiad. See Jackson op. cit. p. 455.
3. File E. Minute from DERD 9.4.47.
4. File C. Minute 1.5.47.

power, and Napiers were optimistically promising that the coupled version would be ready for flight by June 1948.

The problems with the Double Mamba were the subject of a meeting between Ministry of Supply officials and Armstrong Siddeley representatives on the 26th June 1947.[1] The firm revealed that they had abandoned their existing method of turbine blade fixing, and were reverting to the standard "Firtree" method, resulting in a two month delay in the development programme. They had also concluded that it would be impossible to develop an effective coupled Double Mamba power plant, and now proposed to couple each engine to one half of a co-axial propeller. This arrangement was identical to that originally advocated by Fairey in late 1945. The Ministry representatives were dubious about the timescale of this new power-plant, as they believed it would be necessary to develope a new, larger, co-axial propeller for it. It was suggested that any failure to develop the coupled engine would lead to the cancellation of the whole Mamba programme. This engine was now being developed solely for the Fairey GR17/45 as it had been decided to switch from the Mamba to a Merlin engine in the Balliol advanced trainer, the only other aircraft in the military aircraft programme which had planned to use it. It was hinted that this radical change in the nature of the turbine power-plant might lead to the Griffon 57 piston engine being adopted as the definitive power plant for the Fairey GR17/45 design.

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1. File F. Minutes of meeting on Double Mamba with Armstrong Siddeley representatives 24.6.47.

Reports of this meeting created considerable alarm within the Directorate of Engine Research and Development, as they had been sponsoring three other coupled turbine-propeller engine projects besides the Mamba. These were the Twin Naiad, the Rolls Royce coupled AP25 Tweed and the Bristol coupled Proteus. They feared that the problems encountered with the Mamba were likely to be present in the other coupled engines and hastily convened a meeting with representatives of Armstrong Siddeley and Napier to discuss the issue. It transpired that Armstrong Siddeley had abandoned work on their coupled engine because they believed that if one engine should fail on take-off, the entire coupled unit would stall,[1] and that devices to prevent this would be too complicated to be airworthy. It was eventually concluded that the problem was unique to the Mamba, and would not occur in the coupled Naiad or the other engines.[2] It was

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1. Ibid. Minutes of Meeting with Armstrong Siddeley and Napier, 12.7.47 and File E, DERD Minute 12.7.47.

2. The technical explanation for this relates to the surge line of the engines. In any gas-turbine engine, there is for a given speed of the turbine shaft (usually measured in revolutions per minute, RPM) a maximum amount of fuel that can be burned in the combustion chambers before combustion ceases due to insufficient oxygen and the compressor stalls. The closer that an engine approaches to this point under operating conditions, the more efficient it will be. The Mamba was designed to approach nearer this point at full-power than the Naiad. If one engine of the coupled Mamba were to fail, the sudden loss of power would lead to a slowing of the propeller mechanism, which would be transmitted through the gearbox to the other engine. Its rpm would then fall, but fuel would continue to flow at the rate appropriate to the original speed. The result would be excess fuel in the combustion chamber and an engine stall, thus producing total power failure. In theory this could be overcome by devices linking turbine shaft speed to fuel delivery, but the time available for such adjustments would be limited. With the Mamba, the firm believed that no mechanisms could be developed to do this reliably. With the Naiad, where a lengthened time period was available, Napier believed that it could be accomplished.

agreed that the coupled Twin Naiad installation in the GR17/45 could proceed, but that the Double Mamba should be converted to a co-axial arrangement. Coupled engines were still seen as having major technical advantages over co-axial arrangements as it was believed that propeller vibrations would be filtered out by their reduction gearing, whereas in co-axial arrangements they would be transmitted through the turbine to the airframe.

Fairey had readily agreed to this change in the nature of the Double Mamba power plant as it was in conformity with their wartime work on twin-engined naval aircraft. They were told that the only reason why this arrangement had not been adopted in 1945 was that the propeller firms did not think they could produce the necessary co-axial installation within the prototype development timescale envisaged at the time. By utilising an existing design for the front half of the new co-axial arrangement, it was estimated that the rear half would be completed by February 1948.

Armstrong Siddeley were asked to provide a new estimate of their delivery date following the July meeting, and they responded by stating that their first co-axial engine would be ready for test in September 1948. It was estimated within the MoS that this would enable Fairey to receive a flight engine during February, 1949.[1] This meant that it was probable that the Twin Naiad engine would be available for flight trials six months ahead of the Double Mamba.

'From August, 1947 to January 1948 the services were ...

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1. File F. AD/Eng. RD Minute 28.7.47.

under repeated pressure for economies of all kinds.'[1] One impact of these pressures was an attempt to reduce the number of engine projects being undertaken. In September, 1948, a meeting was held by the Controller of Supplies (Aircraft) [CS (A)] to discuss this issue.[2] In the course of it, the Director of Military Aircraft Research and Development (DMARD) was asked to explore the possibility of eliminating either the Double Mamba or the Twin Naiad from the engine programme by installing one of these engines in both the Blackburn and Fairey prototypes. His response was to emphasise that the two engines had different power outputs, and each of the two prototype designs was laid out in conformity with this. To put the Mamba into the Blackburn design would produce an underpowered aircraft, while to put the Naiad into the Fairey design would increase its weight beyond that specified by the Naval Staffs. He argued that it was imperative that the differing engines should be retained for each type, unless a high level policy decision was taken to eliminate one of the engines from the programme. This succeeded in retaining both engines in the programme.

The advantageous first flight dates for the Twin Naiad engine and the Blackburn GR17/45 design only lasted for three months. By October the situation had changed radically. Napier had reported to the MoS that the development of the Twin Naiad engine had been delayed by two sets of factors outside their immediate control.[3] The first of these was that the

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1. C.J. Bartlett, op. cit., p. 23.
2. File D. Minutes of CS (A) Aircraft Planning Meeting 10.9.47.
3. File D. Summary Minute dated 17.10.47.

construction of the prototype engines had lagged behind schedule due to slow deliveries of steel, castings and forgings. This was due to the industrial disruption experienced during the severe winter of 1946/47 and the resulting fuel crisis. The second was that construction of their new turbine engine test facilities had been delayed due to difficulties both in obtaining Treasury approval for the capital expenditure involved and securing building licences. These problems had been experienced by almost all the turbine engine manufacturers, but were especially acute for firms such as Napier which had only entered the field in 1945.

These problems induced an estimated twelve months delay into the Naiad programme. They meant that the first coupled engine would not be ready for bench testing before October 1948. Flight testing in the Spearfish test bed was planned to start in April, 1949, and it was anticipated that Blackburn would receive their first flight engines in September or October, 1949. This would be seven to eight months after Fairey was scheduled to receive a Double Mamba flight engine.

It was now clear that the GR17/45 airframe construction programme and its associated turbine engine development were evolving on radically different timescales, with the first airframes scheduled for completion in early 1948, while the engines were unlikely to be ready before early 1949. This led to proposals to fit Griffon 57 piston engines to both aircraft types, though no suggestion was made that the programme should be radically reviewed in the light of these engine development delays. The prevailing sentiment seems to have been that the Admiralty had little choice but to wait until the engines were developed and available before making any production decisions.

An economy drive of late 1947 produced a second proposal to limit expenditure of the GR17/45 programme, this time by reducing the number of Blackburn prototypes from three to two,[1] both eventually to be powered by the Twin Naiad. DMARD visited Brough to discuss this possibility, and a counter-proposal was generated that the third prototype should be converted to take a Double Mamba power plant, in view of the minimal saving (£25,000) that would result from its cancellation.[2]

DMARD noted in his report of this visit that Blackburn's request to be allowed to fit the Double Mamba into the third prototype arose from their belief that it would be some years before the Twin Naiad completed its development programme. If their design was to have the best chance of going into production, they felt it was essential that it be fitted with the first twin turbine engine that became available.[3]

He had reservations about the proposal as it could result in the production of three Blackburn prototypes powered by three different engines. He felt this would delay the aircraft's entry into operational service, as a production decision on the engine would be difficult to obtain. He noted that such a

1. Ibid. Minute 25.11.47.
2. Ibid. Minute from AD/RDN 25.11.47.
3. Ibid. Minute from DMARD 1.1.48.

situation had recently arisen over the Westland Wyvern strike aircraft, where two batches of prototypes existed, each with a different engine. He recommended that the Twin Naiad should be cancelled and that the second and third Blackburn prototypes should be fitted with Double Mamba engines.

No action seems to have followed this recommendation, for in March, 1948, it was proposed that a Double Mamba should be fitted to the second Blackburn prototype, and that the Griffon engined first prototype should be fitted with a Twin Naiad engine when it became available. This would enable the second prototype to be flown in February/March 1948, as soon as it was completed, rather than having to wait a further six months for an engine. Work on the third prototype would be suspended.[1]

The Blackburn programme was now in such difficulties as a result of the Twin Naiad delays that it was the subject of a special review meeting between MoS and Admiralty representatives in late March 1948. DMARD supplied a background paper for this meeting which outlined the engine difficulties and anticipated delivery dates and contained rather different proposals for overcoming them than those which had emerged from his discussions with Blackburn. He argued that both the Double Mamba and Twin Naiad versions of the aircraft should be proceeded with: the former in order to allow Blackburn to have a turbine propeller version of their design flying at the same time as their competitor, the latter because the Blackburn aircraft was designed around it and, in theory, this scheme came nearest to meeting the original

1. File D. Minute 12.3.48.

Staff Requirements. He believed that there was little point in starting development of a propeller unit specifically for the Blackburn Mamba aircraft, and that the firm would have to accept the engine and propeller unit designed for the Fairey aircraft. He emphasised that Blackburn's whole future was at stake on the GR17/45 aircraft, as this was their only remaining design contract, and implied that the MoS should make every possible effort to assist them.[1]

Most of the subsequent meeting was devoted to a discussion of the estimated performance of the various versions of the Blackburn aircraft, and the weight escalation that had arisen out of unplanned increases in equipment weight. No decisions were taken on the proposals to put a Double Mamba engine into the second prototype and suspend the construction of the third prototype.[2]

A decision on fitting a Double Mamba power plant to a Blackburn prototype was eventually taken in May 1948 by members of the Aircraft Research and Development Committee, who conducted a review of the Mamba and Naiad programmes with a view to terminating one of them. DCNR informed the committee that the GR17/45 was a key aircraf t, that the designs were competitive and that both engines were required if each design was to be demonstrated in its best form. It was eventually agreed that

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1. <u>Ibid</u>. Note from DMARD 23.3.48.

2. <u>Ibid</u>. Minutes of Meeting 23.3.48.

both programmes could continue, but that no orders should be placed for a Mamba engined Blackburn design as it would result in an aircraft of inferior performance to the Naiad version.[1]

This decision was possibly influenced by information that the Double Mamba development programme had encountered new problems, while accelerated progress had been reported on the Naiad programme. No detailed monitoring of the progress of any of these engine programmes appears to have taken place at this time, the MoS being content with half-yearly progress reports compiled by the firms themselves. Consequently, Fairey's complaint in April 1948 that they had not yet received a mock up of the Double Mamba engine seems to have been the first intimation received by the MoS that this programme was running into fresh problems.[2] A review of the situation was made early in June 1948, and it was discovered that Armstrong Siddeley had also suffered setbacks to their programme due to delays in issuing building licences to construct engine test benches. This meant that Double Mamba flight engines would not be available until July 1949, five months later than the target date offered in July 1947. By contrast, although the official target date for delivery of Twin Naiad flight engines remained September 1949, considerable progress had been made with development work, and the gearbox had been tested. Napier maintained that they could deliver flight

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1. Ibid. Extract from Aircraft Research and Development Programme Committee Minutes of Meeting held 22.5.48, para. 16.

2. File F. Letter from Fairey 16.4.48.

engines to Blackburn in March 1949, and DERD was sufficiently impressed by their progress to believe that the likely delivery date would be August 1949.[1] These developments invalidated the argument that a Double Mamba engine should be fitted to the Blackburn GR17/45 in order to allow a turbine engined prototype to fly nine months earlier than would otherwise be possible. Indeed, the delivery dates for the two engines were now starting to coincide. This decision on the Blackburn Double Mamba proposals by the Aircraft Research and Development Committee was followed by a further ad hoc meeting on this topic on 18th June. At this it was decided that no further action should be taken on the proposals as the Admiralty was not prepared to order a Naiad version of the aircraft on the basis of its Mamba performance. It was agreed that there was an urgent need to get one of the designs into production as rapidly as possible and a proposal was generated that Blackburn should produce an operational Griffon engined version of their design as insurance against further delays with the Naiad, or the failure of the Fairey Mamba GR17/45.[2]

The underlying causes of the delays to the GR17/45 programme was discussed for the first time in July 1948, at a meeting called to review its progress. It was stated that the main cause of estimated prototype completion dates having proved unreliable was the completely untried and undeveloped nature of the power plants. This situation still persisted, making it

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1. File D. Memo from DERD 1.6.48.
2. Ibid. Minutes of Meeting held on 18.6.48.

impossible to give a likely production date for the aircraft.[1] The newly appointed CNR queried the choice of propeller-turbines as the power plant, and was told by DMARD that twin engined reliability was the main attraction and by DCNR(A) that the desire had been to introduce the best and most modern type of aircraft in about five years. He observed that propeller-turbines had been oversold in 1945.

The optimism generated in June by the favourable reports of Naiad development progress was soon to be shattered. In October, 1948, further slippages in the Naiad programme were reported, and the Ministry recognised that there was no hope of fitting Naiads to Blackburn's second prototype at the time of its completion. September 1949 was now regarded as the earliest date at which the Naiad would be ready for flight.[2] The firm regarded this date as very optimistic because of the vast amount of research work that remained to be done. They therefore requested that they be allowed to complete their second prototype as an operational three seater with a Griffon engine,[3] and this was agreed to by the Ministry.[4]

A detailed investigation was now made of the Naiad programme, and a report presented to an ad hoc meeting attended by Admiralty and MoS representatives in the middle of November. This stated that the Naiad engine had developed compressor problems and an

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1. Ibid. Minutes of meeting to review the position of the GR17/45 in the light of recent Staff Proposals to include a third crew member. 19.7.48.
2. Ibid. Minute 4.10.48.
3. Ibid. Letter from Blackburn to MoS, 28.10.48.
4. Ibid. Letter from MoS to Blackburn, 28.11.48.

interim redesign of that component was being undertaken. Information on its effectiveness would be available by the end of December, and it was decided to wait for this data before making a decision on whether or not to continue developing the coupled version of the engine. It was observed that even if Napier succeeded in producing an effective redesign of the compressor, it would be March or April 1950 before a flight engine would be available. This produced agreement that the Naiad was not going to be available in time to power any of the Blackburn prototypes, but that a decision on cancellation of the engine programme itself should be delayed until the end of December.[1]

A retrospective analysis would suggest that at this point the Blackburn aircraft should have been cancelled. It had been designed around the 3,000 eshp Twin Naiad engine, and relied on this to give it its short take-off characteristics. The alternative power units were the Griffon 57 of just over 2,000 shp and the Double Mamba of 2,400 eshp, but both would produce an underpowered aircraft unless its wing area was substantially increased. It was reported to the November meeting on the Naiad, that it was likely then that an extra 100 eshp would now be obtained from each of the Double Mamba engines bringing its power up to 2,600 eshp. The cancellation of the Blackburn design was not raised at this meeting, and two possible explanations can be offered for this.

The first was that Blackburn had been engaging in written lobbying of the MoS since late October, stating that they had

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1. Ibid. Minutes of Meeting on GR17/45 prototype aircraft programme. 15.11.48.

warned the latter about the Naiad position and implying that the resulting situation was not their fault, and was something which the MoS and the Admiralty ought to take rapid action to rectify.[1] As a result, the MoS investigations into fitting the complete Fairey Mamba power unit to the Blackburn aircraft, which had been suspended in mid-June, had been re-opened. These suggested that the decreased weight of the Double Mamba engine compared to the Twin Naiad might compensate for its lesser power output. It was also estimated that a Fairey Double Mamba power unit could be made available to Blackburn in May or June 1949, unless it was necessary to redesign the gearbox to suit the Blackburn aircraft, in which case the date would be the end of 1949.[2]

The second reason was that in the event of hostilities occurring in the near future, turbine engine production capacity would be in short supply, and the Navy might have no choice but to rely on piston engined aircraft. In this situation, a Griffon engined Blackburn GR17/45 would be the only modern anti-submarine aircraft available for rapid production, as no Griffon version of the Fairey design was being developed. One of the major attractions of the Blackburn design was increasingly becoming its ability to revert to a piston engined power-plant if this became necessary.

No firm decisions on the future Blackburn GR17/45 programme were taken at the November meeting, but it was agreed to institute

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1. Ibid. Letters from Blackburn to DCNR and AD/RDN 1.11.48.
2. Ibid. Minute 11.11.48.

further investigations into the issue. These were to include asking Blackburn's views on the installation of the Double Mamba in their second and third prototypes, and having DMARD investigate both the estimated performance of a Double Mamba engined Blackburn design and the possible need for a new gearbox.

These investigations revealed that the complete Fairey power plant could be fitted to the Blackburn aircraft with a minimum of modifications. No attempt was made to investigate the possible advantages of delaying the completion of the second prototype so that the Double Mamba engine could be fitted to it. The result was a new programme, comprising the first non-operational Griffon prototype, with an estimated completion date of March 1949; the second operational Griffon three seater prototype, with an estimated completion date of July 1949, and a Mamba or Naiad engined third prototype, with an estimated completion date of September 1949. The latter date was based on the assumption that a gas turbine power-plant could be delivered by June 1949.[1]

Development of the Twin Naiad engine was finally terminated on the 7th February 1949, in the course of a discussion between the Under-Secretary (Air), the CS(A), Deputy Director of Technical Development (Air) (DD/TD(A)) and DDERD. It was concluded that although the existing Naiad engine test programme should be continued for research purposes, there was no point in going on with either the single or coupled Naiad as flight engines, and that Napier's resources should be redirected to the development

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1. Ibid. Notes of discussion on fitting of Fairey Mamba powerplant into Blackburn GR17/45 17.11.48.

of their Nomad engine.[1] A failure of communication then seems to have occurred, as Blackburn was not informed of this decision. On the 15th February they wrote to the MoS asking whether, as had been implied in recent discussions, it had been decided to cancel the Naiad as a possible powerplant for the GR17/45, and whether they should have had instructions to stop work on this installation.[2] They were eventually informed in early March that they were to stop all Naiad work, and concentrate on producing the Griffon 57 powered first and second prototypes and a Double Mamba powered third one.[3] This conformed with the decision taken in mid-February by the Sub-Committee for Naval Aircraft Design that the second prototype should have the Griffon engine as a Double Mamba powerplant would not be available in time.[4] This decision confirmed the policy which had already been formulated lower down in the hierarchies.

The decision to power the third Blackburn prototype with the Double Mamba engine gave rise to minor friction between Blackburn and Fairey over possession of the Double Mamba mock up engine. Blackburn had been promised on the 6th January that this would be sent to them, for without it they found it difficult to redesign their aircraft to take this engine.[5] Fairey requested that they be allowed to retain it until the arrival of their first

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1. Ibid. Notes of Meeting between US Air, CS(A), DDTD (A) and DDERD 7.2.49.
2. Ibid. Letter from Blackburn to MoS 15.2.49.
3. Ibid. Letter from MoS to Blackburn 6.3.49.
4. Ibid. Minutes of Sub-Committee for Naval Aircraft design 10.2.49.
5. Ibid. Letter from Blackburn to MoS 8.3.49.

flight engine, which was scheduled for the 7th April.[1] The issue of turbine engine development progress then slid into the background, and the Double Mamba engine flew for the first time in the Fairey GR17/45 prototype in late September 1949,[2] while a Double Mamba for the Blackburn aircraft was delivered early in November.[3] This compared with the original date for Fairey prototype completion of June 1948,[4] and for Blackburn prototype completion of January 1948.[5]

Two new problems associated with the turbine power plant arose once the major engine development problems had been overcome. The first concerned the method of starting the engine, the second the propellers. The issues associated with the first problem had first been appreciated in late 1948, when discussions were initiated on methods of starting the engines in flight. It was stated in January 1949 that Fairey had been given little information on the installation of the starter mechanism, mainly because the whole engine was still in the early stages of development.[6] This meant that it had been very difficult to design the engine cowling and adjacent structure, as the only information Fairey possessed on the turbo-starter unit and its

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1. File E. Letter from Fairey, 15.3.49.
2. File D. Minute 19.9.49.
3. <u>Ibid</u>. Minute 5.10.49.
4. File E. Brochure on current position of Fairey GR17. 3.10.47.
5. File D. Minutes of Advisory Design Conference. 2.9.46.
6. File F. Minute 14.1.49.

cartridges was an undimensional layout drawing.[1] These problems seem to have been overcome without difficulty, but the same was not true of those which afflicted the propeller.

These had first been recognised early in 1949, when a set of 11 ft. propellers designed specifically for the Fairey GR17 had failed at the blade-root retention points during preliminary development testing.[2] Rotol, the propeller firm involved, initially believed that the provision of an annular engine air intake and new spinners would alleviate this problem, though these changes would make it impossible to supply Fairey with a flight engine by the target date of April 1949.[3] The changes failed to resolve the problem, and it proved necessary to increase the stiffness of the blades by cutting 6 inches off them, thus reducing the diameter of the propeller to 10 ft. With this temporary airscrew, Fairey and Blackburn could fly their aircraft at light loads pending the design and production of new larger propellers for both designs of 11 ft. and 11 ft. 9 inches diameter respectively.[4] The earliest possible delivery date for these new propellers was November 1949. In addition, Rotol asked both Fairey and Blackburn to alter the position of the power plant in their airframes in order to reduce the stresses upon the propeller. Blackburn agreed to do this, but Fairey refused on the grounds that it would involve major changes in their existing prototype, and worsen the pilot's view.[5]

1. Ibid. Letter from Fairey to MoS, 23.12.48.
2. File G. Minute on GR17/45 on Propeller Position 9.9.49.
3. Ibid. Minutes of Meeting 1.2.49.
4. Ibid. Minute on GR17/45 Propeller Position, op. cit.
5. Ibid.

Two general conclusions emerge from this narrative. One is that those within the MoS responsible for the GR17/45 programme appear to have been very infrequently and badly informed of the progress of the engine development programme. The second is the sheer unpredictability of progress on these projects, which made a back-up development strategy imperative for them. Unfortunately, since the Double Mamba was not a direct substitute for the Twin Naiad, the strategy chosen was really the worst of all worlds, and the only true piece of back-up development was the initial assignment of both the Tweed and the Twin Naiad to the Blackburn design. The estimated completion date of both Naiad and Mamba flight engines fluctuated appreciably during 1947 and 1948, with first the Naiad having a six month advantage; then the Mamba almost being cancelled after the reversion to a co-axial arrangement; then the Naiad being delayed for 12 months and the Mamba going ahead; followed by a near coincidence of target dates and finally the cancellation of the Naiad. At any point during this period it would have been impossible for the MoS to make an authoritative prediction on which engine would reach flight status first. Whether an improved level of progress reporting would have altered this situation is unclear, given the inherent unpredictability of the process of technical development.

iii. The GR17/45 Griffon Programme.

The proposals to fit the Griffon engine to the GR17/45 aircraft were initially inspired by delays in the development schedules of the Tweed, Double Mamba and Twin Naiad gas turbine engines. The major reasons for the consistent adoption of the Rolls Royce Griffon 57 as the alternative power plant were that it both offered a high power output at a relatively low weight, and was readily available, having been developed to power the RAF's Shackleton long-range, land based maritime reconnaissance aircraft. Both Fairey and Blackburn believed it was likely that a Griffon powered aircraft would be ordered into production by the Admiralty. There were two reasons for this belief. One was that with the Griffon engine installed, the take-off weight of the aircraft was appreciably less than with a propeller-turbine engine, although take off distance was longer due to its lower power output. The second was that the Admiralty had originally planned to start production of the GR17/45 during 1949, but by mid-1947 it was clear that this target date was unlikely to be achieved by a gas-turbine powered aircraft. The production of an aircraft with piston engines that could later be converted to take a gas-turbine appeared a possible compromise strategy if pressures to expand the Navy's anti-submarine forces increased. In addition, there was a school of thought within the Navy which actively favoured the continued use of piston engines. It was argued that this would avoid costly changes in maintenance methods and flying techniques; that the reliability of gas-turbine propeller engines was an unknown factor, and that a single piston engine from an established production line would be appreciably cheaper than two gas-turbine engines operated together. The firms were always aware of this diffuse undercurrent supporting a piston engined aircraft, and wanted to ensure that they would be in a position to supply it if required.

The first proposal to fit a Griffon engine to one of the GR17/45 prototypes was made in May 1947 by Blackburn. It followed the cancellation of the Rolls Royce Tweed engine, and the notification of a three month delay in the Twin Naiad development programme. The firm wrote to the MoS asking to be allowed to substitute a Griffon for the Tweed in their first prototype airframe, in order to allow it to be flown as soon as it had been completed. This conversion would result in a worsening of the pilot's view compared to the other variants, but it would have a lower fuel consumption and consequently a lower take-off weight than them. Ministry personnel estimated that this version would have a take-off weight of 16,500 lbs. compared with the Naiad version's 17,500 lbs; its take-off run would be 483 ft. compared to the Naiad version's 450 ft., but 4 hours flying required only 230 gallons of fuel, compared to the 3.8 hours that was the maximum that could be achieved with the Naiad version's total tankage of 320 gallons.[1]

Soon after this proposal had been received Armstrong-Siddeley decided to abandon development of their coupled Double Mamba power plant in favour of a co-axial arrangement. Late in May, Fairey wrote to the Ministry to express their anxiety over the likely delivery dates of the Double Mamba, and informed them that they were working on a design for a Griffon engined GR17/45.[2] The Ministry's response to this information was cautious: they

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1. File D. Letter from Blackburn to MoS, 5.5.47 plus RD Projects' comments.

2. File E. Letter from Fairey to MoS, 23.5.47.

indicated that it might be acceptable to fit a Griffon in the first prototype for a short period, in order to clear the aerodynamics of the design.[1]

The design study of a Griffon engined version of the Fairey aircraft culminated in the production of a brochure dated 24th June 1947. This stated that the reason for the proposal was that the Double Mamba might be delayed, and the Fairey GR17 airframe be ready for flight before it was available. A Griffon version would avoid delay in starting flight development. In addition, 'the proposed Griffon engined type is intended to function as a fully operational aircraft complying in all respects with the requirements of the GR17/45 specification.'[2] What was then proposed was a radically redesigned aircraft. 'In connection with the Griffon installation, the forward portion of the fuselage is entirely redesigned.'[3] 'The centre section wing ... leading edge is completely redesigned to accommodate ... engine coolant and oil radiator units'[4] and the 'rear fuselage unit ... is modified to include a cockpit for the use of the observer at the forward end.'[5] It was emphasised that such a design could 'be produced without delay as an efficient interim fully operational anti-submarine aircraft.'[6]

This first design study was followed by a further brochure

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1. Ibid. Notes on a meeting in D.Eng.R.D. Office, 28.5.47.
2. RAFM AC-73/30 (41/b/1). Gannet (2) Brochure dated 24.6.47, p.1.
3. Ibid.
4. Ibid., p. 2.
5. Ibid.
6. Ibid., p. 3.

prepared in early August. This described an aircraft which differed from the previous one only in the placement of the observer further down in the fuselage, so that his cockpit canopy merged into its contours. It was stated that the Griffon engine planned for this version would deliver 2,500 bhp at sea level, and give a take-off distance at full load of 438 ft.[1]

Neither of these brochures was submitted to the Ministry immediately, and when DMARD visited the Fairey works at Hayes on the 14th August, representatives of the Fairey management discussed the prospects for a Griffon engined GR17/45 with him. They told him that although the design of the Double Mamba powered aircraft was proceeding to schedule, the delays to this engine programme had led them to contemplate transferring some of their design team to a Griffon engined version. They revealed that preliminary investigations had demonstrated that problems with the centre of gravity of the aircraft made a simple power-plant change impossible, and to resolve them it would be necessary to remove the observer's cockpit to the rear fuselage. This version would be virtually a new type, and it would not be possible to perform a simple substitution of the twin-turbine power-plant for a Griffon, as was proposed for the first Blackburn prototype.

The Fairey representatives also indicated that they were not convinced that a Griffon engined version of their current GR17/45 design was the best aircraft to meet the Admiralty requirements, and that they had started a complete redesign of

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1. Ibid. Brochure dated 7.8.47, p. 1.

the aircraft to make it smaller and lighter, using a Griffon with a single propeller, a tail wheel undercarriage and a small bomb bay capable of accommodating part of the prescribed armament, the rest being carried externally.[1] This would result in a smaller aircraft, with a take-off weight of 16,400 lbs. compared with 17,250 lbs. for the GR17/45 Double Mamba and 17,000 lbs. for the Griffon version of that design.[2]

These two Fairey proposals were discussed within the Admiralty and MoS and seem to have received a uniformly negative response.[3] By the end of September it had been decided that none of them could be supported, and that Fairey should be told to adhere to the original Double Mamba scheme, or, alternatively, a Twin Naiad version of it. The main grounds for this decision were that none of the reasons for the Naval Staff favouring turbine engines, such as increased safety in aircraft carriers from the use of less volatile fuels, decreased maintenance costs and twin-engined reliability, had been invalidated by the delays in their development. It was also felt that the proposed Fairey Griffon GR17/45 was an underpowered aircraft with no scope for development, while the redesigned aircraft was a reversion towards the Firefly, and therefore retrograde in character.[4]

The impression that an operational Griffon engined GR17/45 aircraft would be attractive to the Admiralty seems to have gained

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1. File C. Notes on DMARD's visit to Hayes, 14.8.47.
2. A detailed brochure on this proposal may not have been produced, as no copy exists in the Fairey Archives at the RAF Museum.
3. File E. Notes on Discussion, 25.9.47.
4. File C. Minute 29.9.47.

wide currency, for in October, Blackburn wrote to the MoS suggesting that the proposed power plant installation for their first prototype should be refined to optimise its performance, and that the Ministry should consider building a series of pre-production aircraft with the Griffon engine. The Ministry refused to accept these proposals.[1]

The decision that the construction of a Griffon engined version of the Fairey design was not to be supported produced vigorous responses, both within the MoS and from Fairey. It was pointed out by DERD that it was rather illogical to refuse Fairey permission to re-engine their aircraft because it would then be underpowered compared with their 2,400 eshp Double Mamba version when Blackburn had been allowed to replace the 3,000 eshp Twin Naiad with the Griffon engine in their first prototype.[2] Fairey's response was to appeal against the decision, and offer to convert their airframe to take the Griffon at no cost to the Ministry. They again emphasised that their airframe would be ready in July or August 1948, but a Double Mamba flight engine was unlikely to be delivered before December of that year.[3] This offer revealed the commercial motivations that had underlain the previous three proposals, for all that was now envisaged was replacing the power-plant, altering the engine cowling, and using ballast to deal with the centre of gravity problem. The changes were very similar to those Blackburn were making in their first prototype.

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1. File D. Letter from Blackburn to MoS, 31.10.47.
2. File E. Minute from DERD, 21.10.47.
3. Ibid. Letter from Fairey to the MoS 27.10.47.

The similarity between the Blackburn Griffon and the new Fairey Griffon proposals, and their unambiguously non-operational characteristics resulted in a consensus that it was no longer possible to refuse Fairey's offer. It was agreed that Fairey could proceed with a Griffon conversion and that an engine and propeller would be supplied to them free of charge, but that all other expenses had to be met by the firm. They were also to be reminded that there was no requirement for a Griffon engined GR17/45, and that this engine was to be replaced by a Double Mamba as soon as the latter was available.[1]

Fairey reacted quickly to this revised decision, and early in November supplied a list of the materials they needed to undertake the Griffon conversion.[2] At the end of November, Rolls Royce were instructed to supply mock up Griffon 57 engines to both Fairey and Blackburn.[3] The twelve month delay in the Naiad programme and the parallel improvement in the Double Mamba position, led Fairey to review the position during February 1948, and as a result they informed the Ministry that they had decided not to proceed with a Griffon conversion. The two reasons they gave for this decision were the rapid progress made with the Double Mamba, and the heavy expenditure involved in a Griffon conversion. They asked to be allowed to retain their mock up Griffon engine in reserve and to retain the option of producing a Griffon conversion should further delays occur in the Double Mamba development programme.[4]

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1. File C. Minute 29.9.47.
2. File E. Letter from Fairey to MoS 5.11.47.
3. Ibid. Letter from DERD to Rolls Royce, 29.11.47.
4. Ibid. Letter from Fairey to MoS, 23.2.48.

This mock up engine arrived at Hayes in April.[1]

The Naiad delays led to the proposal to fit a Double Mamba to the second Blackburn prototype, but this was rejected in June 1948. It was then decided that as an insurance against further engine development delays it would be preferable to produce the best possible Griffon engined version of that aircraft.[2] Calculations were made within the Ministry on the effect of fitting a specially designed propeller to the Blackburn Griffon aircraft, rather than using the existing Shackleton propeller. These indicated that the take-off run would be reduced from 810 ft. to 590 ft. without water methanol injection for the engine, and 480 ft. with it.[3] These calculations were revised in August 1948 when it was decided that the increased weight of a specially designed propeller was likely to outweigh any performance gains.[4] Blackburn contested this conclusion and the Ministry eventually accepted that the firm's calculations were correct. Their figures demonstrated that a specially designed propeller would give an appreciable performance gain, and offer the best chance of making the Blackburn Griffon an acceptable operational aircraft.[5] As Naiad development seemed to be satisfactory, it was decided in September to fit a Shackleton propeller to the first prototype, and make a decision on the power plant

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1. File F. Minute 28.4.47.
2. File D. Minutes of meeting 18.6.47.
3. <u>Ibid</u>. Undated paper placed in file at 6.48.
4. <u>Ibid</u>. Minute 4.8.48.
5. <u>Ibid</u>. Minute 4.9.48.

for the second Blackburn prototype at a later date.[1] A month later it became apparent that the Twin Naiad had encountered further development problems, and Blackburn proposed that they should complete the second prototype as an operational Griffon-powered aircraft.[2] This was agreed to in November.[3] In addition, they renewed their request for a larger, specially designed propeller for this aircraft.[4]

Fairey produced two further brochures describing Griffon powered versions of their aircraft during 1949, although neither had been requested by the MoS or Admiralty. The first of these brochures was for an aircraft with a new type of Griffon engine featuring a "blow down" turbine. The theme of the brochure was that the Double Mamba version was the better aircraft, but if the Admiralty wanted a Griffon version, they were prepared to provide it. It stated that 'the performance of the twin "Mamba" version is superior to that of the "Griffon" engined type, due largely to the fact that the endurance required is too short to enable the low fuel consumption of the "Griffon" ... to offset the effect of the large all up weight of this type of power plant.'[5] This version did not envisage the major redesigns of the first two 1947 versions though it would 'be necessary for the fuselage to be completely redesigned forward of the front spar ...'[6] Given

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1. Ibid. Minutes of Meeting 16.9.48.
2. Ibid. Letter from Blackburn to MoS 28.10.48.
3. Ibid. Minute 11.11.48.
4. Ibid. Letter from Blackburn to MoS 23.12.48.
5. RAFM AC-73/30 (41/b/1) Gannet (2) Brochure dated 19.7.49, p.1.
6. Ibid.

the generally unenthusiastic tone of the document, it is unclear whether this was intended to strengthen the case for the Double Mamba version, or make it clear to the Ministry that they could produce a competitive aircraft to the Blackburn Griffon.

Fairey produced a further brochure on their Griffon GR17/45 in November 1949, which adopted a more positive and enthusiastic approach. Although the design presented was virtually identical to the July proposals, it was introduced by the statement that

> 'Throughout the period during which the design of the Anti-Submarine Aircraft to specification GR17/45 ... has been proceeding, the possibility of installing an alternative piston engine has been borne in mind. The most suitable engine appears to be the Rolls Royce "Griffon 57" with contra-rotating propellers ... with or without "blowdown" exhaust turbine power augmentation.'[1]

The brochure then proceeded to argue that

> 'In considering the "Griffon 57" installation, there are certain advantages which can be claimed. First, this engine is a well tried power plant, already in production, and in use in existing types of aircraft, and is thus readily available for immediate use. Secondly when cost is considered, the advantage is again in favour of the Griffon 57. Thirdly, in the long range case, there is a saving of some 600 lbs. in AUW which might be used to increase the range or carry additional stores. Offsetting these advantages to some degree would be the necessity to use 100 octane petrol with the Griffon installations ... and also the need to use water-methanol to obtain the required take off.'[2]

In the performance tables which followed, the normal take-off weight with fuel for 4½ hours was given as 19,234 lbs. for the Double Mamba version and 18,636 for the "Turbine Griffon"

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1. RAFM AC-73/30 (41/b/1) Gannet (5) Brochure dated 10.11.49, p. 1.
2. Ibid.

version, take-off distances into a 17 knot wind being 430 ft. and 440 ft. respectively.[1] This brochure seems to indicate that Fairey now considered it possible that the Admiralty would decide to purchase a piston engined version of one of the GR17/45 designs, and were taking steps to publicise their ability to produce such an aircraft. Blackburn, who were already producing such an aircraft, would have a clear advantage in that event. This perception may well have been a product of information being received about the attempts by both the MoS and the Admiralty to effect drastic economies in the existing defence programmes.[2]

iv. The progress of the Blackburn and Fairey airframe designs, January 1947 - April 1948.

The airframe ADC's held during 1946, had resulted in the broad outlines of the Fairey and Blackburn designs being frozen, but many detailed issues remained to be settled. In March 1947, Fairey produced a brochure setting out the changes that had occurred in their design since the ADC.[3] It had been decided to use upward folding wings, rather than the original rearward folding ones, because it had been calculated that the aircraft would have a tendency to tip on to its tail as the wings were folded. This change also eliminated the tail wheel unit that had previously seemed necessary to insure against this happening. The main undercarriage units now folded inwards rather than

1. Ibid., p. 5.

2. File A. Minutes of Meeting of Airframe Research and Development Programme Committee, 9.9.49.

3. RAFM AC-73/30 (41/b/1) Gannet (2). Undated typescript of brochure on GR17/45 position.

backwards, while twin nose wheels had been introduced. The jet pipes had been considerably shortened, while the 36 inch radar scanner had been incorporated in the design. Finally a more modern sting-type arrester hook had been introduced and load carrying stations built into the centre sections of the wings. These changes were formally approved at the mock up conference in April.[1]

Throughout this period, information on the progress of the winged anti-submarine homing torpedo, Zeta, was sparse. There were allegedly two versions of this weapon, one, Zeta an anti-submarine weapon, the other, Zoster, an anti-surface shipping weapon.[2] Fairey decided in August 1947 to make 'provision only' for Zeta in their aircraft, and to produce a detailed scheme for its carriage only when it became available.[3] Despite this, a brochure they supplied to the Ministry in October 1947 describing their GR17/45 programme still featured Zeta as the main weapon load.[4] In November 1947 Zeta was stated to have been removed from the requirement, because the latest estimate of its development time suggested it would not be available during the operational lifetime of the GR17/45 aircraft.[5] On receipt of this information, Fairey pointed out that the bomb-bay of their aircraft was now six inches longer

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1. File C. Notes on mock up conference on Fairey GR17/45 held 1.4.47.
2. File E. Minute 1.8.47.
3. <u>Ibid</u>. Letter from Fairey to MoS 14.8.47.
4. <u>Ibid</u>. Brochure on current position of Fairey GR17/45, 3.10.47.
5. File D. Minute 2.11.47.

than necessary, and that they could not change this as the jigs upon which the prototypes were to be built had already been designed.[1] They expressed concern that any alternative to Zeta should not exceed the existing bomb-bay dimensions.[2]

The Blackburn GR17/45 programme was reviewed by the MoS and Admiralty in March 1948, and the main purpose of the aircraft was still stated to be the carriage of Zeta and all its weight and performance estimates were based upon it. In the course of the meeting it became apparent that little progress had been made with its development, and that anti-submarine bombs were likely to be the main strike weapon.[3] Despite this admission, it was not until July 1948 that Blackburn were informed that Zeta had been removed from the requirement.[4]

Information on the progress of the ASV15 radar was also sparse, but some data had been released on the new United Kingdom sonobuoys. In April 1947 Fairey was told that their weight plus that of their carriers would be 584 lbs. This

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1. The main reason for this inflexibility was a new type of production method that Fairey was experimenting with called envelope jigging. Instead of being built by hand, the prototypes were built on what were in effect production jigs. This meant that it was very costly to change the external configuration of Fairey's aircraft once the jigs had been built. In contrast, it was much easier to change the Blackburn design because few special jigs were used to produce it. For a description of this Fairey technique see The Aeroplane, July 13, 1956, p. 53.

2. File E. Minute 19.11.47.

3. File D. Minutes of Meeting to review Blackburn GR17/45 programme, 23.3.48.

4. Ibid. Minute 29.7.48.

greatly exceeded the official estimates and the firm complained bitterly to the MoS that their attempts to decrease the structure weight of their aircraft, were being negated by increases in the weights of Ministry supplied equipment. The bomb sight was cited as an example of this, the latest weight for it being 110 lbs.[1]

This escalation of weapon and equipment weights exacerbated the existing difficulties over the take-off weight of the GR17/45 designs. The draft requirement had specified a normal take-off weight of 16,000 lbs. and a take-off distance of 450 ft. The latter had been reduced to 400 ft. in the Staff Requirement, but as a result of the ADC's this was changed back to 450 ft. The acceptable take-off weight had been the subject of prolonged discussion, which eventually resulted in a revised Staff Requirement of June, 1947, specifying a normal take-off weight of 17,500 lbs. and an overload weight of 18,500 lbs.[2]

Initial estimates of the performance of the Blackburn design suggested it would easily meet these requirements. In January 1947 it was calculated that the Naiad powered version would have a take-off weight of 17,008 lbs. and a take-off run of 408 ft. Similar figures for the Tweed powered version were 16,500 and 395 ft.[3] By contrast, the weight position of the Fairey design had always been very critical, and the revised weight figures for the British sonobuoys caused it to deteriorate

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1. File E. Minute 8.4.48.
2. File C. Naval Staff Requirement NR/A9 for an anti-submarine aircraft, June 1947.
3. File D. Table dated 21.1.47.

further. The take-off weight of the Fairey design, with full strike and search load and sufficient fuel for four hours endurance, was estimated by the Ministry in April, 1947, at 19,500 lbs. and take-off distance 600 ft.[1] Despite these estimates, the possibility of terminating the prototype contract was never raised, even after the revised Staff Requirement specifying a 17,500 lbs. normal weight and a 450 ft. take-off run had been published.[2] The firm maintained that the normal take-off weight of their aircraft would be 17,250 lbs.,[3] and it was not until February, 1948, that the Ministry became seized of this issue.

In that month, it was realised that the firm's own calculations at the end of January indicated that the normal take-off weight of the Fairey aircraft would be 17,607 lbs. In addition, Fairey had just been told by Armstrong Siddeley that the Double Mamba would both be 68 lbs. heavier than had previously been reported and have a higher fuel consumption than had been anticipated. This would increase the fuel needed for a 4 hours flight from 323 to 340 gallons. The Ministry calculated that Fairey would report a take-off weight of 17,800 lbs. at the end of February, which was 300 lbs. above the Staff Requirement. This information was widely disseminated within the MoS and Admiralty, with the implication that positive action should be taken over the problem.[4]

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1. File E. Minute 8.4.47.
2. File C. Naval Staff Requirement, June 1947, op. cit.
3. Ibid. Notes on Visit of DMARD to Fairey's factory at Hayes, 14.8.47.

The escalating weight of the GR17/45 aircraft was raised again a month later during a review meeting on the Blackburn GR17/45. It was stated that the November 1946 weight estimate for the Blackburn prototype of 16,956 lbs. had increased to 17,103 lbs., though a more realistic estimate was probably 17,400 lbs. It was anticipated that increases in the Naiad power-plant weight would eventually produce a normal take-off weight just below 18,000 lbs. On the basis of the 17,400 lbs. estimate, take-off weight with a Zeta and six externally stored sonobuoys would be 17,850 lbs. At this weight single engined cruising was impossible, and take-off run was estimated at over 500 ft.[1] The meeting concluded that it would be desirable to mount a further review of the Staff Requirement because of the weight escalation and the uncertainties over weapons and sonobuoys.

In parallel with these discussions on the Blackburn design, Fairey had included the revised weight of the Double Mamba and its increased fuel consumption in their monthly weight estimate, and reported a 600 lb. increase in take-off weight. Fairey appear to have become highly alarmed at this, and perceived that their contract might be terminated unless positive action was taken to retrieve the situation. The latter consisted of suggesting to the Ministry that the only solution to the GR17/45 weight problem was to split the roles of the aircraft so that it would either carry search equipment or strike weapons, but not both.[2] It was at this juncture that the situation was made more complex by a decision to revise the GR17/45 requirement in order

1. File D. Notes on position of Blackburn GR17/45, 23.3.48.
2. File E. Letter from Fairey to MoS, March 1948.

to accommodate a third crew member in the aircraft.

v. The Revised Staff Requirement for a three seater anti-submarine aircraft.

The GR17/45 requirement had been conceived at a time when the Naval Staff was aware of the techniques and equipment available for hunting submarines from the air, but had had little opportunity for performing their own operational evaluation of them. As information on these topics increased, the Naval Staff realised that an additional crew member was necessary if all the sensors specified in GR17/45 were to be operated effectively. In parallel, three major areas of controversy had arisen over the requirement in addition to the upper weight limit at which the aircraft could be operated from Escort carriers, and these impinged upon the process of producing a new three-seater GR17/45 requirement and revised designs of aircraft to meet it.

The first controversy, and the one which represented the most basic disagreement with the requirement, was reported to have involved the CNR from 1945 to 1948 and the Naval Staff. CNR was alleged to have believed that it was wrong for the Navy to try to produce a miniature version of Coastal Command's long range maritime reconnaissance aircraft. The latter often patrolled in areas where Naval surface forces were absent, and this necessitated them carrying their own search-radar sets for detection purposes. The prime function of naval anti-submarine aircraft was to patrol around convoys protected by radar-equipped escort vessels, and to ensure their safe passage. CNR apparently regarded airborn search radar sets as non-essential equipment for such naval aircraft, as search and detection could be performed by the radar-equipped surface escorts, 'carrier born aircraft being merely the long range artillery.'[1] These views were favourably received by Sir Richard Fairey, for the deletion of the search radar set would solve the weight problems being experienced by his GR17/45 design. The new CNR appointed during 1948 was reported to have held very similar views to his predecessor on this subject.[2] Sir Richard seems to have found this situation very frustrating, as his views and those of the CNR were very similar, yet both had been ignored by the Naval Staff when they produced GR17/45.[3]

This lack of an effective dialogue between both the Fairey Board and CNR and the Naval Staff, seems to have been parallelled by a similar lack of consultation between the Naval Staff and the staff of the Anti-Submarine school at Londonderry. This was described in a report produced by two Fairey directors after a visit to the school in July 1948, ostensibly to gather views on the type of equipment the definitive anti-submarine aircraft should carry. This stated categorically that:

> 'The Staff of the Anti-Submarine School had never agreed with the two seater requirement in the GR17/45 specification, but had previously held the view that the criticism of specifications did not fall within their terms of reference. This was considered the prerogative of the Naval Air Staff. However, as no action had been taken to amend the specification in the light of their recommendations, they are now pressing strongly to bring this about.'[4]

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1. Letter from Sir Richard Fairey to Mr. Chichester Smith, 7th May, 1948, p. 1 - supplied by Mr. John Fairey.
2. Ibid.
3. Ibid., p. 3.
4. Summary of discussion with Staff of Anti-Submarine School, Londonderry. Fairey Aviation Co.Ltd., 22nd July, 1948 - supplied by Mr. John Fairey.

In the course of these discussions, it had become plain that the staff of the anti-submarine school disagreed with the requirement in several major areas. Perhaps the most important of these was endurance:

> 'The normal period for search or the monitoring of sonobuoy barriers is assessed at $2\frac{1}{2}$ hours. There is then the possibility at the end of the $2\frac{1}{2}$ hours search that contact will be made with a submarine which may involve an extended hunt, only limited by the fatigue of the crew. This is assessed at a further $2\frac{1}{2}$ hours ....
> Apart from aircraft limitations, therefore, the view of the Anti-Submarine School is that endurance should be $2\frac{1}{2}$ hours search, plus the possibility of $2\frac{1}{2}$ hours hunt, with reserves to return to the carrier, giving 6 hours in all. The 4 hour normal requirement in the specification is, in the view of the Anti-Submarine School, too short a period to make effective use of the aircraft.'[1]

On two further issues, however, the staff of the anti-submarine school appear to have held divergent views about the requirement from CNR and Sir Richard Fairey. First, they appear to have seen naval aircraft performing their anti-submarine role primarily <u>beyond</u> the immediate area of the convoy:

> 'In convoy protection work, submarine destruction will be carried out by surface vessels.'[2]

The major task for Naval aircraft was

> 'to deny the surface to submarines and to force them down, with consequent restrictions on performance. This points to the absolute necessity for carrying scanning equipment at all times, plus an effective strike armament.'[3]

In addition

> 'It is realised that the homing torpedo will not be available before 1953 at the earliest .... This leaves the rockets as the main striking armament against a surface submarine, and depth charges as the only interim method of attacking under-water submarines. ... In view of the

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1. <u>Ibid</u>., p. 3.

2. <u>Ibid</u>.

3. <u>Ibid</u>.

> unsatisfactory state of under-water armament, the school takes the view that most aircraft submarine "kills" will result from targets of opportunity by catching submarines on the surface at night or in poor visibility.'[1]

Whereas CNR and Sir Richard Fairey viewed the functions of a naval anti-submarine aircraft as being strictly limited to the immediate area around a convoy, and its main search role being against underwater targets, the anti-submarine school saw it as a means of forcing submarines operating in the path of convoys to submerge and be placed at a tactical disadvantage, with its main search and strike roles being against submarines on the surface. It must be pointed out that this school had an intimate working relationship with RAF Coastal Command, one of the latter's squadrons being integrated into it, and these views reflected the wartime experience of that force, when many of the submarines it had destroyed had been 'targets of opportunity.'

The second divergence of opinion with the Fairey Company was that the school rejected completely the idea of splitting the functions of the anti-submarine aircraft into search and strike roles.

> 'The Anti-Submarine school insisted that the completely split role would be useless to them. It was essential ... to always carry a rocket strike load in conjunction with the search load and alternatively it would always be essential to carry scanning equipment with the full strike load .... The use of two aircraft to do the task planned for one would reduce the efficiency of operation and be wasteful of equipment.'[2]

When it was pointed out that this implied an aircraft with a

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1. *Ibid.*
2. *Ibid.*, p. 4.

take-off weight of 20,000 lbs., the discussion moved to the issue of the Navy's future carrier policy.

> 'The Director stated that he was appalled with the suggestion made recently that light fleet carriers only would be used. He said that this would alter the whole sense of the operation and the aircraft would be employed in defending the carrier rather than hunting submarines. He was convinced that the Woolworth type carrier[1] would have to be reintroduced and if necessary accelerated take-off would have to be used as a normal launching operation to cope with the increased weight.[2]

The comments attributed to the Director of the Anti-Submarine school concerning the future functions of the Navy's carrier fleet highlight the third area of controversy which was impinging upon the GR17/45 programme. By the end of 1946, only one Escort carrier remained in service with the Royal Navy. The large fleet of U.S. built Escort carriers was being converted into merchant ships, leaving only those wartime Escort carriers that had been operated by the USN in reserve in the United States. This situation created a divergence of opinion over whether the requirements for the anti-submarine aircraft should include the ability to operate from Escort carriers that _might_ be either provided by the United States or built in Britain during a future war, or whether they should be based upon the carriers immediately available for convoy escort duties, which were predominately Light Fleet carriers of the _Colossus_ class. A move to the latter assumption would allow considerable relaxation of the performance parameters of this aircraft, as

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1. This was a wartime description applied to the U.S. built Escort Carriers operated by the R.N.

2. Ibid. - The wartime Escort Carriers had been equipped with a catapult, which was originally termed an accelerator.

these carriers had flight deck lengths of 690 ft. compared with the 442 ft. of the wartime U.S. built Escort carriers; a top speed of 25 knots instead of 17 knots; and an ability to operate considerably heavier aircraft.[1] Specifically, it would allow anti-submarine aircraft heavier than those specified in GR17/45 to operate in a convoy escort role.

The original decision to specify only two crew members for the anti-submarine role seems to have been greatly influenced both by a desire to restrict the weight of the aircraft, and the lack of firm evidence that a third crew member was necessary. By May, 1948, the Naval Staffs reconsidered the requirement, and decided that the implications of putting a third seat into the GR17/45 aircraft should be formally investigated. This action was stimulated by reports they had received that the strain of either continuously watching the ASV radar or listening to the sonobuoy receiver, together with the time-consuming plotting activities involved in attacks by aircraft on submarines, would necessitate an additional crew member. The Naval Staffs requested that this investigation should include an examination of the trade-offs in armament or equipment that might be required if the take-off weight of the resulting aircraft was to conform to that specified in the existing requirements.[2]

The information accompanying this request indicated that the additional crew member should be located in the same cockpit as the observer, and they should both be in a position to use

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1. Lenton, op. cit., pp. 111, 133, 135 and 141.
2. File H. Minutes of meeting 22.4.48 - extract in Files C and D.

the automatic sonobuoy plotting board, the sonobuoy receiver and the ASV radar set. In addition both had to be able to keep a visual look out, particularly to the side and rear of the aircraft.[1] It was emphasised that this was an exploratory investigation and that no positive decision had been taken to alter the existing requirement.[2]

Blackburn appear to have been made aware of the possibility of such a request sometime before Fairey, for they reported to the MoS on the 20th May that they had already worked out a scheme for a three seater GR17/45,[3] and that this would resolve a major problem which had just arisen with their Twin Naiad powered design.[4] The weight estimate for the de Havilland propeller being produced for this version had been increased by 171 lbs., and besides increasing the gross weight of the aircraft, this had advanced its centre of gravity to a point detrimental to its handling capabilities.[5] The addition of a third crew member in the rear fuselage would compensate for this at a cost of an increase in the take-off weight by approximately 400 lbs. When this information was received by the MoS, it was suggested by one official that it reinforced the argument recently advanced by Fairey that the Naval Staff should seriously consider splitting the roles of the aircraft.[6]

Fairey was not officially approached for proposals on

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1. Ibid.
2. File D. Note of 28.5.48.
3. Ibid. Letter from Blackburn to MoS 20.5.48.
4. Ibid. Note of 28.5.48.
5. Ibid. Letter from Blackburn to MoS 20.5.48.
6. Ibid. Note of 28.5.48.

the addition of a third seat to their GR17/45 design until the 7th June 1948.[1] The request was seen as indicative of the inability of the Naval Staffs to either grasp the issues raised by their requirement or resolve them. Sir Richard Fairey's reaction to the request was that:

> 'I do not question the operational necessity or otherwise for the third seat but I feel very strongly that if this really is a primary requirement it is strange indeed that it has taken them all these years to find it out, and can it therefore be so very important?....
>
> ... What I have in mind to put before them on top level is that they should face the facts and consider whether they should not withdraw and re-issue the specification anew after full consideration of all the factors that would arise from discussion with us.'[2]

He believed

> 'that the aircraft we should ultimately turn out to the specification would operate on nothing smaller than a light Fleet-Carrier, of which we have eight or nine, or a Fleet-Carrier, of which there are only two that are operational. What equipment will they have for the Escort and Merchant Carriers? ....
>
> ... In my opinion the only clear line of policy would be to reconsider the whole question as to what aircraft they really do need, in terms of what they could have. What are the real requirements of an anti-submarine carrier-born aircraft; what functions does it perform and what weapons should it carry?[3]

He then went on to suggest that the correct way to draw up a new requirement was

> 'that the take-off and landing requirements should be settled first and then as much load as possible put into it.'[4]

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1. Letter from Sir R. Fairey to Mr. Chichester Smith 19.6.48, supplied by Mr. John Fairey.
2. Ibid.
3. Ibid., p. 2.
4. Ibid.

The Fairey Company did not welcome the proposal to add a third crew member to the requirement, as it confronted them with two major problems. One was financial. As an exasperated Sir Richard Fairey stated it:

> 'My grievance is, that having carried along with this specification for some two years in which we have already spent all the allotted money and are now facing an expenditure of some half a million of our own, they spring this on us at the last moment and expect us to incorporate it.'[1]

The second was technical. It was going to be much more difficult and expensive to incorporate a third seat in their design than in the Blackburn one, because of their use of envelope jigging for prototype production.[2]

Sir Richard's indignation was translated into a very aggressive foreword to the brief design study of a three seater GR17/45 aircraft that Fairey supplied to the Ministry on the 15th July. This stated that:

> 'Our one aim and object is to design a type which will endure in service. If operational developments demand a three seater, we are perfectly willing to design and build a three seater, and conversely we have no interest in designing and building an aircraft which does not meet stabilised requirements .... The primary object of the GR17/45 specification was to produce an anti-submarine aircraft which could operate from Escort carriers and MAC ships and the resulting limitations on weight, performance and dimensions exercised a controlling influence on our design. If these limitations no longer hold, then it is possible that an entirely new design to a new specification would give the most satisfactory solution .... We have up to now met the original dimensional and performance requirements, but the all up weight has, through circumstances outside our control, increased beyond the 17,000 lb. limit. We are gravely concerned by the amount by which we have already exceeded the specification limitation, and we must ask you to join

1. Ibid.
2. Ibid.

> with us in resisting further overload. It is time to call a halt, and if the three seater arrangement is established as a firm requirement, then the equivalent weight must be removed from the aircraft. Our constructive proposal is that the decision be taken to split the roles of the type into search and strike, which will accomplish the reduction in weight.'[1]

The firm made little attempt to underplay the difficulties they faced in converting their two seater design into a three-seater one.

> 'It must be fully realised, however, that the conversion of a two seater design at this stage to a three-seater is a major operation, involving a major amount of additional design effort and expense.'[2]

and

> 'However the conversion is carried out, whether by ordering a new aircraft or converting an existing type, we would stress the point that a major operation is involved which would require major amendments to contract.'[3]

They further argued that:

> 'If the proposal to convert to a three-seater goes ahead, we would most strongly recommend that an order be placed for a third flying prototype so that delay may be avoided on test development work which can well be carried out by the two-seater prototypes now in course of construction. If one of the two-seater prototypes were converted instead, there is no insurance against an accident to the first aircraft, and the whole programme of flight development would be greatly extended.'[4]

Finally, in order to try to start the dialogue they were seeking with the Naval Staffs, they suggested

> 'that before any final decision is taken ... a conference be held at these works to consider all the implications of the proposed change.'[5]

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1. File E. Brief design study of three seater Fairey GR17/45, 15.7.48, paras 1, 3 and 4.
2. Ibid., para. 2.
3. Ibid., para. 6.
4. Ibid., para. 5.
5. Ibid., para. 7.

To reinforce the arguments in this Brochure, Faireys submitted a comprehensive memorandum setting out their views on the GR17/45 requirement.[1] This argued that the addition of the third crew member and its associated design changes would increase take-off weight by 550 lbs. This implied a take-off weight of 18,500 lbs. to achieve four hours flight endurance with a full strike load. To obtain the six hours endurance desired by the Anti-Submarine School at Londonderry[2] take off weight would have to be increased to 20,130 lbs. They then complained that

> 'in spite of our combined efforts at an earlier stage to restrict the total weight of the GR17/45, there is now a very real danger of the prototype becoming badly overloaded even before its first flight, and the situation is thus getting out of hand. We attached the greatest importance to the anti-submarine type which we regard as the logical development of the Swordfish, and it is our intention to produce a type which will have the same enduring service life. We are convinced that overloading at the prototype stage will materially reduce the chances of attaining this end. We have a constructive proposal to stop this drift towards overloading, which is that the decision be taken to split the roles into either search or strike. A three-seater search aircraft, carrying a load of 12 British sonobuoys plus 12 marine markers, but no strike load, would have its AUW reduced to 16,800 lbs., and a two seat strike aircraft with no search load would have its AUW reduced to 17,400 lbs. ... A three-seater aircraft with combined search and strike loads is definitely restricted to Light fleet or larger carriers, but with the split role arrangement, the total weights are reduced to the point where operation from the smaller type of carrier again becomes a possibility.'[3]

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1. Ibid., Memorandum from Fairey Aviation 15.7.48.
2. Summary of discussion with the Staff of the Anti-Submarine School, op. cit., p. 1.
3. Ibid.

Fairey's three seater GR17/45 design involved the deletion of the observer's cockpit immediately behind the pilot, and the incorporation of a new two seat rear cockpit above the wing leading edge.[1] By comparison, the changes to the Blackburn design were restricted to a rearward extension of the obverver's cockpit, and a matching extension of the cockpit canopy.[2]

The revised designs were discussed at an ad hoc meeting called by CNR on the 19th July and attended by Naval Staff and MoS representatives. The briefing notes for this conference stated that the GR17/45 aircraft were experiencing difficulty meeting the normal take-off weight and take-off run figures specified in the Staff Requirement. This was a product of increased propeller weight; increased fuel consumption; increased equipment weight, particularly the larger and heavier ASV scanner; increased weight of the UK sonobuoys; proposed increases in the normal strike load and finally the possible addition of a third crew member. The latter two proposals would add an additional 800 lbs. to the take-off weight, which now stood at 17,300 lbs. for the Blackburn design and 17,800 lbs. for the Fairey one. Three alternative courses of action had been identified for discussion by the meeting. These were (a) To relax the Staff Requirements for take-off weight and run, on the premise that the aircraft would never be required to operate from anything smaller than a Light Fleet carrier.

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1. For a sketch of this rear cockpit see the drawing of the fuselage of the third prototype in The Aeroplane, July 13, 1956, p. 50.
2. The changes are shown in the drawings of the Blackburn B54 and B88 in Jackson, *op. cit.*, p. 461.

The limiting factor would then be the load carrying ability of their lifts. (b) To split the role of the aircraft, so that two aircraft would operate together, one carrying the search equipment, the other the anti-submarine weapons. This was current United States Navy policy, the Grumman XTB 3F being used for search and the XTB 3F2S for attack. (c) To convert an aircraft other than the GR17/45 designs to meet the Staff Requirement.

In support of the latter option, a table had been prepared of the take-off weights and runs of the Blackburn and Fairey GR17/45 aircraft, the Short Sturgeon, the Supermarine Seagull amphibian, the Fairey Spearfish, the Fairey Barracuda and new variants of the Fairey Firefly. The Sturgeon was shown as having a 22,000 lbs. take-off weight and 600 ft. take-off run, similar figures for the Seagull and Spearfish being 15,000 lbs. and 450 ft. and 22,000 lbs. and 700 ft. respectively. The Seagull, Firefly and Barracuda were unable to carry the ASV15 with a 34 inch scanner. Of the aircraft listed, the Barracuda seemed to be the most promising alternative to the GR17/45 designs as it could carry all the search and strike load specified in the requirement with the exception of the ASV15 with 34 inch scanner, though it could accept a version with the smaller 22 inch scanner.[1]

DAW opened the meeting by explaining that the evolution of sonobuoy equipment and anti-submarine techniques since 1945 had led the Naval Staff to conclude that a three-seater aircraft was now required, with all the crew positions having a good

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1. File E. Background notes for CNR meeting, 19.6.48. The scanner sizes mentioned were probably erroneous, as 36 and 18 inches were the standard scanner sizes.

field of vision. It had originally been envisaged that the GR17/45 would be operated from Escort carriers, but the composition of the peacetime fleet made it inevitable that they would now be operated from Light Fleet carriers during peacetime and the initial phases of any future war. It was possible that these ships might suffer heavy losses in wartime, and to insure against this it was judged necessary to have aircraft capable of operating from hastily constructed Merchant Aircraft Carriers. To safeguard against this wartime eventuality, the GR17/45 take-off requirement would have to be met, but if this proved impossible, armament or equipment load would have to be reduced.

CNR and DCNR then raised a number of the points made by Fairey in their Brochure and Memorandum of the 15th July. The limitations imposed on operations from the existing Light Fleet carriers by their lift capacity, arrester gear limitations and deck strength were noted, and it was emphasised that any further increase in take-off weight was most undesirable. They emphasised that the firms were very reluctant to allow further weight increases which would result in an underpowered aircraft. Fairey's idea of a split role aircraft was then put to the meeting, but DAW rejected it as unacceptable. He pointed out that although the aircraft could operate at a 16,000 lbs. take-off weight with the search equipment only, it would be difficult to rapidly remove this under operational conditions. Consequently, the only weight reduction possible in the strike role would result from the absence of the sonobuoys, marine markers and the third crew member.

DAW then stated that he would welcome information on any aircraft that could meet the GR17/45 specification and which would come into service appreciably before the existing GR17/45 designs. In the ensuing discussion the Sturgeon and the Spearfish were ruled out on grounds of excess weight, and the Seagull because of the major structural alterations that would be involved. The Barracuda was eliminated when it was discovered that all the production jigs had been destroyed. It was concluded that any converted anti-submarine aircraft was unlikely to be available before the Griffon engined Blackburn GR17/45, and DAW indicated that he would prefer to use the Firefly as an anti-submarine aircraft in the interim.

Production of the three-seater GR17/45 design was then discussed. It was reported that the addition of the third crew member was unlikely to delay production deliveries of the Blackburn design, but Fairey would incur considerable delays because of the extensive structural changes they proposed making to their design. DAW indicated that if necessary he was prepared to accept the first thirty or forty aircraft as two-seaters if it would permit more rapid production of the type.

A four point plan of action emerged from this meeting. Its components were:

(i) The Naval Staff should re-examine the GR17/45 requirement to see if they could accept a reduction in endurance, or weapon load, or operational equipment, which would in turn reduce the normal take-off weight.

(ii) Blackburn should complete their first two prototypes as two seaters and their third as a three seater.

(iii) Fairey would also complete their two prototypes as two-seaters, but build a third, three-seater fuselage which could be fitted to one of the two-seater prototypes later.

(iv) Both firms would use the two-seat versions to evaluate the handling and aerodynamic characteristics of the designs. Tactical evaluation of the three-seater versions would follow later.[1]

Three major premises underlay much of this discussion. The first was that it was prudent to base the take-off limitations imposed on the type upon a scenario describing the possible course of a future war, rather than the limitations of the existing and likely future peacetime carrier fleet. Second, the addition of a third seat seems to have been tacitly accepted as a firm requirement. Third, the placing of a fully equipped anti-submarine aircraft into service was now seen as an urgent task. There is no direct evidence to link this with the start of the Berlin Blockade in June, 1948, although the USSR had by now become established as the Royal Navy's potential enemy. This is illustrated by the briefing given to the Fairey directors by the Londonderry Anti-Submarine School when

> 'It was stated that the Russians are known to have over 300 ex "U" boats plus an unknown quantity of later type submarines. ... Tactics have to be designed to cope with either type.'[2]

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1. Files C and D. Minutes of Meeting called by CNR on recent staff proposals to include a second crew member in the GR17/45 aircraft, 19.7.48.

2. Summary of discussion with the staff of the Anti-Submarine School, Londonderry, op. cit., p. 2.

The formal review by the Naval Staff of the GR17/45 requirement proceeded rapidly, and by early August, DCNR (A) was able to notify the MoS of the result. It had been agreed to make three major changes in the requirement. The first of these was to reduce the normal endurance from four to three hours, the overload endurance with external drop tanks being an additional one and a half hours. The second was that only four sonobuoys and three marine markers would be carried in addition to the homing torpedo, and in all other cases the combined weapon, sonobuoy and marine marker loads would not exceed 2,000 lbs. The third was that assisted take-off would be accepted as a standard practice.[1]

Fairey submitted their detailed proposals for a three-seat GR17/45 aircraft in mid-August. These involved moving the ASV scanner backwards 5 inches to provide sufficient room for the rear cockpit and increasing the length of the bomb-bay to enable most of the strike weapons to be carried within it, thus reducing drag and improving performance.[2] Almost simultaneously, they were informed of the concessions the Admiralty had made in respect of the original GR17/45 requirement.[3]

Although clear decisions had been taken on the majority of the outstanding issues surrounding GR17/45 at the CNR/DAW level, and the firms had been informed about them, this requirement and the designs based upon it were placed on the agenda of the 24th meeting of the Sub-Committee for Naval Aircraft Design, chaired

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1. Files D and E. Minute for DCNR (A) 11.8.48.
2. File E. Letter from Fairey to MoS 15.8.48.
3. File C. Letter from MoS to Fairey 18.8.48.

by the Fifth Sea Lord. In preparation for this, a further meeting was convened by CNR on the 9th September 1948, to consider future policy for meeting the requirements for an anti-submarine aircraft. The bulk of this discussion was concerned with finding an interim anti-submarine aircraft, but it was also reported that a major operational limitation had been uncovered in the GR17/45 designs. When the bomb-bay doors were opened, the ASV scanner positioned behind them would be blanketed for an estimated period of 30 seconds. During this period, the aircraft would have covered a distance equivalent to the range at which the ASV 15 could detect a submarine's schnorkel. This would make an attack on a schnorkeling submarine with internal stores very difficult, and implied it could only be attacked after it had dived, when sonobuoys could be used to fix its position.

Considerable confusion still existed over the status of Zeta, whose inclusion in the original specifications was blamed for this unsatisfactory positioning of the ASV scanner behind the bomb bay. DAW indicated he believed it would be ready by 1951, but others thought 1955 a more likely date.

A consensus emerged from this meeting that the first squadron equipped with GR17/45 aircraft was unlikely to be operational before the summer of 1951. It was also noted that the need to choose between the two types and hold competitive trials made any improvement on this timetable improbable. CNR than suggested that the result of these deliberations was that the Navy would receive in three years time an unsatisfactory aircraft. This proposition was discussed, but DAW confirmed that the revised Staff Requirement would stand.[1]

The 24th Meeting of the Sub-Committee for Naval Aircraft Design discussed both the proposal to add a third crew member to the requirement, and the ability of the GR17/45 designs to operate from the existing Colossus class Light Fleet carriers. Examination of the operational effectiveness of the designs as anti-submarine aircraft was adjourned to a later meeting on the 7th October. The meeting was informed that the landing weight of the Fairey design with Zeta and one hour's fuel was estimated by the MoS to be 15,800 lbs. The Fifth Sea Lord asserted that a landing - weight greater than 15,500 lbs. was unacceptable. DAW then put forward Fairey's proposals that the anti-submarine aircraft should operate either in a search or a strike mode. It was suggested that if this was to be accepted, it might be preferable to retain the existing two-seat design. The Fifth Sea Lord ruled that nobody present was fully qualified to decide this issue, and directed that a full investigation be made of both the two and three seat GR17/45 requirement, in collaboration with the Assistant Chief of the Naval Staff. In the interim, work on the three seater designs was to continue.

The meeting then moved to a discussion of an interim anti-submarine aircraft, but later returned to the issue of GR17/45 landing - weights. The Fifth Sea Lord stated that the First Sea Lord had expressed concern that the Navy did not appear to

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1. File D. Minutes of Meeting held 8.10.48 to consider the future policy for meeting the requirements for an anti-submarine aircraft, paras 3 and 4.

have an anti-submarine aircraft in prospect which could operate from all types of carriers, and had requested that he give him a specific assurance that the GR17/45 aircraft would be able to operate from unmodified Colossus class carriers.

The meeting was told that the limitations of these carriers were 18,000 lbs. take-off weight, and 15,500 lbs. landing-weight at 60 knots entry speed. The figure of 15,800 lbs. landing - weight for Fairey's design was only an estimate and no hard information existed as to whether landing - weights of the GR17/45 designs would be less than or greater than 15,500 lbs. In the light of this statement, the Fifth Sea Lord directed DAW to prepare a Staff Requirement for an aircraft with better seating arrangements than the proposed three-seater GR17/45, and with take-off and landing-weights that would allow it to operate without any shadow of doubt from Escort carriers.[1] The future of the GR17/45 designs now seemed to be very uncertain.

The Agenda for the next meeting of the Sub-Committee for Naval Aircraft Design consisted of two items. The first was whether the revised staff requirements would produce an acceptable anti-submarine aircraft; the second whether it was worth converting the Short Sturgeon into an anti-submarine aircraft.[2]

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1. File H. Minutes of the 24th Meeting of the Sub-Committee for Naval Aircraft Design held 10.9.48 (extract in File E). It is unclear whether the Escort carriers referred to in this context were the wartime ones or the Colossus class Light Fleet carriers.

2. File H. Agenda of the 25th Meeting of the Sub-Committee for Naval Aircraft Design held 7.10.48 (Extract in File E).

As a result of this meeting, it appears to have been decided that the GR17/45 three seat designs should continue to be developed.

At the end of October, the deteriorating international situation exercised its first direct influence upon the GR17/45 programme. CNR felt that the existing prototype plans did not offer a design capable of being placed into immediate production should the threat of active hostilities intensify. He convened a meeting in mid-November to discuss possible changes in the prototype plans to enable prototype testing to be carried out at the earliest possible date.[1] It was stated at this meeting that the changes in the GR17/45 requirement had made it feasible for the designs to be operated from Light Escort and Light Fleet carriers.[2] This was a product of the removal from the original requirement of 800 lbs. of equipment and the endurance corresponding to 1,200 lbs. of fuel, which reduced estimates of normal take-off weight to below 17,000 lbs. The consumption of 2,000 lbs. of fuel would then allow the aircraft to land at a weight of 15,000 lbs. the maximum permissible landing-weight for these types of carriers.

Fairey's request to be allowed to build a complete third prototype instead of just a three-seater fuselage was then considered. This was agreed to as it was felt that the additional expenditure on wings and engines would be small, the total airframe costs for such a third prototype being estimated at £50,000.[3]

1. File C. Minute by AD/RDN 28.10.48.

2. It is again unclear what was meant by a Light Escort carrier in this context. It may merely have referred to a Colossus class carrier being used in an escort role.

3. Files D and E. Minutes of meeting to discuss the prototype programme for the GR17/45 aircraft 15.11.48.

While these discussions had been proceeding between the Admiralty and the MoS, Fairey and Blackburn had been engaged in planning the production of their three-seater prototypes. Fairey wrote to DMARD on the 20th October to inform him of their plans. They were currently engaged in building a mock-up three-seater fuselage which was almost complete. They then planned to build a fully equipped three-seater fuselage which would be available by September 1949.[1] On the 29th October these plans were approved by the Ministry, but on the same day the firm wrote to the Ministry presenting a case for building a complete three-seater prototype. They stated that there would be significant time savings if a complete aircraft was built, and this might be important in view of the priority the Admiralty assigned to the type. They also argued that their past experience suggested that the time needed for testing a new type of aircraft was directly related to the number of prototypes available, and that the existing order for two prototypes was too small.[2] The decision of the meeting on the 15th November to agree to this request resulted in Fairey being told officially on the 17th that they should plan to build a complete three seater prototype, but that before a contract could be let for this, they would have to submit a cost estimate.[3]

Confirmation of the Admiralty's positive interest in a Griffon powered version of the Blackburn design was provided

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1. File C. Letter from Fairey to MoS 20.10.48.
2. File E. Letter from Fairey to MoS 29.10.48.
3. Ibid. Letter from MoS to Fairey, 17.11.48.

by a summary of the GR17/45 programme prepared early in November. The preamble to this stated that a Griffon powered version of the Blackburn aircraft had become more attractive as a result of the addition of a third seat to the requirement. Such an aircraft was likely to be 1,000 lbs. lighter than the Fairey Double Mamba version and 500 lbs. lighter than the Blackburn Naiad version. To illustrate this point, the following table of weights and performance was appended.[1]

	Take-off weight (lbs)	Take-off distance in 17-knot wind (ft)	Approach Speed (knots)
Blackburn Naiad	16,860	440	83
Blackburn Mamba	16,432	450	82
Blackburn Griffon	16,350	365	82
Fairey Mamba	17,480	430	70.5

This summary of the GR17/45 position seems to have represented an interim stage in the investigations into the landing weights of the GR17/45 designs. The final report on this was completed in mid-December, and was very inconclusive. It contained three different assessments based upon alternative assumptions, and leading not unnaturally to three differing conclusions. The first assessment was an impressionistic one. This stated that as an interim guide, the performance of the Fairey Mamba and Blackburn Naiad would be about equal, the Blackburn Mamba would be inferior to these, and the Blackburn Griffon was likely to be the worst. The second assessment was of the performance of the aircraft carrying a full strike load, but with a reduced fuel load such as to allow the aircraft to take off within 450 ft.

1. File D. Summary of GR17/45 position 11.11.48.

This resulted in the following table:-

	Take-off weight (lbs)	Endurance (hrs)	Landing -weight (lbs)	Approach speed (knots)
Blackburn Naiad	17,233	2.3	16,374	82.5
Blackburn Griffon	16,559	1.6	16,225	82
Blackburn Mamba	16,896	2.4	15,884	81.5
Fairey Mamba	17,333	2.35	16,233	75

The third assessment was to assume the use of rocket assisted take-off, and a take-off weight of 17,500 lbs. including a full strike load of 2,418 lbs. The resulting endurance of the aircraft would be 2.75 hrs. for the Blackburn Naiad, 4.5 hrs. for the Blackburn Griffon, 3.25 hrs. for the Blackburn Mamba and 2.75 hrs. for the Fairey Mamba.[1] Any assessment of the superior aircraft was dependent upon a prior weighting of the qualities demanded of an anti-submarine aircraft, such as endurance, take-off weight, take-off distance, landing-weight and landing speed.

The Second Issue of the GR17/45 requirement, which incorporated the third crew man and the concessions on equipment weight, strike load, endurance and take-off was published on the 16th December 1948.[2] This left only two issues related to the GR17/45 prototype programme unresolved. These were the completion of a contract for the Fairey three-seater prototype and the choice of an engine to power the second Blackburn prototype, which was also their first three-seater prototype. DMARD had estimated the likely cost of a third Fairey prototype at

1. Files D and E. Minute 14.12.48.

2. File C. Naval Staff Requirement NR/A9 Issue 2 - Registry date 16.12.48.

£50,000, but in late January the firm provided their own estimate of £300,000. The magnitude of this figure was stated to be a product of an agreement reached between the firm and the Director of Contracts in connection with the GR17/45 and other aircraft. The most likely explanation was that Fairey was using this new contract to try to recoup some of their own money which had been spent on the two seat versions of the aircraft.

This estimate seems to have confronted the MoS with a major problem, as DMARD felt they could not agree to the expenditure of £300,000 on one prototype. Unfortunately the production of this three-seater version was deemed necessary in order to obtain an effective competitive evaluation of the Fairey and Blackburn three-seater designs. It was eventually agreed that financial sanction would have to be obtained for this expenditure, but in the meantime the Director of Contracts was instructed to try to obtain a reduced estimate from the firm.[1] This demand for a revised estimate was reinforced by the comparable cost figures submitted by Blackburn for converting their second and third prototypes to three seaters. These totalled £27,925.[2] The Ministry's attempts to revise Fairey's cost estimates resulted in the contract for the third Fairey prototype remaining unsigned until the 28th June, 1949. Throughout the intervening period, the firm promised delivery of the third prototype eight

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1. File C. Minute dated 22.1.49.
2. File L. History of cost of Blackburn GR17/45 design changes 18.11.48.

months after the date of receipt of contract. In November 1949, however, Fairey informed the Ministry that their target date for delivery of the third prototype was June 1950. The Ministry queried this in the light of the previous assurances, and were told that the firm had added a three month reserve to their original estimate in case flight testing of the two-seaters indicated that changes might be necessary in the three seater.[1]

Finally, it had been assumed for some time that the second Blackburn prototype would have an operational Griffon installation, and work had been proceeding since November 1948 on this basis. The formal decision to go ahead with this was taken at a meeting of the Sub-Committee for Naval Aircraft Design in February 1949.[2]

vi. The search for an interim anti-submarine aircraft, 1948-1949.

In the course of meetings of the Airframe Research and Development Programme Committee in 1945 and 1946, the GR17/45 requirement had been described as serving both as a Swordfish and Barracuda III replacement. These aircraft had been operated from Escort carriers during the wartime period, but by the end of 1945 both had been retired from operational squadrons, and no replacement anti-submarine aircraft had been made available to the Navy. When the international situation started to deteriorate in mid-1947, the Naval Staffs realised that it

1. File C. Minute 1.11.49.

2. File H. Meeting of Sub-Committee for Naval Aircraft Design 10.2.49 (excerpt in File D).

would be at least 1950 before the GR17/45 could come into service and they could start to build up an effective carrier borne anti-submarine force. It was also realised that the Navy had little knowledge or experience of the operational problems of airborne anti-submarine warfare and the new detection techniques that were available. This led to a search for suitable aircraft to bridge the gap until the GR17/45 arrived in service, and the initiation of a programme to develop the techniques needed to undertake effective airborne anti-submarine warfare.

One of their first moves was to commission the Naval Air/Sea Warfare Development Unit at RAF Thorney Island to carry out trials with a three-seat Barracuda III, which had been modified to represent a possible two-seat anti-submarine aircraft. It was configured to carry twelve sonobuoys, two homing weapons and a mock-up of an ASV 13 radar installation.[1] The official reason given for the trials was that pending the introduction of two-seat anti-submarine aircraft into the Navy, a requirement existed for an interim aircraft of this type both for training aircrew and examining the problems likely to be encountered in future two-seat anti-submarine aircraft.

Several conclusions emerged from the trials. It was felt that such a conversion would result in an acceptable, but not ideal anti-submarine aircraft. Major structural alterations would probably be necessary if a working ASV 13 radar set

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1. The Barracuda III had originally been fitted with ASV 10 radar equipment. Thetford, op. cit., p. 149.

and scanner was to be fitted: the alternative of installing the United States ASH radar in a wing pod precluded the carriage of the two homing weapons.[1] The Admiralty's next move was to form an operational carrier borne anti-submarine squadron during December 1947. This was 815 squadron, based at Eglinton in Northern Ireland, where it formed an integral part of the Londonderry anti-submarine school. This squadron was equipped with Barracuda III aircraft retrieved from 744 training squadron.[2]

The search for an interim design that could be produced in quantity did not gather momentum until July 1948. The context for this was the continued uncertainty over turbine engine development times, and the proposal to add a third crew member to the GR17/45 requirement, which was likely to further delay its entry into service. At a review meeting on the GR17/45 in that month, DAW stated he would welcome any aircraft which remained within the GR17/45 weight limitations, could perform the anti-submarine role and which would come into service appreciably before the GR17/45 designs. The Sturgeon, Spearfish and Seagull were considered, and then rejected, either on grounds of weight or the need for extensive structural alterations. The Barracuda III was suitable, but had to be eliminated when it was discovered that its production jigs had been destroyed. Two differing views on an interim aircraft emerged from this meeting.

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1. File J. Report No. 516/47 of Naval Air Sea Warfare Development Unit, RAF Thorney Island. 27.10.47. Trial No. 125/NASWDU/28 - Barracuda III as a two seat anti-submarine aircraft.

2. Thetford, op. cit., p. 152.

DAW felt that the extensive design changes that would be necessary to produce an interim anti-submarine aircraft from an existing aircraft made it imperative to use the existing Firefly IV as an interim anti-submarine aircraft. AD/RDN on the other hand seemed to favour the rapid development of the Griffon engined Blackburn GR17/45 design to fill this gap.[1]

One product of this meeting was that preliminary investigations were started to see if the Firefly IV could be adapted for use in a specialised anti-submarine role. Its existing ASH wing-mounted radar had very poor detection capabilities against submarine schnorkels, and it was suggested that it would need to be replaced by either a fuselage mounted ASV15 or ASV13 radar set.[2] The capabilities of the existing ASH installation in the Firefly had already been discussed by the Fairey directors in their visit to Londonderry in July. They reported that it had proved impossible to work up to an acceptable level of efficiency with Firefly IV's fitted with this equipment. Its detection range was very small and before the radar sighting of the submarine could be transferred to a visual one, the target had disappeared into the pilot's 'blind' area underneath the engine cowling. The pilot then had to start manoeuvring the aircraft to gain contact, and this usually

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1. File D. Minutes of meeting to review the position of the GR17/45 in the light of recent staff proposals to include a third crew member, 19.7.48.
2. File K. Minute N/A/DCD to D.D.CD. (2) 12.8.48.

resulted in the pilot either failing to sight the target, or giving it adequate time to submerge.[1]

A further meeting to discuss possible interim designs was held in early September.[2] At this, the Director of Aircraft Equipment (DAE) pointed out that in a few years, the Navy would be equipped with aircraft carriers capable of operating aircraft with a 30,000 lbs. take-off weight.[3] This stimulated a discussion on whether the Navy should plan to produce two types of anti-submarine aircraft. One could be of limited size and weight and capable of operating from Escort carriers, but would have a relatively poor search and strike capability. The other would be fitted with the best search and strike equipment available, but could only be able to operate from the larger Fleet carriers. It was agreed that in principle this was an attractive and valid concept.

It was against this background that the meeting moved on to discuss a proposal for converting the Short Sturgeon into an interim anti-submarine aircraft. This aircraft had been designed in 1943 as a twin-engined bomber-reconnaissance type, with the intention that it would operate in the Pacific theatre from the Fleet Carriers then under construction. At the end of the Pacific War a new specification had been written around the design

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1. Notes of discussion with the Staff of the Anti-Submarine School, Londonderry, op.cit., p. 5.

2. File D. Minutes of Meeting held 8.9.48 to consider the future policy for meeting the requirements for an anti-submarine aircraft.

3. This was presumably a reference to the carriers of the Audacious and Hermes classes.

to convert it into a target tug.[1] It was now proposed to modify the nose of the original design to accommodate two crew members and an ASV 15 radar set, and re-engine it with two single Armstrong Siddeley Mamba Turboprops. The general consensus was that it would result in a good anti-submarine aircraft, but one that was very heavy, though it was believed that this aircraft could be operated from modernised Light Fleet carriers, and possibly even unmodernised ones.[2] Modernised Light Fleet carriers would not be available before 1952 and DAW ruled that any interim aircraft had to be able to operate from unmodernised Light Fleet carriers. This made the modified Sturgeon unacceptable as an interim anti-submarine aircraft unless the Admiralty were prepared to accept the limitation that it could only be operated from the large Fleet carriers then under construction. In the meantime, it could be used for training and evaluation of anti-submarine techniques. Its major attraction was that it was possible that production deliveries would start approximately two years before those of the GR17/45.

This discussion led to an agreement that the anti-submarine

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1. For a history of this aircraft see C.H. Barnes: Shorts Aircraft since 1900, Putnam 1967, pp. 413-419.

2. Precisely what was understood by a 'modernised Light Fleet carrier' in this context is unclear. With one exception, none of the Navy's Colossus class carriers underwent anything other than routine refits during their operational career. The one exception was Warrior, but her 'modernisation' in the early 1950s was in practice little more than an extensive refit.

version of the Sturgeon should be examined in detail by the MoS with a view to its adoption by the Navy as an interim anti-submarine aircraft. It was emphasised that such a decision would have to be taken in the full knowledge that the aircraft might only be capable of operating from large carriers. It was agreed that this investigation was to be given the highest priority and to have precedence over work on the N40/46 Naval Night Fighter aircraft.

In the course of the meeting, a brief discussion occurred on the development of a three-seater Firefly with fuselage mounted ASV as an interim anti-submarine aircraft. It was pointed out that the structural changes necessary to incorporate this equipment made it unlikely that production deliveries could commence within two years. This led to the Chairman ruling that no further consideration was to be given to this type of Firefly variant. This left the Firefly V, a version of the Firefly IV with cannon armament removed as the only possible interim aircraft for Escort carrier operations, and it was decided that production of these ASH equipped Firefly Vs should continue. As a consequence of this decision, Fairey were informed later in the month that the Admiralty was no longer interested in the Firefly VI with a fuselage mounted ASV 15 radar set.[1]

These issues were considered afresh at a meeting of the Sub-Committee for Naval Aircraft Design held two days later. CNR, Vice Controller (Air) in the Third Sea Lord's Department, initiated the discussion by stating that three conversions of

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1. File K. Letter from MoS to Fairey, 24.9.48.

existing designs had been considered as alternatives to the initiation of a three-seat GR17/45 requirement. The first of these was a redesigned Firefly with three seats, which had been rejected as quite impractical. The second was the Seagull, but it had been found that this aircraft could not carry a search-radar set. This left the Sturgeon as the only other alternative. It was hoped to reduce the weight of this design so that it would have a normal take-off weight of 20,000 lbs. and a landing-weight of 16,800 lbs. The only anti-submarine weapon it could carry would be depth charges, as it could not be easily altered to take Zeta, but it would be suitable for search operations. DAW stated that the prototype of a Zeta type anti-submarine weapon was not expected to be available until 1952, and implied that the Sturgeon's strike deficiencies were not serious. Doubts were expressed about the utility of such a large aircraft, but it was agreed that it was the only possible interim design available despite its serious limitations. The Committee then confirmed the earlier decision that a detailed examination of its anti-submarine capabilities should be undertaken in conjunction with the MoS.[1]

This investigation proceeded rapidly during October, and it was confirmed that the armoured Fleet and modified Light Fleet carriers could operate aircraft with normal take-off weights of 20,000 lbs. The critical issue then became whether the limited amount of fuel, weapons or search equipment the aircraft

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1. File H. 24th Meeting of the Sub-Committee for Naval Aircraft Design, 10.8.48 (excerpt in File E).

could carry at this weight made it useless as an operational type.[1]

The issue was placed on the Agenda of the 25th Meeting of the Sub-Committee for Naval Aircraft Design in early October,[2] but due possibly to a failure to complete the detailed investigations in time, no decision was taken until a meeting of the Committee early in December. In the interim, the proposal was considered at a lower level at a meeting called by CNR in mid-November to discuss the prototype programme for the GR17/45 aircraft. It was stated that although the weight of the Sturgeon was high, the layout was very attractive, as the two equipment operators were together in a large fuselage cabin and the nose mounted radar eliminated the bomb-bay door blanketing problem likely to be experienced with the GR17/45 designs. Short's 18 month production forecast would also enable it to fill the gap which would exist before the entry into service of the GR17/45 aircraft. Scepticism was expressed about this production estimate, with two years being given as a more realistic figure. The aerodynamics of this new version would also be different from the existing aircraft, and prototype trials might be required before production could commence.

It was agreed that because of these doubts, no decision could be taken until the firm's design and production capacity

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1. File D. Undated Minutes from DCNR placed at October 1948 in file.
2. File H. Agenda for 25th Meeting of Sub-Committee for Naval Aircraft Design. 7.10.48. (excerpt in File E).

had been investigated, and wind tunnel tests had been done on the likely aerodynamic qualities of the modified design.[1] It was noted that Short were in the process of transferring the centre of their activities from their Rochester works to Belfast, which would cause dislocation to their design and production work, and made assessments of their capacity difficult.[2]

In mid-December, the Sub-Committee on Naval Aircraft Design held a special meeting to make a decision on whether to order the Sturgeon anti-submarine conversion into production.[3] They had before them a paper tabled by CNR setting out the main characteristics and estimated performance of the Sturgeon anti-submarine aircraft and the Fairey and Blackburn GR17/45 designs. It was rapidly agreed that the Sturgeon conversion could not be quickly produced, and was unlikely to be able to fill much of the gap that would exist before the Fairey or Blackburn GR17/45 aircraft arrived in service. The most optimistic estimate available suggested that it might be in service six months before the GR17/45. It would only be operable from a minority of carriers because of its high take-off weight, and could not be regarded as directly comparable or competitive with the other types. Because of these factors, the First Sea Lord had made it clear that the Board of the Admiralty was not prepared to place an immediate production order for the type, nor was it likely

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1. File D. Minutes of Meeting to discuss the prototype programme for the GR17/45 aircraft 15.11.48.

2. Barnes, op. cit., pp. 31 and 32.

3. File H. Minutes of Meeting of Sub-Committee for Naval Aircraft Design called to consider the need to order prototypes and production of the Sturgeon converted as an anti-submarine type 20.12.48 (excerpt in File D).

that it would be ordered into production at a future date.

A lengthy discussion then ensued on whether an experimental prototype of the Sturgeon conversion should be produced. It was agreed that there was general ignorance within the Navy on the best equipment and tactical methods to be used for fighting and killing submarines. The Sturgeon layout, with its three crew and radar scanner forward of the wing appeared to possess many advantages over the GR17/45 layout. Apart from the development need, a prototype of the Sturgeon conversion would also offer a long term insurance against the complete failure of both the Blackburn and Fairey types. It was reported that the MoS was technically in sympathy with such a proposal, though they felt there was no evidence to suggest that either the Blackburn or Fairey aircraft would be failures. It was also noted that CS(A) had given provisional approval for the inclusion of this prototype expenditure in the December review of his Aircraft Research and Development Programme. It was concluded that there was a good case for ordering prototypes of the Sturgeon conversion for anti-submarine development work, and CNR was deputed to write to CS(A) asking him to order two prototypes.

This decision meant that the Sturgeon had been rejected as an interim anti-submarine aircraft. The only interim aircraft now available was the ASH equipped Firefly which was already in production. This two-seat aircraft had major operational deficiencies, and to alleviate some of them it was now suggested that a three seat version equipped with ASH should be examined, despite such a design having earlier been branded as impractical.

The origins of this proposal are rather obscure, for the Fairey design brochure gives the impression that it was their idea, while the Admiralty representatives in the MoS seemed to see it in terms of a project to make use of the new British sonobuoy equipment that would soon be available. Fairey's 'proposed Firefly anti-submarine Mark 6 three-seater aircraft' was 'a proposal whereby Firefly Marks 4 or 5 can be converted into a three seater, carrying all the necessary equipment, including British sonobuoys, for use as an interim anti-submarine aircraft.'[1] They argued that their 'proposal had considerable value in making available an interim type of anti-submarine aircraft for training and operational use, which will fill the gap until such time as the GR17/45 becomes available in service.'[2] The brochure emphasised both the fact that this was a conversion involving the minimum of effort, and that it could quickly be produced. 'The value of this conversion lies in the shortness of time required for its introduction. We therefore stress the point that it should be regarded as a conversion and as an interim and the minimum amount of change should therefore be our objective.'[3] 'It is estimated that provided an almost immediate start can be made and that Rolls Royce programme is fulfilled, squadron strength of this Mk 6 may be expected by

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1. RAFM AC-73/30 (41/c/3), Fairey Aircraft Data. Brochure dated February, 1949: Proposed Firefly Anti-Submarine Mark 6 three-seater aircraft, p. 1.

2. *Ibid.*

3. *Ibid.*, p. 6.

July 1950 ... (i.e.) 25 aircraft off the production line ... (the) first prototype should be ready at the end of eight months, with other prototypes, if required, following at six week intervals ... a further eight months from the first prototype should see 25 aircraft off the production line, thus making a total time to this stage of sixteen months from the word "go".'[1]

The proposals contained in the brochure were discussed at a joint meeting between Admiralty, MoS, Fairey and Rolls Royce representatives early in February.[2] It was stated that a three-seater version of the Firefly 5 was being considered for anti-submarine purposes, in order to place British sonobuoy equipment in service as soon as this was available. It would also be needed as a substitute for the heavier GR17/45 for operations from Light Fleet carriers should there be a delay in the modernisation of these carriers. It was emphasised that modification of the existing aircraft, rather than a redesign, was necessary because of the need to introduce it into service as quickly as possible. Because of this, the ASH radar was acceptable as the main search equipment. The Admiralty's tentative requirements were then outlined. These were:

(a) that the aircraft was to have three crew, and be capable of carrying full British sonobuoy equipment and ASH radar;

(b) that it would have a maximum landing-weight of 13,000 lbs. with full sonobuoy load and one hour's fuel remaining and

(c) that it should be in squadron service by mid-1950.

It was confirmed that the new sonobuoy equipment would be

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1. Ibid., p. 8.

2. File L. Minutes of Meeting on proposed three seater Firefly, 7.2.49.

ready in mid-1950, with first production items being available at the end of 1949. Fairey's representatives stated that the aircraft was basically a Firefly V with a Barracuda V pattern power plant. This had chin type radiators, which would replace the leading edge type in the Firefly V.[1] The other change was an enlargement of the rear cockpit so that it could take a third crew member and the sonobuoy equipment. It was proposed to use a Griffon 57 as the engine, which would drive a single propeller.

Some doubts were expressed about the availability of Griffon engines to sustain the planned production rate. The tentative programme was for ten engines in January 1950, and 14 a month thereafter. Rolls Royce were confident that these schedules could be achieved if production orders were placed quickly. Fairey's prototype proposals were that a Firefly FRMK1 should be fitted with a mock-up rear cockpit hood and a Barracuda V, Griffon 37 powerplant for initial handling trials. One or more prototypes of the Firefly V conversion would follow, fitted with Griffon 37 engines if the 57 was unavailable for initial trials. They estimated that the first converted Firefly V prototype would be ready after eight months, and 25 aircraft should

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1. A chin type radiator is one fitted immediately below the engine. A leading edge type is situated at the front of the wing, usually close to the fuselage. There is no evidence to indicate why it was decided to change back to the chin arrangement for this conversion, rather than retaining the existing leading edge designs. Fairey should have been aware that they had abandoned the chin arrangement in 1943 when the Firefly Mk 4 was being developed, because of the unsatisfactory flight characteristics produced by this type of radiator - see Thetford, op. cit., p. 164.

have been produced at the end of another 8 months. This implied initial prototype trials by November 1949, and squadron service by July 1950.

This meeting is especially significant for the comments made about the capabilities of the GR17/45 designs. It was overtly admitted for the first time that the GR17/45 designs were incapable of operating from either Escort or unmodified Light Fleet carriers, and that the converted Firefly was needed to perform their intended role.

The sense of urgency which had permeated the discussions on naval anti-submarine aircraft from September to December 1948 had become dissipated by March 1949, for despite the apparent urgent need to place the new mark of Firefly into production as an interim anti-submarine aircraft, action to convert plans into production orders was lacking. Three possible reasons account for this. One was that the Berlin situation appeared to have stabilised, the blockade being lifted early in May 1949. The second was that although expenditure on defence production rose by nearly one third to over £200 million in 1949 and 'the air force and navy were given priority'[1], the Navy was embarking on a very expensive aircraft production programme consisting of the Attacker and Sea Hawk jet fighters and Wyvern turbo-prop attack aircraft, besides trying to modernise its carrier force. Money was scarce, and production of the glamorous initial jet fighters had priority over more mundane piston engined interim anti-

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1. Bartlett, op. cit., p. 49.

submarine aircraft. The third element was that 'the major economic crisis of 1949, with the consequent devaluation of the pound in September, forced the government to cast a critical eye over defence spending yet again.'[1]

The rate of progress of the Firefly VI project can be judged by the frequency of meetings on it during 1949. Six weeks after the initial meeting of early February, a meeting was convened to discuss the engine and propeller arrangements for the aircraft. This merely confirmed the Fairey proposal that a single propeller and the Griffon 57 engine be fitted to the aircraft.[2] In mid-April 1949, it was decided that the aircraft would be known as the Mk VII and not VI,[3] while in mid-June 1949, the Naval Staff produced a formal Staff Requirement for the aircraft. This was NR/A28, the MoS specification being M101D.[4] The functions of this aircraft were

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1. Ibid., p. 50.
2. File L. Minutes of Meeting on Engine and Propeller arrangements for Firefly VI, 21.3.49.
3. Ibid., Minute from RDM 14.4.49. The Firefly VI designation was reallocated to a variant of the Firefly V which had the cannon armament removed, and was specifically equipped for anti-submarine duties.
4. At some point in early 1949, the MoS changed their system for listing specifications, adopting in its place a cumulative system starting at 100. The prefix letters were also modified, the old GR being replaced by M for Maritime Reconnaissance, and a new designation ER for Experimental Research being introduced. Suffix letters were also added to indicate the stage of development reached by the design, P being Production standard and D indicating an aircraft, still at the design and development stage. M101D indicated a Maritime Reconnaissance type; the second requirement listed under the new system, and one which was still at the design and development stage.

identical to the GR17/45 specification, but the normal take-off weight was specified as less than 14,700 lbs. though it was stated that 15,400 lbs. was acceptable. Maximum landing-weight was to be 13,000 lbs. and endurance four hours. Two depth charges or two small homing weapons were to be carried as the strike armament.[1] This specification was amended in early September to include the carriage of two mines as alternative armament,[2] but it was the end of December 1949 before moves were made to submit plans for Firefly VII production to the Admiralty Board.[3]

In the interim, work had proceeded on the Firefly I conversion which was intended to replicate the external features of the Mark VII design. A meeting was held at the MoS in mid-December to discuss the results of these trials. This aircraft had been found to possess certain basic faults, but the meeting decided that these were not sufficient to justify delaying the placing of a production order until a fully representative prototype had been built and tested. It was recommended that the aircraft should go straight into production. Following this meeting, DAW proposed that the Admiralty inform the MoS that the Firefly Mark VII should replace the Mark VI on the Fairey production line in May, 1951. The total requirement was estimated

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1. File M. Naval Requirement A28 18.6.49. The Navy listed their aircraft requirements under their own cumulative system that had been started towards the end of the war. NR/A28 was the 28th aircraft registered under this Naval Requirement system.

2. Ibid. DNAW (Directorate of Naval Air Warfare) minute covering Amendment to NR/A28 6.9.49.

3. File N. Minutes of Meeting 12.12.49.

at 160 aircraft, and it was suggested that the initial order should be for 120, though if a cheaper unit price could be obtained by the MoS ordering the full 160, this recommendation could be considered.[1]

The financial basis for this estimated requirement for the Firefly VII was investigated in greater detail by the Naval Staff during December 1949, prior to an agreed recommendation being forwarded to the Admiralty Board early in January 1950. It was assumed that about £10 million would be available for the purchase of new aircraft in 1950/51, 1951/52 and 1952/53. The forward production programme for 1951/2 had provided for the purchase of 90 Firefly VI aircraft at a unit price of £20,268. The estimated cost of the Mark VII was £25,500, and this would only allow for the purchase of 10 Firefly VI and 63 Firefly VII during that financial year, if the original budget figure was to be retained. It had been planned to phase the Firefly VII out of production in 1952/53 in favour of one of the GR17/45 designs, and finance for only 50 Firefly VI had been written into the forward estimates. This would only provide for 40 Firefly VII, which meant that at the end of 1949, financial provision only existed for just over one hundred Firefly Mark VIIs.[2]

vii. The evolution of the Blackburn and Fairey GR17/45 designs, June 1948-December 1949.

The major issues which concerned the two firms' technical departments during the second half of 1948 and 1949 were the

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1. *Ibid.* Minute 31.12.49.
2. *Ibid.* Minute 31.12.49.

addition of a third crew member to the specification, and the continued uncertainties over the engine supply position. Once the take-off weight requirements had been relaxed with the issue of the revised specification, this ceased to be an issue of central concern to Fairey. Both designs had now been virtually frozen, and further problems would only be expected to arise once flight trials had begun. The one exception to this concerned the wing planform for the Blackburn aircraft.

In August, 1949, Blackburn wrote to the MoS informing them that acute centre of gravity problems were being experienced with their design, which might affect the handling of the aircraft during approach and landing. They pointed out that when the aircraft had originally been designed, it was intended that it should be powered by either the Twin Naiad or the much lighter Rolls Royce Tweed engine. It had therefore been necessary to accept that the Naiad version would have its normal centre of gravity as far forward as possible, and when the heavier Griffon engine had been adopted for the first prototype the resulting centre of gravity problem was resolved by adding 270 lbs. of ballast to the tail of the aircraft. The firm had gained the impression that the Griffon engined version of the aircraft might become the operational one when CNR had visited them a month previously, in which case the carriage of 270 lbs. of ballast in its tail would be unacceptable. In addition, they believed that the weight of the Twin Naiad engine and propeller might increase further. If this occurred, the centre of gravity of this version would also be too far forward, and

Blackburn proposed that they be allowed to revise the wing planform to eliminate this problem. This revision involved deleting the existing sweepback on the outer wing and increasing its dihedral. They asked for Ministry agreement to make this change;[1] and rapid agreement was obtained.[2] It was later confirmed that all three prototypes should have wings of this type.[3] Blackburn were given formal contract authority to produce these new wings in December 1948, but it was suggested that as the fitting of the Mamba engine to the design might bring the centre of gravity of the aircraft aft again, Blackburn should safeguard against this by producing one set of wings to the original design from components that had already been manufactured.[4]

The advisability of this precaution was confirmed in February 1949, when the Royal Aircraft Establishment produced a report on the anticipated stability of the Blackburn aircraft. This threw doubts on its stability with the new wing, and suggested that the original design was likely to be better. This resulted in agreement that wings of the original design should be fitted to the third Double Mamba prototype.[5] Blackburn themselves accepted the validity of this analysis in November 1949, when they abandoned the idea of producing the third set of revised wings and decided to replace them with a second set

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1. File D. Letter from Blackburn to MoS, 15.8.48.
2. Ibid. Minutes of Meeting, 31.8.48.
3. Ibid. Minutes of Meeting, 16.9.48.
4. Ibid. Letter from MoS to Blackburn, 11.12.48.
5. Ibid. Report from RAE and associated Minutes, 7.2.49.

of wings to the original design.[1] This basic design uncertainty cannot have increased the confidence of MoS officials in Blackburn's design expertise.

Although the take-off weight of the GR17/45 aircraft was no longer crucial after the changes in the requirement that occurred in June 1948, any further increases were likely to affect other aspects of the aircraft's performance. This became apparent in May 1949, when a detailed review was conducted of the progress of the Blackburn design. This disclosed that the weight of the Double Mamba version had increased by 776 lbs. since June 1948, mainly because of the need to carry more fuel to cope with increases in the estimated rate of fuel consumption. In part this was due to an underestimation of the drag of the aircraft, which meant that single engined cruising would only be possible once the weight had been reduced to a point between 16,800 lbs. and 17,300 lbs., depending on the external stores being carried. At higher weights, fuel consumption increased by 30% due to both engines being required to maintain height, and this reduced the endurance of the aircraft. It was hoped that increases in the power of the Double Mamba engine might cancel out this deficiency. Performance calculations related to these weight figures suggested that the aircraft would take-off in 545 ft. at a weight of 17,000 lbs., 650 ft. at 18,000 lbs. and 800 ft. at 19,000 lbs.[2]

The existence of these estimates suggests that all thoughts

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1. Ibid. Letter from Blackburn to MoS, 28.11.49.
2. Ibid. Review of Blackburn GR17/45 aircraft, 23.5.49.

of these aircraft being able to operate from the Escort carriers that had originally determined their design had by now been virtually abandoned. In addition, the calculations were based on the search equipment and strike weapon loads specified in the original requirement. The reduction of the combined strike and search load to 2,000 lbs. in mid-1948 seems to have been ignored, despite the fact that with the heaviest combination of this equipment and weapons the aircraft's endurance was estimated to be only 2 hours.

The problem of the endurance of the Blackburn design was highlighted by the figures in Table 1. This was produced in October 1949, as part of a review of the four major naval anti-submarine prototypes under development. No action was taken to encourage Blackburn to take steps to alleviate the problem.

Table 1

		Fairey GR17-Double Mamba	Blackburn GR17-Griffon 57	Blackburn GR17-Double Mamba	Short Sturgeon Conversion-2x Mamba 3
Strike case 3-3,090 lbs. of stores plus fuel for 3 hrs.	Take-off Weight	18,010	17,722	18,090	20,975
	Landing Weight	16,683	16,669	16,217	19,318
	Fuel	2,027	1,503	2,573	2,700
Search 1 case-1816 lbs. of stores plus fuel for $4\frac{1}{2}$ hrs.	Take-off Weight	18,250	17,731	17,999	22,061
	Landing Weight	16,015	16,001	15,549	18,922
	Fuel	2,935	2,180	*	4,450

*With full tanks, maximum endurance only $3\frac{3}{4}$ hrs.

The review also identified two factors as central to the choice between a Griffon engined and a Mamba engined anti-submarine aircraft. One was that although the Griffon engine used much less fuel than a gas-turbine, its high octane petrol presented major storage problems on carriers. The second was that a Griffon engine could be purchased for £5,000 but a Double Mamba would cost approximately £25,000.

viii. The Military Aircraft Development Programme, 1947-1949.

The decisions made during 1945 and 1946 on the main lines of military aircraft development, and the projects to be allocated to each of the aircraft firms, determined the development of military aircraft in Britain for the rest of the decade. The chief management activities from 1946 onwards were centred around initiating the projects programmed for succeeding years, and providing finance for the earlier projects which were starting to move into the heavy spending phase of their development cycle. These two activities proved at times to be mutually incompatible, and problems arose over the balance between design and development work. The desire to retain as many industrial teams in these two areas as possible often clashed with the need to keep within stipulated budget ceilings, while the increasing emphasis on development activities led to a lack of money both to maintain design teams in being and to start new projects.

These general problems started to have a significant effect upon the military aircraft development programme in the early part of 1947. A number of the 1946/47 projects had not been started due to lack of finance, while a number of new aircraft, such as a long range strategic bomber, had been added to the planned programme. The Admiralty had not yet produced the requirements for the advanced single-seat naval strike aircraft it wished Fairey to develop, but they had formulated a requirement for the naval night fighter which the MoS had assigned to Blackburn's design team.[1] This was NR/14A, MoS specification N40/46. Design work on the Fairey N16/45 strike fighter had been terminated in March 1947,[2] but Fairey had been designated as one of two possible design teams for the AOP helicopter project included in the 1947/48 programme.[3]

Confusion continued to exist in the planners' minds over the purpose of the two GR17/45 prototypes. Early in May 1947, the Blackburn version was described as a replacement for the Firefly IV in 1950, while the Fairey version was described as a Firefly V replacement, the implication being that both would go into service.[4]

Fairey had meanwhile been developing as a private venture a new defence concept, and in February 1947 presented to the MoS an unsolicited brochure 'setting out proposals for a specification for a Delta Wing Research aircraft.'[5] This related

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1. File A. Paper circulated within Directorate of Technical Development, Ministry of Supply, 11.4.47.
2. File D. Minute, 24.3.47.
3. File A. Airframe Research and Development Programme Committee: aircraft to be ordered during 1947/48, April 1947.
4. Ibid. Table contained in Minutes of Meeting of Aircraft Development Programme Committee, 1.5.47.
5. RAFM AC-73/30 (41/c/1) E10/47. Brochure dated 2.47.

to a project initiated in the spring of 1946 to investigate 'the problems associated with the vertical launch of aircraft.'[1] Proposals had been made for such a programme to the Director of Scientific Research in July 1946, 'but his view was that the initial stages of such a development might be hazardous, and should be explored by pilotless models.'[2] Fairey's new proposal was that 'a further contribution to the general problem could be provided by a simple form of aircraft arranged on a delta platform.'[3] This view was accepted by the MoS and specification E10/47 was drawn up and issued on the 13th September 1947, to cover a project to provide data on the aerodynamic characteristics of delta wing aircraft and the use of jet thrust as a means of control, as well as to conduct research into the problems of vertical launching.[4]

In June 1947 the original MoS work allocation plan was revised, and Fairey was asked to undertake a design study of the N40/46 night fighter, a project previously allocated exclusively to Blackburn, who had produced a brochure on their design in late 1946.[5] The initial requirement had been amended immediately prior to the request to Fairey, and both firms were asked to undertake a design study to meet the revised requirement.[6]

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1. Ibid., p. 1.
2. Ibid.
3. Ibid.
4. Ibid. Spec. E10/47 issued 13.9.47.
5. Jackson, op.cit., p. 527.
6. RAFM AC-73/30 (41/b/3) Misc. specs. 1940-46. NR/A14/N40/46/ 1st amendment 7.6.47.

The Blackburn design, known as the B74 was probably submitted late in October 1947.[1] The Fairey design, with two Rolls Royce Avon engines, a 25° wing sweep and radars in the nose and one wing tip was submitted in September, 1947.[2] No prototype orders were placed following these design studies, probably because of budgetary problems.

The need for defence economies led, in August 1947, to a review of the military aircraft programme aimed at eliminating some of the prototype programmes and reducing current and anticipated future expenditure. The cancellation of the Tweed engined version of the Blackburn GR17/45 design produced a suggestion that one of the Blackburn prototypes should also be cancelled, but this was countered by the argument that the new Griffon engined first prototype had taken its place, and the need still existed for two prototypes of the Twin Naiad version.[3] A further attempt to reduce the GR17/45 programme was made in September 1947, when DMARD was asked if he would explore the possibility of eliminating either the Mamba or the Naiad from the programme. This was successfully resisted with the argument that the two aircraft were designed to take maximum advantage from each of the engines.[4] Despite this economy drive, the design study for the AOP helicopter to specification

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1. Jackson, op.cit., p. 528
2. RAFM AC-73/30 (41/c/1) Spec. 40/46 - brochure for Naval Night Fighter to N40/46 9.47.
3. File A. Minutes of Meeting of Aircraft Development Planning Committee on economies in the Military Aircraft Prototype Programme 10.8.47.
4. File D. Minutes of Aircraft Planning Meeting called by CS(A) 10.9.47.

A7/47 went ahead as planned. Fairey submitted a modified version of their Gyrodyne experimental helicopter to the requirement,[1] but failed to obtain a prototype contract. Instead, specification E16/47 was written around the Gyrodyne to fund the work on it already in progress.[2]

Neither Blackburn nor Fairey could view the situation with complacency at the end of 1947. Both had made attempts to diversify out of military aircraft into the civil aircraft field, but since the policy of assigning firms to contracts had been pursued by the MoS in this area also, neither had been successful.[3] This led the Technical Directorate (Plans) in the MoS to predict early in 1948 that both firms would have to reduce their design staffs unless new contracts were given to them, the jobs of up to one-third of Fairey's design department being in jeopardy.[4] When the Aircraft Development Committee met in April 1948 it was Blackburn's design department that appeared to be in immediate danger.[5] They were told that the contract for the improved Firebrand had been closed, leaving the GR17/45 as their sole surviving design and development

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1. RAFM AC-73/30 (41/c/2) Spec. A7/47 - Brochure on AOP helicopter to A7/47 dated August, 1947 - the original Gyrodyne aircraft had been the subject of a Brochure in November 1945 - see RAFM AC-73/30 (41/a/3) Gyrodyne.

2. File A. Airframe prototype programme 1948-49 Minutes of Meeting of Aircraft Development Programme Committee. 27.4.48.

3. For a listing of Blackburn design studies in this area, see Jackson, op.cit., p. 528. For Fairey work see RAFM AC-73/30 (41/a/3) FC2.

4. File A. TD Plans Forecast of Available Design capacity - placed on file at February, 1948.

5. Ibid. Airframe Prototype Programme 1948/49, Minutes of Meeting of Aircraft Development Programme Committee. 27.4.48.

contract. This was the background to DMARD emphasising that the future of Blackourn was at stake on their GR17/45 aircraft during the first set of discussions on the fitment of Double Mamba engines to the Blackburn design between January and May 1948.[1] By contrast Fairey seemed to have many more future options available, although their Spearfish and N16/45 contracts had been terminated, and the GR17/45 was their only major development contract. They were engaged in design and development work on their vertical take-off, delta wing fighter concept, and this programme included the building of three E10/47 piloted research aircraft and six pilotless VTO models. In addition, they had the contract to cover the testing of their Gyrodyne aircraft. Finally, they and de Havilland had been nominated as design firms for a series of three types of naval aircraft it was hoped to order in 1948/49 within the ambit of the NR/A14:N 40/46 requirement, Blackburn having been dropped from this project. The plans for this requirement called for four prototypes of a single-seat naval night fighter, four of a naval day and night two-seat fighter and three of a day strike fighter. These variations on a single design were clearly intended to form the backbone of the defensive and offensive power of the Fleet in the 1950s, and if they could obtain the contract for this aircraft, Fairey's future would be relatively secure.

The pressures for economies which had first manifested

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1. File D. DMARD note on the proposal to fit a Double Mamba to the Blackburn GR17/45. 23.3.48.

themselves in September 1947 reappeared in May 1948, and a further attempt was made to limit expenditure on the GR17/45 programme by the Aircraft Research and Development Programme Committee. They were told that the GR17/45 was a key aircraft which was certain to go into production, and that two competitive variants were under development. An attempt to eliminate one of the engines was repulsed by the well-proven argument that each design was optimalised on the characteristics of one of the engines, and that both were required to present the aircraft in its best form. This defence undermined any argument favouring the fitment of the Double Mamba to the Blackburn aircraft, and it had to be agreed that this proposal should be abandoned.[1]

The pressing problem of keeping both Blackburn's and Fairey's design staffs in being was temporarily resolved during 1948 by the allocation of a number of design study contracts to these firms. Blackburn started design work on a maritime reconnaissance flying boat requirement for RAF Coastal Command, OR 231:R2/48. A design study was submitted in December 1948, but no prototype order was forthcoming.[2]

The work allocated to Fairey was of a more variegated nature. In July 1948 they were asked to provide the MoS with a Primer Trainer, a Belgian design which Fairey proposed to manufacture under licence. A specification, T11/48, was written

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1. Ibid. Extract from Minutes of Airframe Research & Development Programme Committee. 22.5.48.

2. Jackson, op.cit., p. 528 and RAFM AC-73/30 (41/b/3) Misc. Spec. 1947/48.

around this,[1] and in late December 1948 Fairey was asked to tender this design to the new RAF primary training requirement T17/48,[2] though production contracts did not materialise for it.

In August 1948 a more substantive design contract was given to Fairey. This was for a transonic research aircraft, capable of conversion into an interceptor fighter. The requirements for this were published early in August, and Fairey were invited to produce a design study two days later.[3]

From September 1948 to February 1950 Fairey produced a series of ten design studies to this requirement.[4] Numbers 1 and 2 were submitted in September 1948, and were of a twin engined aircraft with highly swept wings, capable of a speed of Mach 1.5. In November 1948, a design study of the military version of this aircraft was produced.[5] None of these designs proceeded further, the prototype contract going to English Electric with their P1 design, later to become the Lightning. Interest then switched to a delta wing design, with which Fairey had had experience through their E10/47 contract. Three further design studies, numbers 3, 4 and 5 were produced in

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1. RAFM AC-73/30 (41/a/3) Primer - MoS Specification T11/48 dated 21.7.48.
2. RAFM AC-73/30 (41/a/1) Spec. 16/48: Invitation to Fairey to tender a design to the specification. 23.12.48.
3. RAFM AC-73/30 (41/b/3). Misc. Spec. 1947/48. Letter to Fairey from MoS 5.8.48.
4. RAFM AC-73/30 (41/a/1). Transonic.
5. RAFM AC-73/30 (41/b/3) FD 2. Spec. ER103. Brochure dated 1.11.48.

April 1949, these featuring a delta wing and either single or twin engines. These were produced as part of an ongoing design contract,[1] and this work was continued by means of studies number 6, 7, 8 and 9 which were completed and submitted in July 1949. The final design study, of a single seat, single engined delta aircraft derived from the E10/47 was submitted in February 1950. Although this work eventually produced the FD2 experimental aircraft, which in much modified form was later used as the aerodynamic prototype for Concorde, it also served a valuable function of keeping part of the Fairey design team together at a time when work was scarce, and this may well have been a major purpose of the exercise.

In December 1948 the military aircraft programme was reviewed, and a revised programme for 1949/50 produced.[2] This included an expanded programme of Fairey VTO work, comprising three E10/47 aircraft, 6 VTO pilotless models, 6 supersonic ground launched models, 3 'Stooge' models and three 'Stooge' models with low acceleration launch.[3] In addition they were listed as the design firm for a projected large ram jet helicopter. Fairey's status in the naval NRA/14 night fighter project was degraded to that of insurance design firm, de Havilland being named as prime design firm for this and the NRA/18 two seat day and night strike fighter. The NRA/19

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1. Ibid. This contract was 6/Aircraft/3480/CB 27(b).

2. File A - List forming part of Minutes of Meeting of Airframe Research and Development Programme Committee 1.12.48, issued for circulation by Air (2) MoS 31.12.48.

3. The Stooge was the prototype of an elementary ground to air defence missile.

single seat strike variant was removed from the programme.

Fairey entered 1949 with two major projects at the design study stage, in addition to the GR17/45 and E10/47. The first of these was the 'Rotodyne', an aircraft with a large single rotor and two turbo-propelled engines mounted on stub wings, a brochure having been submitted to the MoS on this project in December, 1948.[1] The second was the naval night fighter. The original N40/46 specification had been re-issued in draft form early in 1949 as N14/49.[2] Design work had been continuing on this since the original design study of late 1947, and an advisory design conference was held on the aircraft in April 1949,[3] after which the specification was officially issued.[4]

In September 1949 sterling was devalued. In the same month fresh attempts were made to reduce expenditure on the military aircraft prototype programme. At a meeting in early September, the MoS proposed that either the Blackburn or the Fairey GR17/45 programmes should be terminated, to produce an estimated saving of £250,000, together with work on the anti-submarine version of the Sturgeon.[5] A further meeting was held a week later, in which CNR successfully opposed the first of these proposals. He emphasised the importance of these aircraft

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1. RAFM AC-73/30 (41/a/2) Rotodyne - brochure dated December, 1948.

2. RAFM AC-73/30 (41/c/1) Spec. 40/46 - Draft specification N14/49 Naval Night Fighter 16.2.49.

3. Ibid. Minutes of ADC 5.4.49.

4. Ibid. Specification N14/49 (Naval Night Fighter) 1st Issue 21.4.49.

5. File A. Minutes of Meeting of Airframe Research and Development Programme Committee 9.9.49.

to the Navy, and stated that if it was essential to reduce the number of types being developed, it should be the Sturgeon conversion, M6/49, which should be cancelled, rather than one of the two GR17/45 types. This was agreed to, although it was pointed out that much of the expenditure on this aircraft had already been incurred. At least one participant opposed this on the grounds that he would prefer to see the closure of Blackburn as a design team rather than Short Bros.[1]

These industrial issues were reopened at a further meeting in mid-November, in the course of which, CNR indicated that if the Admiralty was faced with choices which meant that some of its aircraft design firms would have to be disbanded, it would be prepared to see this happen to Blackburn and Short, but not to Fairey. This led to a discussion on how Fairey's design capacity could be maintained, in the course of which CNR was told that the only course open to the Admiralty was to award them the contract for the N14/49 night fighter, as the GR17/45 aircraft would only provide work for a small part of their design team.[2] This advice appears to have been accepted, for when the 1950/51 Draft Aircraft Research and Development Programme was approved early in 1950, the de Havilland N14/49 aircraft was stated to have been cancelled as an economy measure, leaving the Fairey aircraft to proceed alone.[3] The

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1. Ibid. Minutes of Meeting of Airframe Research & Development Programme Committee, 15.9.49.
2. Ibid. Minutes of Meeting of Airframe Research and Development Programme Committee, 18.11.49.
3. Ibid. Extract from draft Aircraft Research and Development Programme 1950-51, placed in file at April 1950.

number of naval aircraft programmes cancelled or reduced at this point suggests that the problems of the expanding development costs of the projects started in 1946 and 1947, coupled with the tight budgetary limits, were having a crippling effect upon the long-range plans for the development of naval aircraft. It had also become clear that the Admiralty did not have the resources to maintain all their aircraft design teams in being, and that the award of any large scale production contract for a naval aircraft was going to determine which design teams would survive.

ix. Parliament and Naval Policy, 1947-1949.

The years 1947-1948 produced no changes in the numbers and types of aircraft carriers possessed by the Royal Navy, though the majority of the armoured carriers were now assigned to the reserve fleet.[1] Construction of the surviving units of the *Hermes* and *Audacious* classes continued at a very slow pace. It was recognised that the entry into service of the generation of naval aircraft initiated during the 1945-46 period would have to be accompanied by a major carrier reconstruction programme. This was necessary because the take-off and landing - weight limitations of the carrier fleet prevented it operating these heavier, faster aircraft. Some effort was expended during this period in achieving a revolutionary solution to these problems by dispensing with the normal landing techniques. The basic idea was to catapult undercarriageless

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1. For a listing of the carriers in the operational and reserve fleets during this period see Appendix 2.

aircraft off the bow of a carrier vessel, and recover them at the stern on a short rubber deck. They would then be replaced on the catapult by a crane or derrick. Experiments were conducted with rubber decks and under-carriageless aircraft, culminating in a series of trials on board HMS Warrior in early 1949, using a modified Sea Vampire.[1] These do not appear to have been completely successful, as Warrior's rubber flight deck had been dismantled by the end of the year, and no further experimental work of this type was undertaken.[2] Attention then reverted to improving existing carrier operating techniques.

The Admiralty was also faced with a further technical problem in relation to their existing carrier fleet. Although the Colossus class carriers had hangar heights more than adequate to accommodate both the largest British naval aircraft then under development and those United States aircraft that might be made available in times of emergency, the three later armoured carriers of the Illustrious class were unable to store aircraft such as the Wyvern and Avenger, which were over 14 feet high. This situation represented a potential political embarrassment to the Navy, for these large carriers had only been completed in 1944, yet without major structural reconstruction they would be virtually useless once the new generation of naval aircraft entered service.

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1. Thetford, op.cit., p. 92 and Janes Fighting Ships 1949-50 op.cit., p. 23.
2. For a more detailed treatment of this concept see J.Simpson and F. Gregory, 'The Evolution of British Naval Equipment, 1945-70', Paper presented to Conference on Issues in the Evolution of British Defence Policy, 1945-70, Wessex Hotel, Winchester, 30th April, 1975, p. 3.

These technical issues led the Admiralty Board to draw up ambitious plans for modernising their existing carrier fleet. Modernisation of the Light Fleet carriers was to be restricted to measures to enable these vessels to operate heavier and faster aircraft, but a complete reconstruction was proposed for the large armoured carriers.[1] The Director of Naval Construction was instructed to prepare plans for the modernisation of the armoured carriers in February, 1948. These plans included the ability to operate aircraft up to 30,000 lbs. in weight, and the lifting of the flight deck by four feet to obtain an unrestricted hangar height of 17 ft. 6 ins.[2] Although the first of these modernisations was publicly announced in March 1949, it was not until a year later that HMS Victorious was sent to Portsmouth for the work to commence.[3] Behind the scenes, a major dispute had arisen within both the Ministry of Defence and the Chiefs of Staff Committee over both these modernisation plans and the Navy's desire to retain their large carriers. The core of this dispute was reported to be the inability of the Chiefs of Staff to make a decision 'as to whether this country retain their largest carriers or not. Ministry of Defence recommend them out; Admiralty want them retained. General opinion: we cannot afford them. If M & D get their way there will be no Fleet carriers.'[4] This dispute was only

1. Interview with Slattery, op.cit., and M. Apps Send Her Victorious. William Kimber: London, 1971, p. 22.
2. M. Apps, ibid., pp. 22 and 23.
3. Ibid., p. 22.
4. Letter from a Fairey Director to Sir Richard Fairey reporting on a conversation with officials in the MoS 21.4.50, supplied by Mr. John Fairey.

resolved in the course of 1950, and the threat of limiting the Royal Navy to small carriers was a background factor throughout 1948 and 1949. Its impact upon the GR17/45 programme was perceived to be that if there were to be no fleet carriers, there would be 'no GR17s (of any type).'[1] Why this should be so is unclear, unless it was by then widely recognised that the GR17 aircraft would be too heavy to operate from Light Fleet carriers.

This internal dispute over the future of the armoured carrier fleet was parallelled by public attempts to secure a well-defined place for the Navy in the country's evolving defence strategy. In February, 1946, the new Labour Government had firmly stated that their defence policy was to 'be guided by the following four principles:

a. Concentration on Research. Scientific and technical progress at the present time is so rapid that safety lies far more in the maintenance of an adequate organisation for pure and applied research then in the building up of stocks of obsolescent equipment.

b. Limited introduction of equipment of the most modern kind, e.g. jet propelled aircraft.

c. The maximum use of accumulated stocks.

d. The maintenance of a reasonable war potential.'[2]

In 1947, the Government listed the defence priorities of the country as:

'i The security of the United Kingdom ...

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1. Ibid.

2. Statement Relating to Defence, 1946, p. 7, paras 15 and 16 Cmd. 6743. Accounts and Papers, (6); 1945-46; Law and Misc; XX.

ii The safeguarding of communications ...

iii The contribution of forces to the United Nations Organisation.'[1]

The 1948 Defence Statement was permeated with references to the need for financial stringency in defence spending. It was specifically stated that 'the Service Estimates for 1948-49 have been prepared on the assumption that no unforeseen requirements are likely to arise during the year,'[2] and that 'under current conditions direct production for defence must necessarily be restricted.'[3] In the case of the Navy Estimates 'the basis of the Naval production programme for 1948-49 is the maintenance and repair of the active Fleet expected to be in commission during the year .... Work will also be continued on ships under construction, though at a slower pace and the re-equipment of the Naval Air Arm with newer British types of aircraft, which was begun in 1947-48, will be carried further during the year. A limited number of experimental types of aircraft will be produced.[4] Despite the generally restrictive tenor of the Defence Statement, it did assert that 'the Royal Navy, with its air arm, must be enabled to perform its vital role in the control of sea communications and to execute such tasks overseas as are laid upon it.'[5] The major role of the Navy within the post-war defence structure was reaffirmed as

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1. Statement Relating to Defence, 1947, p.5 para 10. Cmd. 7042. Accounts and Papers, (2); 1946-47; Air, Army and Navy: XVI.

2. Statement Relating to Defence, 1948, p.6 para 28. Cmd. 7327. Accounts and Papers, (2); 1947-48; Air, Army and Navy: XVIII.

3. Ibid., p. 7, para 36.

4. Ibid., p. 6, para 31.

5. Ibid., p.10, para 60.

the traditional one of defending trade and military convoys against hostile intervention.

In 1948 good progress was reported with 'the development of more advanced types of aircraft, equipment and weapons and of new tactical methods which their use will entail. High priority continues to be given to experiment and research in these matters.'[1]

The inability of the Navy to utilise the carriers it possessed, and the possibility that pressures existed to reduce the future carrier fleet were hinted at in a Defence Debate in the House of Lords later that year. Debates on the Navy in the Lords were of especial interest during this period, because the First Lord of the Admiralty was Viscount Hall, and also because a number of very senior World War II naval officers sat in this House. It is unclear how far the latter were actively used as channels through which the concerns of the Admiralty Board could be publically expressed. Thus, in the 1948 Debate, Earl Howe asked the First Lord 'what strength is the Navy aiming at in aircraft? A week or two ago I saw at Spithead a large aircraft carrier and I asked why it was there. I was told it was lying there because the Admiralty were trying to make up their minds whether or not to keep her .... Can the First Lord tell us what carriers we have, and whether they have a full complement of aircraft ready for them and full complement of trained personnel.'[2] He received no direct reply to these questions.

1. Statement ... Explanatory of the Navy Estimates, 1948-49, p.7. Cmd. 7337. Accounts and Papers, (2); 1947-48; Air, Army and Navy: XVIII.

2. 158 HL Debs: 22.9.1948; Col.172.

The 1949 Defence Statement recognised that procurement of new equipment for the armed forces would soon have to recommence on a considerable scale. It highlighted the fact that there had been an increase in the effective Service Estimates to £547 million compared to the previous years figure of £454.5 million. Two-thirds of this increase was stated to be due to increased purchases of equipment, though this was 'largely attributable to the emergency measures authorised in September 1948.'[1] The Naval programme only covered 'the maintenance requirements of the Active Fleet, and for some progress in refitting ships of the Reserve Fleet. Only a token provision is made for new construction, apart from the continuation of programmes outstanding from former years. Additional aircraft will be provided and the development of new types will be continued.'[2] A Supplementary Estimate was also raised to cover the increased expenditure on naval ship and aircraft construction work from September, 1948, onwards. This involved an increase over the original estimates of £17.5 million though only £5 million of this was assigned to contract work on new ships and aircraft.[3]

The Naval Estimates demonstrated that the Admiralty had been successful in obtaining a reasonable share of the increased defence budget, as their estimate had increased by £36.25 million

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1. Statement on Defence, 1949, p. 7, para 29, Cmd. 7631. Accounts and Papers, (3); 1948-49; Air, Army, Defence: XXIV.
2. Ibid., p. 11, para 49.
3. Supplementary Estimate: Navy, pp. 4-6; 1948-49; (66). Accounts and Papers, (4); 1948-49; Navy and House of Commons: XXV.

over the previous year, to stand at £189.25 million. The majority of the increase allocated to equipment, however, was for 'the refitting of ships in reserve, for the replacement of worn out and obsolescent equipment and for the replenishment of essential stocks.'[1] As 'Commercial shipyards had continued to be engaged almost entirely on merchant ship work,'[2] ships of existing programmes were only 'being progressed as far as circumstances permit or it is desirable to do so.'[3]

Naval Aviation was reported to have experienced a period of consolidation during the preceding year. 'Re-equipment of front line and training squadrons with modern types of aircraft and equipment have steadily continued, and plans have been prepared for the modernisation of aircraft carriers.'[4] By implication, however, no authorisation had been given to implement these plans.

These points were expanded upon by the Parliamentary Secretary to the Admiralty in the succeeding Commons debate on the Navy Estimates. He stated that it was proposed 'to spend quite considerable sums on Naval Aviation this year, and hon. members will see that for that purpose £15¾ million has been allocated. We have now five Fleet and six Light Fleet carriers. We are continuing with the construction of two Fleets,

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1. Statement ... Explanatory of the Navy Estimates, 1949-50, p. 2. Cmd. 7632. Accounts and Papers, (4); 1948-49; Navy and House of Commons: XXV.
2. Ibid., p. 5.
3. Ibid.
4. Ibid., p. 7.

while HMS <u>Eagle</u> is expected to be completed at the end of next year. Work has been suspended on four light Fleets and work is now proceeding on another four .... We intend completely to modernise the carrier 'Formidable'. This carrier will be taken into dock and will have its lifts, its arrester gear, its catapults and its island structure completely altered so that it will be able when ready to fly off the very latest type of plane.'[1]

The underlying theme of this debate, however, was that Members considered the major maritime threat to British interest to be the Russian submarine fleet. The plans for new and modernised Fleet carriers did not appear totally relevant to such a perceived threat, in contrast to the emphasis placed elsewhere in the Estimates on improved anti-submarine escorts. Despite this no member was prepared to argue that the Fleet carriers should be sacrificed in favour of Escort carriers though a number were critical of the policy towards anti-submarine forces. It was argued by an opposition member that 'it is rather hard to expect the Navy to fulfil its duty in protecting our trade routes with so few aircraft carriers. During the war we had a large number of escort carriers, but now we have only one because they have had to go back to America... the light escort carrier has an important part in anti-submarine work.'[1]

The official policy up to the end of 1949 was to maintain four Light Fleet carriers in active commission, with the Fleet

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1. 462 HC Debs: 8th March 1949; Col. 1002. It should be noted that the Official Reports lack a consistent policy on whether to place the names of ships in italics or quotations.

carriers in reserve. Emphasis was placed upon maintaining a mobilisation potential in preparation for war, at which point the ships in reserve could be manned, and quickly added to the active fleet. In support of this policy, a substantial proportion of the increased appropriations allocated to the Navy from mid-1948 onwards went towards refitting and modernising ships which were in reserve.

No mention had been made in public pronouncements of naval anti-submarine aircraft, despite the emphasis placed on the submarine threat from the USSR during Parliamentary Debates. The extent of the work required to enable existing carriers to operate the first generation of gas-turbine powered strike aircraft was never publicised. Public pronouncements seemed to imply that not only would the new Fleet carriers be completed, but the existing ones would be modernised. This vision of a possible 'big carrier' fleet eight strong, together with almost a dozen modernised or new light Fleet carriers can be sharply contrasted with the one existing Escort carrier, and the lack of published plans for further vessels of this type. The object of carrier policy appeared to be to sustain a 'big ship' navy and emulate the United States Navy, rather than to meet the perceived threat from Russian submarines. Carrier policy and public perceptions of threat were therefore clearly divorced from each other, though no public comments on this disparity were made at the time.

CHAPTER 5

ANALYSIS 1947-1949

This chapter will continue the systematic examination of the relationship between the propositions on weapon procurement evolved in Chapter 1 and the evolution of the British naval anti-submarine aircraft programme between 1945 and 1956.

Proposition i. Uncertainty is inherent in weapon procurement projects, but the types of uncertainty involved are directly related to the stage that has been reached in the evolution of the project.

In Chapter 3 it was concluded that target uncertainty was the major type of uncertainty present during the first 18 months of the GR17/45 project. Four differing sources of this were identified: uncertainty over the need for the GR17/45 aircraft, uncertainty produced by the formal process of generating requirements, uncertainty over the physical characteristics necessary to fulfil the requirement and uncertainty over cost and schedule estimates. All except the first were found to be present in the 1945-1947 period, but by 1948 this had also become a prominent element in the GR17/45 programme as a result of confusion over the probable nature of future airborne anti-submarine operations, and associated disagreements over the specific characteristics to be incorporated in the aircraft intended to perform them.

Confusion over the probable nature of future airborne anti-submarine operations centred around two separate yet inter-related issues. One was the type of aircraft carrier from which naval anti-submarine aircraft were to operate. This determined the take-off weight and run limitations of the aircraft, as well as whether it would be employed in patrolling around fast naval task forces or slow merchant convoys. The second was whether the aircraft was to be built predominantly as a weapon carrier with very limited detection equipment, or was to be regarded as a fully equipped submarine detection and strike aircraft. The latter implied increasing the number of crew members from two to three.

The Draft Staff Requirement of 1945, which led to GR17/45, had originated in a desire for an aircraft capable of operating from converted Escort carriers and MAC ships used in a convoy protection role. By 1948, only one Escort carrier remained in naval service, while the operational carrier fleet was composed of Light Fleet carriers only. It was accepted that Escort carriers and MAC ships would not reappear in any numbers for some considerable period of time after the outbreak of hostilities, and in the meantime the anti-submarine aircraft would operate from the existing Light Fleet carriers. In addition, the Navy's plans to modernise its armoured Fleet carriers, and bring into service those Audacious and Hermes class vessels under construction, implied that the carrier fleet of the 1950's would probably be composed predominantly of large Fleet carriers. These future prospects were in obvious conflict with certain of the limitations imposed upon the GR17/45 designs by the requirement, such as those of take-off weight and distance. By 1948, these limitations could only be defended on the assumption that either the United States would choose to make her reserve Escort carriers available to the United Kingdom in the event of hostilities or a very rapid programme of merchant ship conversion would be undertaken in British shipyards.

The main implication of these changes in the aircraft carrier fleet was that the GR17/45 aircraft was now very unlikely to have to operate from the 400-450 ft. flight decks of Escort carriers. Instead, it would be operating from light Fleet and Fleet carrier decks which were at least 600 ft. long. In the last resort the 450 ft. take-off run limitation was likely to be disregarded, and this was inherent in the decision taken in 1948 to revise the requirement by allowing the use of RATOG when operating at full load from Escort carriers. The take-off weight limitation proved more difficult to relax, mainly because the slow acceptance that the GR17/45 aircraft would normally operate from light Fleet carriers brought with it considerable confusion over the type of weight limitations possessed by them. Lift capacity, arrester gear strength and landing-on weight were all mentioned as possible limitations in place of take-off weight. During 1949 it became clear that the landing-on limitations of unmodified light Fleet carriers laid down by the First Sea Lord in 1948 were going to be considerably exceeded by the GR17/45 designs, thus making their future dependent on the entry into service of either modified light Fleet carriers or the new Fleet carriers.

Operations from Fleet carriers were likely to involve a very different type of anti-submarine warfare from those performed during the wartime period from Escort carriers. They would be mainly concerned with forcing submarines to submerge and hunting them some distance ahead of fast moving convoys and task-forces, rather than continuous perimeter defence of large, slow convoys. This formed the second major area of basic confusion and debate over the nature of the naval anti-submarine aircraft. Three differing concepts appeared to be involved in this debate. One was associated with the CNR up to 1948, who was reputed to have seen the anti-submarine aircraft operating predominantly as a support vehicle for the perimeter defence of slow moving convoys. Submarines were to be detected by the radar or sonar carried by surface escorts, who would direct the anti-submarine aircraft to the correct spot either to attack the submarine on the surface with strike weapons or attempt to track it submerged using sonobuoys. In this concept, strike weapons and sonobuoys were necessary equipment, but search radar was not. Only two crew members were required, one to pilot the aircraft and one to act as navigator/sonobuoy equipment operator, and it was desirable for both to be in a position to conduct an effective visual search.

The second concept was associated with the staff of the Anti-submarine School at Londonderry. Close defence of convoys was the responsibility of surface escorts in this view, with aircraft operating in a longer range prevention role. Their function was to attack submarines in the path of a convoy, force them to submerge, and attempt either to destroy them or to neutralise them until the convoy had passed. This meant that anti-submarine aircraft had to have considerable range and endurance, and be equipped with radar to detect submarines on the surface at night or in poor visibility, strike weapons to attack such targets of opportunity, and sonobuoy equipment to carry out subsequent underwater searches aimed at neutralising a submarine while the convoy transitted the area. The school appeared to distinguish very clearly between the task of convoy protection by Escort carriers, and anti-submarine operations from Fleet carriers of any description. The latter was seen predominantly as an operation to protect one vessel or a small group of fast moving vessels.

The third concept, the one apparently held by the Naval Staff, was that the best possible type of anti-submarine aircraft should be developed. This implied an aircraft which possessed all the equipment deemed necessary for anti-submarine operations. As the equipment available to the Navy changed, together with their knowledge of the limitations of existing equipment, so too did their concept of the best possible aircraft. In 1945 it seems to have been conceived mainly as an aircraft to exploit the ability of existing radar sets to detect surfaced submarines at ranges of about 10 miles and to swiftly attack them. The capabilities of existing sonobuoys were extremely limited, while the location equipment carried in the aircraft was extremely rudimentary, leading to little priority being attached to it. Between 1945 and 1948 two changes seem to have occurred in this evaluation. One was that it was accepted that future submarine operations were likely to be against craft operating at periscope depth and using a schnorkel. The ability of radar sets to detect these targets was very limited, and visual detection was likely to be just as effective. This made visual search an equally important element to radar search in anti-submarine operations. The second change was that much more effective sonobuoys and airborne location equipment were in the final stages of development, and this, added to the changed concept of the type of submarine threat likely to confront the Navy led to much greater importance being attached to the ability to perform sonobuoy search operations. This produced the two major conceptual changes inherent in the revised requirement issued in mid-1948: the inclusion of a third crew member to operate the sonobuoy equipment while the second was either plotting the position of a submerged submarine or operating the radar set, and the much greater emphasis placed on the ability of the crew members to conduct a visual search.

These conceptual issues formed the substance of the uncertainties produced by the formal process of generating requirements. The existence of differing views about the type of anti-submarine aircraft required, and the everyday exposure of all the protagonists, except the Naval Staff, to the operational problems involved in such warfare, detracted from the authoritiveness of the latter's decisions viz a viz the GR17/45 requirement. They also generated major disagreements over the detailed specification of the aircraft and its equipment. These covered its endurance as well as the more publicised issues of take-off weight and run and landing - weight. The Anti-Submarine School at Londonderry regarded six hours as the minimum endurance for an anti-submarine aircraft, and were able to support this argument on operational grounds. Despite this, the endurance figure in the requirement was reduced from four to three hours by the Naval Staff in December 1948 in a rather artificial attempt to surmount the problems produced by increases in the estimated take-off weights of the aircraft. This meant that once operational deployment occurred, either the aircraft's endurance would probably be regarded as unacceptable, or it would be regularly operated at higher take-off weights than those specified in the requirement, which in turn implied longer take-off runs. Such limited endurance was only likely to be acceptable if the aircraft was to operate very close to fast moving convoys or task forces, so that surface vessels could rapidly take over the task of hunting a submerged submarine.

Cost and schedule estimates were a further component of target uncertainty during this period. Until 1949, cost estimates were relatively unimportant, as the contemporary decision making procedures tended to exclude cost as a policy element during the prototype development stage. Also, Fairey had a fixed price contract and had to carry any cost overruns themselves. In the course of 1949, the general situation of financial stringency led to more attention being focused on cost estimates, and a number of projects were delayed or re-scheduled. Specific instances of this were the delays produced by Fairey's quotation for building their additional third prototype and the lack of urgency over the Firefly VII programme. In addition, the realisation that the cost of the Double Mamba gas-turbine was likely to be five times as great as the Griffon piston engine, reinforced the case for developing a piston engined version of the GR17/45.

Slippages in the development time schedules of the anti-submarine designs were more easily quantified, and seemed to have a greater impact than cost issues. In mid-1946 it had been hoped that the GR17/45 prototypes would be flying by March or April 1948; that a decision on which design to produce would be reached by the end of that year; and that the aircraft would enter squadron service by 1950. Due to delays in the gas turbine engine development programme, first flight dates receded rapidly during 1947, resulting in eventual first flight dates for the Fairey Double Mamba GR17/45 and Blackburn Griffon GR17/45 of September 1949. Given the revolutionary nature of gas turbines, these schedule slippages were not too surprising. Their effect was that even in mid-1948, two years after prototype development had started, it was still believed to be impossible to make any estimate of the likely in-service date of the aircraft.

These problems of schedule delays were intimately connected with the second category of uncertainty identified by the USAF study, technical uncertainty. A number of technical problems were uncovered as development proceeded, the majority of these concerning the GR17/45's gas-turbine engines. In addition, there was the realisation that the bomb-bay doors of both designs would blanket the radome, thus blinding the aircraft at a crucial point in a radar guided attack. It must also be presumed that technical uncertainty was the main reason for the lack of progress in developing Zeta, the winged, anti-submarine homing torpedo.

Engine uncertainties fell into two categories. First, there were the compressor problems experienced by all three engines and which led directly or indirectly to the demise of both the Tweed and the Naiad. Second, there was the stalling problem inherent in the coupling of turbine engines with a certain type of surge line characteristic. This led to the decision to abandon attempts to couple the Mamba and to switch to a co-axial arrangement, which almost led to it being cancelled. Also emerging in 1949 as a major technical problem in the power-plant area was the design and strength of the propellers for the aircraft. Outside the engine field, little information appeared to exist on the state of development and likely technical and operational effectiveness of Zeta, the ASV 15 radar or the new British sonobuoys. In addition, considerable doubt persisted over the accuracy of the estimates of take-off distance and weight attributed to the competing designs, and thus their ability to fulfil two of the major technical specifications in the requirement.

Internal programme uncertainty, the third area of uncertainty identified in the USAF study, stemmed from the peculiar nature of the weapon acquisition strategy used to meet the GR17/45 requirement. This involved not only having only one weapon and one radar set under development, but also having two airframe designs optimised on engines of widely differing power. The only parallel development strategy employed was in the use of both the Tweed and Naiad engines in the Blackburn design, though this situation was soon terminated with the cancellation of the Tweed early in 1947. Because of the differing power requirements of the two airframes, the Double Mamba and Twin Naiad were not really capable of being substituted for each other without a major loss of performance. A decision to fit the Mamba to the third Blackburn prototype could only be justified technically on the grounds that the engine had the potential to produce an equivalent power output to that of the Naiad. Similarly, the decision to produce the operational second Griffon-engined Blackburn prototype had a weak technical basis in view of the much lower power output of the piston engine in comparison with the Naiad. Once the Fairey Mamba had flown, and had shown itself to have acceptable performance characteristics, it is difficult to see how continuation of the development effort on the existing Blackburn designs was justified as none of their components could be viewed as back up systems to those fitted to the Fairey design. A true parallel development strategy would have involved at least two radar development efforts, two weapon development efforts and two airframes to take two different engines of roughly equal power. The GR17/45 prototype competition had none of this redundancy built into it. It is paradoxical that it was the gas-turbine engine and airframe combination for which no substitute engine was provided which emerged in the end as the only one to reach prototype status.

A further unusual decision was to proceed with the Sturgeon anti-submarine conversion but to re-engine the aircraft with single Mamba turbo-props. Insurance against the failure of the Naiad and Mamba GR17/45 designs could have been obtained by retaining its original Merlin engines and altering the front fuselage to accommodate the pilot and two crew. This would still have been consistent with the stated object of the conversion, which was to assess a layout where both the crew and the radome were concentrated in the nose section of the aircraft.[1] No evidence is available to give any indication of why this change was suggested and supported.

The final USAF category of uncertainty, process uncertainty, covers service priorities, the relative importance of other weapon programmes, and wider political and governmental issues. During the period under review, no major problem of conflicting priorities arose with other weapons programmes, but three wider governmental issues did impinge upon the GR17/45 programme. One was the conflict between the Navy and other elements of the defence establishment over the future of its aircraft carrier force. This probably had some effect upon the debates over the type of carriers the anti-submarine aircraft would be required to operate from, and therefore the types of performance characteristics it was essential for them to possess. The second issue was the repeated attempts to limit public spending, which resulted in unsuccessful bids to cancel first one of the two engines for

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1. In fact the Mamba engines created major handling problems with the aircraft and may have been responsible for the cancellation of this prototype programme at the end of 1950. See Barnes op.cit., p. 418.

the GR17/45 aircraft, and then, late in 1949, one of the two prototype designs. The third was the Berlin blockade, which created a perceived need for rapidly placing in operational service a naval anti-submarine aircraft. This stimulated the decisions to initiate the M6/49 Sturgeon anti-submarine conversion programme, and to produce the Firefly VII as an interim three-seat anti-submarine aircraft. It was also a contributory factor in the decision to produce a prototype of an operational version of the Blackburn Griffon GR17/45 design. Similarly, a combination of the apparent stabilisation of the Berlin situation and the national economic difficulties of 1949 halted any effective action to initiate production of the Firefly VII.

The overwhelming impression produced by this period is of a number of autonomous, semi-independent processes at work, all of which compounded uncertainty over the anti-submarine programme. Increased knowledge of anti-submarine techniques, changes in submarine capabilities, and new anti-submarine equipment all served to change the concept of the ideal anti-submarine aircraft held by the Naval Staffs, without adding any element of certainty or authority to their revised concept. This was reinforced by doubts over the type of carriers the aircraft would operate from, and the nature of the anti-submarine capabilities they would demand. It was also facilitated by the existence of interested groups outside the Naval Staffs with independent views on the ideal anti-submarine aircraft. Totally independent of these elements were the technical development processes of the GR17/45 aircraft, their key components, and their equipment, together with the availability of designs capable of being converted to the anti-submarine role. These technical problems and uncertainties appeared to exist in a world of their own. The key to this was that both concepts and equipment were focused upon a point in the future at which a decision would be taken on which design to produce, and, by implication, which type of concept of anti-submarine operations would be adopted. Until that point, the conceptual debates were largely irrelevant for the development process and vice versa. This suggests that all types of uncertainty were present during the prototype development stage of the GR17/45 designs, and that it was anticipated that many of them would only be resolved by the act of making a production decision.

Proposition ii. External factors dominate a weapon project at certain key points, specifically decisions on inception, production and cancellation. At other times, the process operates autonomously.

This proposition encounters certain definitional problems when an attempt is made to apply it to the events recounted in Chapter 4. These centre around the precise delineation between an internal and external factor. Peck and Scherer defined external uncertainties as technological change, changes in strategic requirements or shifts in government policy.[1] Such a categorisation is inadequate for the purposes of this study,

1. Peck & Scherer, op.cit., p. 24.

however, for it evades the central issue of what is a weapon project and the processes internal to it. In particular, it provides no answers to the question of whether a weapon project should be regarded solely as a single military requirement and the activities associated with its fulfilment, or whether it should be expanded to cover the recognition of a distinguishable military need, such as a modern anti-submarine aircraft, and the possibly diverse methods of fulfilling that need. Specifically, the problem arises whether the term 'weapon project' in this study should be associated solely with the GR17/45 aircraft, or whether the Firefly VII and Short M6/49 Sturgeon should be regarded as part of it. As there is no obvious method of resolving this problem, each of these aircraft will be treated as a separate weapon project in the ensuing analysis. A further boundary problem is whether the debate over the future composition of the aircraft carrier fleet was an internal or external factor. Again, there is no obvious method of resolving this problem, and for the purposes of analysis, it will be treated as an external factor.

The GR17/45 prototypes were subject to a number of external influences during this period. The first, which raises the issue of whether there were two distinguishable GR17/45 projects, was the series of technological and tactical developments which led to the decision in 1948 to revise the requirement to allow a third crew member to be carried by the aircraft. Unlike the associated changes in take-off weight and endurance, this clearly originated outside of these weapon projects. A second external influence was the pressure put upon the Navy and MoS to restrict the GR17/45 programme in order to reduce expenditure. These pressures had no discernable effect on the main programme, though they may have been partially responsible for the delay in starting work on the third Fairey GR17/45 prototype.

It may also be argued that a further external factor existed if the Peck and Scherer categorisation is followed, namely the gross underestimation made initially of the time required to develope the gas-turbine engines for the aircraft. In September 1946 it had been anticipated that at least one of these would be ready for flight in January 1948. In fact it was September 1949 before the first one was flight tested, the estimate of 15 months before flight testing having stretched to 36 months. It may be argued that this was a factor internal to the project, although the original estimate seems to have been based on generalised expectations external to it.

One final external factor was the pressure for an early introduction into service of a modern anti-submarine aircraft. This appears to have been stimulated by the increase in international tensions associated with the Berlin Crisis of 1948/49, and impinged upon the GR17/45 project in the form of perceptions that if a further deterioration in the international crisis occurred, a piston engined version of the GR17/45 might be the only one capable of being placed into rapid production. It also induced Fairey to both campaign against such a version, and simultaneously produce design studies of a piston engined variant of their aircraft. It had no lasting effect upon the GR17/45 projects, however, as the resolution of the Berlin crisis was parallelled by a decrease in the pressures to rapidly place a modern anti-submarine aircraft into production.

There were thus a number of sets of external influences at work upon the GR17/45 projects during this period, but only one stimulated a major change in them, namely that associated with the inclusion of a third seat in the requirement. Since this was virtually the inception of a new project, these events appear to reinforce the proposition. Negative reinforcement is provided by the fact that apart from this change the project evolved free from external influences, governed by the abilities of the firms involved to develop, produce and assemble the elements of the GR17/45 aircraft.

Both the Firefly VII and Short M6/49 Sturgeon projects arose from the efforts made within the Admiralty and MoS organisations in the second half of 1948 to explore methods of rapidly placing into operational service a fully equipped anti-submarine aircraft. These efforts, as previously mentioned, coincided with the period of the Berlin blockade, while the loss of impetus in early 1949 coincided with the stabilisation of the Berlin situation. It should be emphasised that, with one exception, no clear documentary evidence has been presented in this study which directly links together these two sets of events. Despite this qualification, it seems clear that in the absence of this change in the external political environment little or no effort would have been made to place an interim three-seat aircraft into service. The decisions to proceed with these aircraft thus appear to have been stimulated almost solely by external factors, reinforcing the proposition that such factors dominate the inception of projects. They also determined the pace of progress of the Firefly VII project, for as international tension declined, so too did the apparent desire to place an early production order for this aircraft.

Proposition iii. Governments act purposefully and as unified entities both to maintain their defence R & D base, and to avoid having to make conscious choices between conflicting alternatives.

In the period 1947-1949, it appeared that government activities were designed, at least in part, to maintain the existing defence R & D base. Two separate sets of activities can be highlighted which support this point. The first was the pressures exerted to give Blackburn every opportunity to develop their GR17/45 design. These produced three major changes in the prototype plans and one attempted change. The major changes were the fitting of a Griffon engine to the first prototype; the modification of the design to allow the second prototype to have an operational Griffon installation, and the further modification of the design to allow a Double Mamba to be installed in the third prototype. The attempted change was the rejected suggestion, made in November 1947, that the Double Mamba be fitted to the second prototype. The decisions to re-engine the second and third prototypes had the effect of maintaining Blackburn in the naval aircraft design field with at least some prospect of future production, despite the major disparity in power between the Twin

Naiad engine and its substitutes.

The second set of pressures were those aimed at perpetuating the design teams of as much of the aircraft industry as possible, and Fairey in particular. By early 1948, it had been recognised that a number of the existing design teams were short of work, and that government funded design work would have to be given to them if they were to remain in being. Three design study contracts were given to Fairey by the MoS in order to sustain their design teams. The first was the contract for the E10/47 aircraft and its associated experimental equipment. It is unclear how far any high priority requirement existed for this type of point-defence system. The second was a contract to prepare design studies for a naval night fighter. This design exercise went through four major phases, first with Blackburn as the nominated design team, then Fairey, then De Havilland with Fairey producing an insurance design, and finally back to Fairey in a conscious decision by the Admiralty to provide them with design work. The third was the series of ten design studies for a transonic aircraft.

The issue of deciding which design teams and aircraft firms should be retained, and which allowed to disband because of lack of work, came to a head in the course of the economy drive conducted in the second half of 1949. In the meetings of that period, a clear preference was expressed for maintaining Short and Fairey in preference to Blackburn. In addition, the Admiralty decided that their first priority was to maintain Fairey's competence in the field of naval aircraft, and to this end they transferred the night fighter design contract to Fairey by terminating de Havilland's contract.

The desire to maintain in business what was regarded by the Admiralty as their most important airframe firm clearly influenced the general policy for assigning design studies to industry during this period. At the same time, a desire to retain at least two predominately naval aircraft design teams in being seems to have led to sustained attempts to aid Blackburn to produce a viable GR17/45 prototype aircraft, and win a production contract for it.

Despite this evidence of decisions which appeared to be motivated by consistent objectives, it is clear from the detailed minutes of the relevant meetings that there was a lack of unanimity over what constituted the minimal R & D base, and that decisions tended to be taken because individuals argued strongly for sustaining the design team of a particular company in a semi-vacuum, with no alternative uses being proposed by others for the resources involved. This situation only changed in the second half of 1949 when a clear decision was taken on priorities. Thus while decisions had the effect of sustaining the defence R & D base, they did not result from a conscious policy implemented by a monolithic group of governmental committees, but from a temporary agreement between the agencies involved.

These R & D decisions formed part of the larger spectrum of decisions on naval anti-submarine aircraft during this period during which ten major sets of choices confronted government decision-makers. Their response to them contained one consistent element: a tendency to try to maintain as many options open as possible, and to refrain from making decisions unless there appeared to be no alternative but to do so. This may have been a product of the uncertain nature of the weapons development process at this time, when there was no guarantee that the design which on paper looked the most likely to succeed would in practice emerge as the better one.

Five of these sets of choices involved the engine for the GR17/45 designs. The first resulted from the cancellation in May 1947 of the Tweed, which had been intended as one of the two possible power-plants for the Blackburn prototypes. The choice that resulted was to either cancel one prototype, or fit a Griffon engine to it in a temporary installation. After a three month delay, it was decided to retain the programme of three prototypes and substitute a Griffon for the Tweed in the first prototype in order to prove the aerodynamics of the design as soon as possible. The second engine choice involved the decision to discontinue work on the coupled Double Mamba in June 1947, and switch to a co-axial arrangement. Here the choice was either to cancel the engine, or allow it to continue in the new form. Given the argument that the delay involved was likely to be only two or three months, and the implication that Armstrong Siddeley had already investigated the new arrangement in some depth, it is not surprising that the decision to cancel was not taken, or even formally raised. The third engine choice was closely associated with this situation. This was whether to allow Fairey to proceed with a Griffon engined version of their aircraft. The initial decision to reject this proposal seems to have been a product both of the fact that the Double Mamba had not been cancelled and of the major redesign of the aircraft that appeared necessary before this engine could be installed. The Admiralty wished to emphasise that a piston engined GR17/45 aircraft would not be placed into production, and this decision was a very positive way of doing this. The subsequent decision to allow Fairey to produce a Griffon engined prototype on the basis of modified proposals involving a simple powerplant substitution, was heavily influenced by a previous decision to allow Blackburn to take similar action. Both of these decisions were taken rapidly.

The fourth engine decision arose in October and November 1947, when a number of events occurred simultaneously. These were the notification of a year's delay in the Naiad development programme; the suggestion that the first Blackburn Griffon prototype should be operationalised; a proposal to cancel one of the Blackburn prototypes; and a counter-proposal to fit a Double Mamba to the second Blackburn prototype. Given the previous decision on Fairey's Griffon proposals, the idea of an operational Blackburn Griffon prototype could be rapidly rejected. The request to fit a Double Mamba to the second prototype could not be so rapidly disposed of, and it took three months to produce a negative answer. This rejection was a logical consequence of the main argument deployed to ensure the continuation of the Naiad engine development programme, namely that the aircraft's design was optimalised around it. If Blackburn were to be allowed to fit the lower powered Mamba to their aircraft, the case for continuing the Naiad programme would be completely undermined. A further factor was that Mamba and Naiad development schedules now closely parallelled each other, and little time advantage appeared likely to accrue from fitting the Mamba into the Blackburn prototype. By delaying a decision, the problem had largely resolved itself.

The fifth engine decision occupied the period from November 1948 through to February 1949. It was precipitated by the realisation that the Naiad was unlikely to be available to power the third Blackburn prototype airframe, and that the logical choice was between cancelling the Blackburn design or installing an engine of equivalent power in it. In practice, such a choice was never considered, partly because the question of whether the GR17/45 aircraft should have piston, rather than turbine, engines had now become important. It was eventually agreed that the second Blackburn prototype should be completed with an operational Griffon engine installation, and the third with a Double Mamba. A period of four months elapsed between the tacit recognition that the Naiad would not be available in time and the instructions to Blackburn in February 1949 to terminate work on the Naiad installation. Again, the tendency was to allow the decision to emerge naturally from the evolution of the situation.

A fundamental debate about the engine appears to have underlain all these discussions, namely whether the GR17/45 aircraft should be fitted with piston or turbine engines, though it never reached the point at which a decision became necessary between the alternatives involved. This debate was complicated by the fact that although the second Blackburn Griffon prototype was to have an operational Griffon installation, a Griffon engined version of the lower powered Fairey GR17/45 design only existed on paper. Any decision to fit piston engines to production aircraft would therefore be tantamount to selecting the Blackburn design for production.

The sixth decision taken during this period was to convert the design from a two to a three-seater. There seems to have been little opposition to this from within the Ministries concerned, but Fairey complicated the issue by proposing that the search and strike roles of the designs should be separated. This decision seems, therefore, to have been one taken by the Naval Staff and passively accepted by those responsible for implementing it. The major delay over its implementation was a product of the seventh decision, whether to order a further Fairey three-seater prototype or just a spare fuselage. Although it was agreed by November 1948 that a complete prototype was desirable, the cost estimate provided by Fairey was so much in excess of the internal estimate upon which the decision had been based that it was a further six months before the contract was signed.

The eighth decision was to identify the Sturgeon as the most suitable design for conversion into an interim anti-submarine aircraft and then to decide to develop it in prototype form only. This decision process occupied six months, starting with the initial expression of interest in July 1948, and terminating in December with the decision to proceed only with experimental prototypes.

The key issues in the final decision seem to have been both the difficulty of operating the aircraft from smaller carriers and the likelihood that the aircraft would not be available before one of the GR17/45 designs was in service.

The ninth decision was to revert to the three-seater Firefly VII as the potential interim aircraft. This seems to have been a decision taken by default, as, despite its limited capabilities, there was no other suitable aircraft capable of rapid production. The delay in placing a production order can be attributed to the decrease in importance attached to having such an aircraft in service once the Berlin crisis was over.

The final decision was that of the Admiralty designating Fairey as their most important design firm over the other possible claimants for naval aircraft contracts, and acting upon this by transferring work to them. This involved making Fairey the sole design team for the naval night fighter, and cancelling an existing contract with de Havilland.

The evidence from these ten decisions suggests that governmental action was, in part, related to the type of situation involved. It was believed to be more desirable to maintain the GR17/45 prototype building programmes in being by agreeing to incremental changes in them, than to initiate a new anti-submarine development programme based on a revised specification. Such decisions tended to be taken relatively rapidly. It was much more difficult to obtain a decision on new policies, such as fitting a Double Mamba to the Blackburn prototype while the Naiad programme was still in existence, or instituting an

M6/49 or Firefly VII production programme, mainly because of their financial implications. This was the case also with the third Fairey three-seater prototype. Decisions which continued the existing programme therefore tended to be taken rapidly, but those which involved new financial commitments involved very lengthy consultation, and took time to evolve.

An outstanding feature of this period was the refusal of the Naval Staff to consider abandoning the GR17/45 designs, and starting afresh with a new specification and new projects. This seems partly to have been based on arguments over the timescale of such a new project, and partly because it would clearly have produced major disruptions in the naval aircraft programme. The nature of the decisions taken during the period reflected not only the substantive issues involved, but also the pressures and groups existing within the decision-making process. Decisions to continue projects or revise them incrementally had little difficulty in generating support as nothing had happened to alter the reasons for making previous decisions. New departures tended to generate lack of harmony and delay until a consensus could emerge, or be created, among the groups and interests involved. Thus all policies which superficially might have appeared to be the purposeful activity of a monolithic entity were the product of pressures and group interests, whose direction and strength were changing over time.

Proposition iv. The weapon acquisition process is conducted solely through closed politics, and public debate and discussion exercises no influence over it.

In the second half of 1948, the problems encountered by the GR17/45 development programme was considered for the first time by a wider forum than ad hoc Mos/Admiralty Committees, when the Sub-Committee for Naval Aircraft Design, chaired by the Fifth Sea Lord, examined in detail both the estimated performance of the GR17/45 designs and the possibility of ordering an interim anti-submarine aircraft. It seems probable that these issues were discussed at Admiralty Board level, in view of the First Sea Lord's reported insistence both that an assurance be obtained that the GR17/45 aircraft would be able to operate from unmodified light Fleet carriers, and that the Sturgeon anti-submarine conversion was not to go into production if it could only be operated from Fleet carriers. It is of interest to note that the stimulus for this activity was not the slippage in the engine development schedules, but the external situation which had focused high level attention upon the preparedness of the Navy to deal with a fresh outbreak of hostilities.

Despite the fact that the pressures for reducing expenditure on the military aircraft programme came from the top of the governmental structure, and that the debate over the types of aircraft carriers which would constitute the backbone of the fleet in the 1950's was being conducted with the other services and the Ministry of Defence, there is no evidence to suggest that any information on the evolution of the naval anti-submarine aircraft programme reached Parliament or the public. If it did, it certainly did not result in any public discussion of the issues involved for, until 1950, the sole public references to the project were pictures of each of the GR17/45 aircraft which appeared in September 1949.[1] Scant attention was paid by Parliament to the state of the Fleet Air Arm during this period. It was pointed out in a Parliamentary debate in 1949 that 47 seconds had been devoted to the subject during the whole of the 1947 parliamentary session.[2] The naval anti-submarine programme continued to be conducted solely through closed politics in this period, and public debate appeared to exercise no influence upon it.

Proposition v. The weapon procurement process is dominated by civilian direction, and industrial and service views or problems have no influence upon it.

The physical process of developing a new naval anti-submarine aircraft between 1947 and 1949 was dominated by the activities of the civilians in the industrial firms involved, while within the governmental structure, the major decisions concerning changes in direction of existing policies or the implementation of new policies were dominated by military officers. The decision to add a third seat to the GR17/45 specification, and the search for an interim anti-submarine aircraft, were

1. The Aeroplane, September 30th, 1949, pp. 462 and 463.

2. Speech by M.R. Langford Holt in the Debate on the Navy Estimates, 8th March, 1949, H.C. Debates 462 col.1063.

both decisions imposed upon the civilians in the MoS by serving officers, yet those same officers were dependent upon the technical expertise of such civilians for the information upon which to base their decisions on the continuation of the GR17/45 projects and the choice of interim aircraft. It is clear from the minutes of meetings that it was largely civilian MoS personnel who were pressing to retain Blackburn as a design team, and they succeeded in this. When financial stringency bit hard in 1949, however, it was left to the Admiralty to decide which firms they wished to retain, and they chose Fairey and Short. This relationship between civilians and officers is not surprising, since the Navy was the customer and the MoS was acting primarily as a purchasing agency. The civilians within the MoS could only dominate naval officers in two sets of circumstances: where they were dependent on civilian technical expertise in making decisions, and where financial cuts were imposed upon the Service by the Treasury. Although the first type of circumstance occurred briefly in late 1948, the Service by virtue of its ability as customer to dictate the type of product it required, retained the dominant role.

This service domination was little affected by the activities of industry during this period. On only three occasions can it be argued that action initiated by industry had a positive effect on this process, and all three involved Fairey. The first of these was their successful attempt to change the decision, made in September 1947, to deny them permission to build a Griffon powered version of their GR17/45 prototype. The reversal of this decision seems to have been a direct result of their protests. The second example was the promotion by Fairey of the idea that the roles of the GR17/45 aircraft should be divided, leading to both a search and a strike variant. This was rejected with little discussion, and had no apparent influence upon events. The third was the suggestion that the GR17/45 requirement had resulted in a poor compromise design, and that the addition of the third crew member made it imperative to reconsider the whole requirement. This view was disseminated by CNR, but the only visible result was a request to the Naval Staff to prepare a requirement for a further anti-submarine aircraft which could be operated with certainty from small aircraft carriers. In addition, the eventual decision to adopt the Firefly VII as the interim anti-submarine design was in line with Fairey's thinking, though they appear to have had little direct influence upon this decision-making process. Although the first of these examples does indicate that on rare occasions industrial views can prevail over service and civilian governmental ones, there is little doubt that during this period industrial views had little or no influence upon governmental policy, though the performance of industry in developing naval anti-submarine aircraft was a major determinant of the progress and direction of the GR17/45 designs.

Proposition vi. Governments do not act as unified entities when taking decisions on defence projects because of the conflicting interests and expertise of the bureaucratic organisations involved. This creates a lack of positive direction and control over projects.

Although the evidence presented in this study indicates that major cleavages existed both between the MoS and Navy, and within the Navy itself during this period, a surprising degree of consensus emerged on the policies to be pursued. None of the parties seemed interested in cancelling the GR17/45 designs, though towards the end of 1949 a major disagreement was arising between the MoS, who favoured a gas turbine engined version on grounds of modernity and progress, and the Navy who were impressed by the reduced capital cost of a piston engined version. While it might be argued that a decision should have been taken in 1948 to terminate the project and start again, and that in 1949 the Blackburn version should either have been cancelled or subjected to a major redesign, in practice the policy of incremental decision-making and drift did allow a consensus to be sustained within government over the project. Similarly, little opposition was generated by either the Short M6/49 or Firefly VII projects. This suggests that during this period the government did act as a unified entity, but at a cost of not facing up to some of the difficult decisions concerning the GR17/45 project that could have been made.

Proposition vii. Certain individuals may, through their personal or organisational position, determine whether a defence project is sustained or cancelled.

This period provides little clear evidence to identify individuals with the outcome of cancellation decisions, mainly because none were seriously threatened at this time. One senior civilian in the MoS did consistently support the Blackburn project, and may have been instrumental in preventing the number of prototypes on order being reduced. This is the only clear example of the influence of individuals during this period, for despite Sir Richard Fairey's ideas and his scathing analyses of the process of procuring naval anti-submarine aircraft, he seems to have had no direct influence upon that process.

Proposition viii. Time is the most flexible variable in the weapon procurement process, followed by cost and quality.

Prior to the middle of 1948, little time pressure had been placed on the GR17/45 project. This was partly due to the management structure involved, for the development of the turbine engines were the subject of a contract between the Directorate of Engine Research and the engine firms concerned, and the airframe firms had no responsibility for, or influence over, their timely delivery. Nothing resembling a critical path for the development programmes existed, merely slightly hazy target dates for the start of prototype development and operational service. In the second half of 1948 time was a major factor in determining whether an interim aircraft would be put into production, as such a decision could only be justified if the aircraft could enter service significantly in advance of the GR17/45 designs. By 1949 this time pressure had eased, and the nation's economic problems were militating against early production orders being placed for this or any other new aircraft.

Cost proved to be a reasonably flexible variable during this period. Fairey had a fixed price contract and the cost to the government of their GR17/45 programme remained static. Any cost increases incurred by Blackburn appear to have been regarded as reasonable. In only two decisions was cost an important factor. The estimate provided by Fairey of the costs of their three seater prototype was regarded as excessive, but eventually this increase over estimated costs had to be accepted. It was also decided that it would be necessary to trade numbers for cost when Firefly VII aircraft replaced Firefly VI aircraft on the Fairey's production line.

Quality proved to be a fairly inflexible variable, the third seat being added and equipment weight increases accepted with little discussion of their impact upon development time and costs. The concessions of mid-1948 in respect of endurance, weapon and equipment weights and take-off capabilities, which had the appearance of being a reduction in quality standards, in practice merely reflected the capabilities of the designs as they then existed and the uncertainties over the types of aircraft carrier that the GR17/45 aircraft would operate from.

The only serious attempt to trade quality for reduced cost was the suggestion that the twin turbine engines of the GR17/45 designs should be replaced by a much cheaper single piston engine, though this proposal had not gained sufficient momentum by the end of 1949 to force the Admiralty to take a decision on it. Events during this period thus provide no evidence to falsify the proposition.

Proposition ix. A weapon project comprises the following sequential phases:

a. Background research and production of a military specification.

b. Design study and competitive tender.

c. Prototype construction.

A review of the period 1947-1949 suggests that three additional operations to those specified were involved in the procurement of naval anti-submarine aircraft. The first stemmed from the nature of the weapon under development. It comprised a number of separate components, which were being developed without the benefit of any central monitoring and controlling authority. Had such an authority existed, slippages in the programme could have been prevented by identifying the components with the longest development times and relating the programme's time schedule to them. The original GR17/45 schedules were based upon airframe development times, which in practice proved to be the most stable and predictable item in the programme. By comparison, engine development times were still uncertain after two years development work had taken place. The military aircraft acquisition process thus involved the assembly of numerous components with differing prototype development time scales, with the airframe having one of the shortest development times.

The second operation was the amending of the Staff Requirement to both allow the aircraft to carry a third crew member and to formally accept its reduced performance capabilities. This suggests that new military equipment may take so long to develop that its original operational concept may have been drastically revised by the time that prototype testing starts. It also implies that as information on the performance of the prototype designs increased and more confident statements could be made about their capabilities, a choice had to be made between terminating the project and acquiescing to performance characteristics previously regarded as unacceptable. There seems to have existed in this case an interaction process between the technical evolution of the designs and the Requirement, in which both the designs and the Requirement changed in response to stimulus from each other.

The third operation was the search for an interim aircraft, and the decision to produce a new requirement for a naval anti-submarine aircraft which was both smaller and lighter than the GR17/45 designs. The former was in part a product of the slippages in the anticipated development schedule of the GR17/45 designs and the existence of a state of external political tension which focused attention on deficiencies in the inventory of existing military equipment. The latter was a product of the technical deficiencies of the GR17/45 design which had led to the recognition that such aircraft would be incapable of operating efficiently from Escort carriers.

The three phase process specified in Proposition ix ignores the multiple feedback process that occurred during this period, when attempts were made to alter the original requirement to accommodate technical deficiencies; to adapt the requirement to accommodate revised operational concepts, and to search for alternative anti-submarine aircraft designs in order to offset slippages in the GR17/45 design's development times. The result was a process of dynamic interaction which is not adequately described by the static and linear three phase process contained in the proposition.

Conclusions

It became apparent during this period that there were many uncertainties inherent in the GR17/45 programme. Few of them had been anticipated in advance, and no coherent plan had been evolved to insure against them. The result was a rapid slippage in the programme time schedule and involuntary acceptance of changes in the performance characteristics of the GR17/45 designs. Three options were available for dealing with this: terminating work on the designs and starting again, adapting them and the GR17/45 requirement to the new circumstances, or attempting to convert another naval aircraft design into an anti-submarine aircraft. The latter option was investigated, but no suitable design was available: the former was rejected on the grounds of unacceptable delay, leaving only the continuation of the project in a changed form as an acceptable policy. This was reinforced by the evolution of the Navy's aircraft carrier policy which militated against any firm insistence on adhering to the take-off characteristics incorporated in the original requirement.

Two more characteristics of this weapon procurement process are worthy of note. One was the way a perceived external political crisis produced an immediate demand for the speeding up of production plans, but had little effect on prototype development work. The second was the almost total lack of influence the industrial firms had over the government departments involved in aircraft procurement and the way in which these departments were able to manipulate the commercial futures of these seemingly independent industrial firms to conform to their own policies.

CHAPTER 6

PRODUCTION DECISIONS, 1950-51.

i. Introduction.

The first Fairey Mamba and Blackburn Griffon GR17/45 prototypes had flown in September 1949 and, in parallel, a debate had taken place within the Admiralty on the advantages of fitting relatively costly gas-turbine engines to the GR17/45 designs. In addition, a major dispute was in progress between the Navy and the other services over the future composition of the British aircraft carrier force. It was anticipated that one of the GR17/45 designs would enter service in late 1952 or early 1953,[1] and that a decision on the design to be produced would be taken during 1950.

There were two major sets of criteria by which the Navy and MoS could evaluate the competing GR17/45 designs. The first was the basic handling qualities of the aircraft, the second was its submarine detection and destruction capability, including its ability to carry a wide range of existing and future weapons and equipment. The existing two-seat prototypes provided a means of comparing the aircrafts' qualities in the first of these areas, but any final evaluation of them, and any examination of the aircraft in terms of the second criteria, would have to await the completion of the three-seat prototypes.

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1. File H. Minutes of Sub-Committee for Naval Aircraft Design, 12.1.50. Excerpt in File N.

Thus the more extensive the evaluation of the two designs, the more the choice was likely to be delayed. This situation was exacerbated by the second Blackburn prototype, expected to fly in early 1950, being a Griffon engined three-seater, while the first Blackburn Double Mamba powered three-seater would not be available before mid-1950. The second Fairey Double Mamba two-seat prototype was likely to fly in mid-1950, but it was anticipated that it would be the end of the year before the third, three-seat prototype was completed. The earliest date at which a full evaluation of both three-seat designs could be completed appeared likely to be mid-1951. This assumed that the Admiralty chose to continue with the turbine engined versions. If they opted for a piston engined aircraft on financial grounds, a choice between the two designs might be delayed beyond the end of 1951, as the MoS would probably insist that Fairey should be allowed to re-engine their design with a Griffon powerplant before any final production decision was made. There was one additional area of uncertainty which might also inhibit a rapid production decision. Delays in the Z weapon programme had led to the development of a new family of more orthodox air-dropped homing torpedoes. The GR17/45 designs would have to be capable of using the anti-submarine version of this new weapon, and this might necessitate some redesign of the aircraft to enable it to be carried within their bomb-bays.

It had also become clear that the Navy would be unable to utilise the GR17/45 designs' load carrying and endurance capabilities if they were operated from small Escort carriers. This had stimulated consideration of the development of a new aircraft with more limited capabilities optimalised for operations from these carriers. In the interim, the Firefly remained the sole British naval aircraft capable of operating from all types of carriers in the anti-submarine role.

ii. The Blackburn and Fairey GR17/45 Prototype Programmes 1950-1951.

In January, 1950, the Blackburn design appeared to be in a strong position to gain the GR17/45 production contract. The debate within the Admiralty over methods of reducing expenditure favoured the cheaper Griffon engined Blackburn design, and no comparable Fairey GR17/45 prototype existed. In addition, the MoS was becoming increasingly critical of the internal organisation of Fairey's GR17/45 prototype development programme. There appeared to be no one person in charge of this, and it had been necessary to have discussions with six different people in order to assess the progress of this programme. The Blackburn prototype had also earned praise for its powered controls, which resulted in a much better standard of aileron response and handling than that of the Fairey prototype.[1]

The Blackburn prototype programme progressed rapidly during the early part of 1950. In February, the Blackburn Griffon two-seat prototype took part in preliminary deck landing trials, which revealed no serious problems. It was also reported that

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1. File C. Summary Minute on GR17/45 position. 20.1.50.

the second Griffon prototype, with a three-seat fuselage and wings of the original planform, would be ready to fly by the end of May.[1] By March, Blackburn were preparing to start preliminary radar and radio trials with the first prototype.[2]

Many new developments connected with the GR17/45 programme occurred during April, 1950. These included the advent of a new anti-submarine torpedo, called Pentane, and further debate on the desirability of a Griffon, rather than Double Mamba, powered GR17/45. A meeting was called by CNR to discuss both these issues,[3] and it was agreed in the course of it that the GR17/45 designs would be able to accommodate the four sonobuoys and one Pentane with drum tail required for the mixed search/strike role. This Pentane variant had an estimated 50% failure rate, due to a tendency to dive to the bottom once it had entered the water. A new design was under development with a monoplane air tail,[4] and with this it was helped to reduce the failure rate, to about 10%. This air tail would probably make the torpedo too long to fit into the existing bomb bays of the GR17/45 designs, but since design work was still in progress, no definite dimensions were available. It was decided to postpone

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1. File D. Minute 16.2.50.
2. Ibid. Minute 8.3.50.
3. Ibid. Minutes of Meeting to consider Naval aircraft projects to specifications N 14/49, N9/47 and GR17/45. 3.4.50.
4. A drum tail was a hollow cylindrical structure fitted to the rear of a torpedo. A monoplane air tail was a wing shaped structure with two end plates which was also fixed to the tail of a torpedo. Both were designed to allow an air-launched torpedo to enter the water at the correct angle.

a decision on whether the GR17/45 aircraft should be re-designed to enable them to carry this version of Pentane until firm figures became available for its dimensions.

The discussion then moved to the comparative performance of the GR17/45 variants and it was suggested that the key issue was whether the Blackburn Double Mamba aircraft could fly on one engine. DAW indicated that the Blackburn Griffon version had acceptable deck landing performance and endurance, and was favoured by the Admiralty because of its relative cheapness. The Director General of Technical Development (Air) (DG/TD/(A)) in the MoS stated that if a Griffon engined aircraft was to be chosen for production CS(A) would expect Fairey to be given the opportunity of building such a prototype, unless a strong case could be presented against this. He then made it clear that the MoS was opposed to the Navy's possible abandonment of the gas turbine GR17/45's because it believed they possessed three major advantages over the piston-engined ones. These were a saving in maintenance effort and costs, twin-engined reliability, and the prospect that the continued development of gas-turbine engines would reduce their capital costs to the point where the financial gains from ordering a Griffon version would largely disappear. An Admiralty representative countered this by pointing out that past experience of introducing new types of engines into the Navy indicated that there was unlikely to be any reduction in maintenance effort over the previous types until the engines had been in service for a considerable time.

The major areas of disagreement between the MoS and the Admiralty having been highlighted, the meeting then degenerated into an inconclusive discussion of the general merits and demerits of the two designs. It was asserted that the Blackburn design could carry considerably more sonobuoys than the Fairey design, and that the Blackburn Griffon had the greatest range on internal fuel of all the types involved. In response, it was argued out that the Blackburn Double Mamba could not cruise on one engine, while the Fairey Double Mamba had a better take-off performance than either of the Blackburn variants.

It was then suggested that a completely new design of aircraft might be needed, especially if the estimated cost of the GR17/45 aircraft was responsible for the Admiralty's reluctance to make a rapid production decision on it. DAW indicated that this decision was being delayed until the Admiralty's Anti-submarine Aircraft Working Party had reported on which carriers would be available when the GR17/45 went into service. The retention of the Colossus class of Light Fleet carriers in the active fleet, and a decision to operate the anti-submarine squadrons from them, would downgrade the need to order an aircraft with very good take-off performance. This would make the higher powered Double Mamba version of the GR17/45 designs less attractive to the Admiralty. It was accepted that even in piston engined form the aircraft was going to be very expensive, and this would probably prevent the Navy buying the full numbers they felt were necessary. A new requirement for a much cheaper, lightweight anti-submarine aircraft had been prepared and forwarded to the MoS, but the Navy had not yet decided whether it should be issued. It was suggested by DG/TD(A) that suitable firms should be informed of the contents of the requirement, and be encouraged to submit preliminary design ideas to the Admiralty and the Ministry.

This meeting also discussed Fairey's work on the N14/49 aircraft. This was the only other project they were undertaking, apart from the GR17/45, which seemed likely to yield production contracts. Fairey's industrial position was now rather more exposed than Blackburn's, who had taken over the Universal Freighter contract from General Aircraft Ltd. when the two companies merged in January, 1949. This aircraft seemed to have a good chance of being awarded a major RAF production contract in the near future, and it was ironic that it was Blackburn's original failure to gain this prototype contract in 1945 which had led to them being assigned to the GR17/45.

It was reported that little effective progress had been made with the Fairey N14/49 contract. The problem was that their design was based upon the earlier N40/46 requirement, which had specified a lower maximum speed than N19/49. The type of wing planform Fairey had adopted for this earlier design and transferred to the new one was judged to be inherently incapable of allowing the aircraft to reach the new target speed of 540 knots at 30,000 ft. DAW indicated that the speed specified in the requirement had to be seen as a minimum, not maximum requirement. It was then pointed out that from a study of the drawings it appeared that neither the single nor the twin-engined Fairey designs to this requirement could accommodate the AI Mark 16 radar with 35 inch scanner specified in it. This produced agreement that Fairey should be told that their current designs were both unsatisfactory and unacceptable, and that they should be instructed to produce a new design study based upon a single engine.

A discussion on the priority to be assigned to the N19/49 aircraft then ensued, because expenditure on it was similar to that for the N9/47 naval day fighter, though the former would comprise only 10% of the Fleet Air Arm's establishment compared with the latter's 40%. DAW indicated that the Staff might reconsider its role if a really successful design was tendered to this specification, though their interest in strike versions of both the N19/49 and N9/47 aircraft was secondary. This discussion indicated that the Admiralty's decision to support Fairey by awarding them the N19/49 contract was absorbing a lot of scarce resources, and they were increasingly disturbed at the firm's inability to produce a satisfactory design.

A report on this meeting was produced by DG/TD(A) and circulated within the MoS.[1] It expressed dismay at the way the Admiralty representatives had demonstrated an overwhelming preference for a Griffon engined version of the GR17/45 aircraft rather than a Double Mamba one. DG/TD(A) thought the major reason for this was cost, though the Navy also seemed afraid they would have trouble maintaining what, to them, was a new

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1. File D. Report of DG(TD(A) on Meeting on 3.4.50.

type of powerplant. He reported his opposition to this view, and his insistance that if a Griffon engined version was adopted, Fairey should be allowed to go ahead with one so that they would be at no disadvantage compared to Blackburn. He also stated that it had been revealed that Pentane required a larger tail to stabilise it than had been predicted, and the resultant weapon would not fit into the bomb bay of either of the GR17/45 designs, and that the sonobuoys had also increased in length. All of these factors seemed to indicate to him that GR17/45 was in serious trouble, especially in view of the new idea of a light, 13,000 lb. take-off weight, anti-submarine aircraft with split search and strike functions which had been discussed at the meeting.

The MoS seems to have moved swiftly to inform Fairey of the Admiralty's attitude, for nine days after this meeting Fairey's General Manager circulated an internal memorandum stating that the installation of the Griffon 57 engine in the GR17/45 aircraft was now under active consideration again and requesting that performance and cost estimates for this version should be drawn up.[1] This work seems to have been given top priority for Fairey's proposals were submitted to the MoS fourteen days later.[2]

The brochure containing these proposals differed from those of 1949 in four main areas. The performance figures

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1. RAFM AC-73/30 (41/d/3), GR17/45 Correspondence March 1949 - June 1950. Memo 12.4.50 from General Manager (Engineering).
2. File F. Brochure from Fairey 26.4.50.

were slightly revised to give the Griffon version a take-off weight with full strike load of 17,820 lbs. compared with the Double Mamba version's weight of 17,962 lbs. In both cases, this would give a flight endurance of 2.45 hours. The layout of the aircraft now showed the two crew members facing each other in a large cockpit situated behind the wing, with a fuel tank separating them from the pilot. It was estimated that the unassisted take-off run of this Griffon version would be 650 ft. compared to the Double Mamba version's 410 ft. Finally, the cost of converting the existing prototype to take the new engine was estimated at £90,000.

The information filtering out of the Admiralty and MoS about the prospects for their GR17/45 design created considerable concern within the Fairey Board, and during April they sought some informal assurances about their position from personnel in the MoS. Their main channel of contact for this was created by the existence of a personal relationship between one of the Fairey directors and DG/TD (Plans). This enabled them to obtain a reasonably accurate picture of the multiplicity of factors which were affecting the project, though the information obtained tended to exaggerate the role played by the MoS in Admiralty decision-taking. The director concerned wrote to Sir Richard Fairey in mid-April setting out the current GR17/45 position as described to him and also evaluating the prospects of further design and development contracts from the MoS.[1]

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1. Letter to Sir Richard Fairey, 21.4.50. Supplied by Mr. John Fairey.

He stated that the future of the GR17/45 rested upon three issues:

'a) A decision by the Chiefs of Staff as to whether this country retain their largest carriers or not. Ministry of Defence recommend them out; Admiralty want them retained. General opinion: we cannot afford them. If M & D get their way there will be no Fleet Carriers and thus no GR17s (of any type).

b) If Fleet carriers are retained the Mamba GR is by no means dead. It will depend financially on the (production) cost of Mambas. Blackburn are still going ahead fitting Mambas to their job.

c) MoS may ask us to fit a Griffon to one of our prototypes - possibly even before a final decision is taken on carriers - with a view to saving time. Coryton has stated that we are to have the chance of Griffon GR evaluation with the Blackburn job.'[1]

In addition, he also reported that:

'The Pentane position is not quite as grim as I thought in that there is one type which will fit in the GR. So far it is only fifty per cent satisfactory. There is a longer job which they expect to be more reliable and accurate - but that will not fit the GR. But this particular slant appears to be of less importance than I had thought.'[2]

It is unclear from this letter what was the precise linkage between the GR17/45 aircraft and the future shape of the Navy's aircraft carrier fleet. It is possible that it centred around the argument that the GR17/45 designs were all too heavy to operate from Escort carriers. The only carriers they could operate from were light Fleet and Fleet carriers, and the improvement in take-off performance offered by the Double Mamba engine was of little value in this as a cheaper, lower powered Griffon version could also operate from such carriers and

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1. Ibid., p. 1. Air Chief Marshal Sir W.A.Coryton, KCB, KBE, MVO, DFC was CS(A) at this time.
2. Ibid.

offered greater endurance with the same installed fuel capacity. The Double Mamba engine would only be attractive if it could be shown that any extra costs incurred by using it produced substantial improvements in the aircraft's capabilities. There is some ambiguity in the letter over whether the argument in the Chiefs of Staff committee was concerned with both the Fleet and light Fleet carriers, or merely the former. The wording suggests that only the Fleet carriers were under discussion, yet if the light Fleet carriers were also capable of operating the GR17/45 aircraft, why was its future seen as totally dependent upon the survival of the Fleet carriers? One possible explanation for this discrepancy is that it had now been tacitly accepted that none of the GR17/45 designs could be operated from unmodified light Fleet carriers because of their weight, while the Admiralty, having committed itself to the modernisation of the Fleet carriers as its first priority, had put forward no plans to modernise the light Fleet carriers in the belief that this would undermine their Fleet carrier case. This interpretation receives partial support from a further section of this letter:

> 'The Light Anti-Submarine a/c. If Fleet Carriers are discarded, this type will come into prominence - although it is not thought that anything beyond a design study (£5,000) contract will be placed during this financial year.'[1]

Such an aircraft would be capable of operating from the existing light Fleet carriers.

This letter went on to deal with two other Fairey aircraft

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1. Ibid., p. 2.

then at the design stage, the N14/49 naval night fighter and the supersonic research aircraft. The former aircraft was reported to be still under discussion at Chiefs of Staff level, but it had been agreed that work could start on the latter project. The award of contracts to airframe and component firms had been delayed pending clarification of the range of contracts which were available for letting in 1950. The letter then concluded with a greatly oversimplified description of the powers possessed by the MoS in awarding contracts to aircraft firms. It implied that the MoS alone determined which aircraft firm was chosen for a particular contract. This led to an equally oversimplified analysis of Fairey's position in relation to the three new designs they were interested in:

> 'We shall certainly not get the three types (supersonic Night Fighter and A/S aircraft). We may very well get two. Obviously the anti-sub is the larger production job eventually, - but contract placing will be well behind that on the Night Fighter. We are possibly presented with the choice of going for and accepting the Night Fighter before the anti-sub comes up for decision. If we accept the supersonic and the Night Fighter we lose the anti-sub. If we pass over the Night Fighter in the hope of getting the anti-sub we <u>may</u> lose both. Quite a choice.'[1]

One of the implications that can be drawn from this analysis of Fairey's future options is that the GR17/45 aircraft was no longer seen by them as the long-term standard anti-submarine aircraft for the Royal Navy. This label was now being attached to the projected light anti-submarine aircraft. This implies that by early 1950, the Navy had begun to accept arguments similar

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1. <u>Ibid</u>., p. 2.

to those advanced by Sir Richard Fairey in 1948 in support of his opposition to an aircraft with a take-off weight above 18,000 lbs.

This rather gloomy outlook for the future of the Double Mamba powered GR17/45 aircraft did not prevent steps being taken to prepare for production of such an aircraft. A meeting was held with Fairey in early May to discuss the changes that would be required in the Double Mamba installation if this version was selected for production.[1] Definitive dimensions of Pentane were also forwarded to Blackburn and Fairey, and they were asked to investigate the problems of redesigning their aircraft to accommodate it.[2]

Development work on the GR17/45 prototypes continued throughout this period, with the second Griffon powered, three seat Blackburn prototype flying on May 3rd.[3] It was reported that reversion to the original wing planform had produced a major improvement in longitudinal stability compared to the first prototype.[4] Fairey had experienced engine difficulties with their first prototype, one of the engines having burnt out during handling trials at the Boscombe Down Aircraft and Armament Experimental Establishment (A & AEE). Fairey were quick to point out to the MoS that this was a powerplant problem for

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1. RAFM AC-73/30 (41/d/3) GR17/45. Correspondence March 1949 - January 1950. Letter 26.4.50 inviting Fairey representatives to a meeting on 1.5.50.
2. File E. Letter to Fairey from MoS 25.5.50 and File D. Letter to Blackburn from MoS 25.5.50.
3. Jackson, <u>op.cit.</u>, p. 459.
4. File D. Minute 4.5.50.

which they bore no responsibility, and that it was a succession of these engine difficulties which were holding up flight development work.[1] The Double Mamba development programme was proceeding satisfactorily in one respect, as it had proved possible to increase the power output of the engine. This was of more interest to Blackburn than Fairey, for it meant that their Double Mamba design could probably be flown on one engine throughout its mission, thus reducing estimates for its fuel consumption, its fuel requirements and the take-off weight of the aircraft.[2]

Doubts seem to have arisen within the Naval Staff at some point in early 1950 over the positioning of the three crew members in the GR17/45 designs. In particular the desire in 1948 to have two crew members in the rear cockpit with common search equipment seems to have come into conflict with the need for an additional pair of eyes besides those of the pilot to conduct a visual search forward of the aircraft. As a consequence Blackburn and Fairey were asked to look into the possibility of revising the crew accommodation to offer improved visual search facilities. Representatives of the Naval Staff visited Fairey's works in early June to examine their proposals for such a revision. In the course of this visit, the firm was told that the new cockpit requirements would omit the previous provisions for physical communication and mutual operability of equipment between the observer and aircrewman, though such

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1. File F. Letter to MoS from Fairey, 4.5.50.
2. File D. Minute 4.6.50.

a facility was to be retained if possible.[1] The full impact of these changes was described in a revised Fairey Brochure on the Double Mamba powered GR17/45. This stated that

> "the rear cockpit is situated in the forward upper portion of the rear fuselage .... The observer occupies a seat in the rear of the cockpit, facing forward, whilst the other occupant faces aft .... Alternative seating for the crew is under consideration. This will provide for a single seat cockpit aft of the pilot and a single seat cockpit in the rear fuselage.'[2]

Simultaneously, Fairey was requested to make a preliminary study of how Pentane could be accommodated in its design. This study concluded that it was impossible to fit Pentane into any of the three existing and planned prototypes. Major structural changes would be necessary to carry it internally, as the radar scanner would have to be moved 17 inches aft, and the bomb bay doors lengthened by the same amount. Such a modification would cost £60,000 for the first prototype aircraft to be converted, and £18,000 each for the other two.[3]

Both firms had supplied proposals for accommodating Pentane in their designs by mid-June, though at the end of that month Blackburn complained to the MoS about the inadequacy of the information available on the weapon. It was claimed that this made it difficult to plan the detailed modifications needed to

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1. RAFM AC-73/30 (41/d/3). GR17/45 Correspondence March 1949-June 1950. Report of examination of aircraft in connection with new cockpit requirements for 3-seater anti-submarine aircraft, 2.6.50, para 10.
2. RAFM AC-73/30 (41/a/3) Gannet. Brochure on Fairey 17, a twin-engined aircraft for anti-submarine duties: undated.
3. File E. Letter from Fairey to MoS 7.6.50.

enable its aircraft to carry the weapon. It was also stated that little information was available on the type of accommodation that would be needed for the British sonobuoys and their equipment.[1]

Fairey attempted in early June to directly influence the discussions between the Admiralty and the MoS over the choice of powerplant for production GR17/45 aircraft. They forwarded to the MoS a lengthy memorandum which, together with a covering letter, diplomatically argued the case for a Double Mamba powered aircraft. In the letter they stated emphatically their belief that the Griffon engine could not satisfactorily replace the Double Mamba in their GR17/45 design. They indicated that if financial stringency was to force the Ministry to proceed with such a conversion, they would be prepared to undertake this task, provided they received a contract to cover their costs. Their rough estimate was that it would cost £1,000 to modify a prototype to take the Griffon engine, £60,000 to increase the dimensions of the bomb-bay to take Pentane or £85,000 to simultaneously alter the bomb bay to take Pentane and revise the rear cockpit layout.[2]

The memorandum argued the case for the Double Mamba powered aircraft in great detail. It stated that

> 'it is understood that the reason for the consideration of this possible change in policy is connected with the greater cost of the twin Mamba installation compared with the single Griffon, and that this may be in the order of £5,000 per aircraft. Quite obviously any means

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1. File D. Letter from Blackburn to MoS, 27.6.50.
2. File E. Letter to MoS from Fairey, 7.6.50.

of reducing the high cost of defence services in these days of financial stringency is most desirable provided only that technical and operational superiority is not jeopardised. The Fairey Aviation Co. consider that there is a serious risk of this occurring if the Griffon is considered as the production engine for the GR17/45 specification as at present laid down. The reasons for this are:

(a) The Double Mamba is rated at 2830 eshp and weighs 2,000 lbs. The Griffon is rated to produce 2430 hp and weighs 2140 lbs., but it must be remembered that the Griffon hp is only obtained by the use of water and methanol and will be reduced by at least 200 hp due to the need to fit flame dampers in operational use, to say nothing of the weight and drag of the flame dampers and interference with the pilot's view. It is not thought that any aircraft built to the GR17/45 specification will meet the take-off requirements at full operational load using the Griffon engine, and it is certain that the weight of the aircraft will increase in service, as will the equipment and the weapons to be carried.

(b) The Double Mamba has ample scope for development to meet normal increases in All Up Weight as a result of developments in service. The Griffon has reached its peak of possible development.

(c) Using the Double Mamba, the forward view for the Pilot, and Navigator if necessary, for deck-landing and anti-submarine search is remarkable, but it is nevertheless only adequate to meet the requirements for weapons sighting. It is impossible to meet this requirement with the Griffon installation.

(d) It is frequently overlooked that the Mamba GR17/45 is a twin engined aircraft, and its cost should not therefore be compared to a single engined type. It should also be remembered that engine failure of a single engined type over water means the loss of the aeroplane, while with the Double Mamba, with its characteristics of symmetry in flight, it should always be possible to return to the carrier, saving not only the aircraft and equipment, but the crew as well. In proof of this, following the failure of one engine at Boscombe Down, the aircraft was flown back to White Waltham on one engine.

(e) The Double Mamba will in future use any type of fuel including ships' boiler fuel. This will give advantages under operational conditions, plus increased safety as regards fire risk in the carriers, and with other factors balances the extra bulk of fuel required for the Double Mamba.

(f) The lower noise level and lack of vibration with the Double Mamba will reduce crew fatigue and improve maintenance of aircraft instruments and delicate radar which is susceptible to aircraft vibrations.

(g) The much reduced maintenance costs of the turbine engine will soon recover the greater purchase price of the new engines.

In conclusion, and taking into account the envisaged higher cost of a Double Mamba installation, we consider that it would be a retrograde step to use a Griffon engine for the production aircraft. We feel strongly that this would not be in the best interests of this type of aircraft.'[1]

Since the Ministry of Supply were strongly in favour of a Double Mamba powered GR17/45, this memorandum was presumably intended for use in their discussions with the Naval Staff. Following this move, Fairey submitted a further brochure to the MoS on a Griffon powered version of their GR17/45. This contained an estimate that it would take eight months to fit a Griffon engine into one of the prototypes. Performance figures were similar to those given in the proposals of the 24th April, with the addition of some interesting figures for landing-weights, which were given as 16,875 lbs. for the Double Mamba version and 17,100 lbs. for a Griffon 57 version.[2] These considerably exceeded the maximum figures demanded by the First Sea Lord in late 1948 to ensure the aircraft could be operated from unmodernised Light Fleet carriers, and go a long way to explaining why production of this aircraft was seen as intimately linked to the survival of the Fleet carriers

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1. File E. Memorandum from Fairey to MoS 7.6.50.
2. Ibid. Brochure on Griffon engined Fairey GR17, received by MoS, 17.6.50.

DMARD prepared a summary minute on these Fairey submissions in mid-June for consideration by the Admiralty.[1] Simultaneously, a series of official competitive carrier trials were being conducted on board HMS Illustrious with the existing GR17/45 prototypes. The initial report on these trials seemed to favour the Fairey Mamba prototype, which had proved satisfactory in almost all respects. The sole exception was that the height of the wing leading edge had created major difficulties for the deck handling party. By contrast, the second Griffon powered Blackburn prototype had suffered a minor accident during the trials, and the tail had been very close to the roof when the aircraft was in the hangar. The power plant had required topping up with water and methanol after every flight, while the aircraft had an unpleasant tendency to pitch onto its nose when the brakes were applied.[2]

Attention centred upon attempts to decide which of the GR17/45 aircraft to recommend for production from mid-June onwards. In parallel, the two firms continued their attempts to develop the GR17/45 prototypes, and widen the basis of support for them. Blackburn made a rather speculative attempt to offer their aircraft to the Air Ministry as a Coastal Command Patrol aircraft at the end of June.[3] The genesis of this offer is unclear, and the response was swift. The idea was instantly rejected, as the Air Ministry had no current requirements for such an aircraft.[4] The episode suggests that Blackburn had

1. File C. Summary Minute by DMARD 15.6.50.
2. File O. Report on GR17/45 carrier trials 19th-23rd June 1950.
3. File D. Letter from Blackburn 29.6.50 and Jackson op.cit. p.529. The latter suggests that work on this project started in mid-May.
4. Ibid. Minute 4: Letter to Blackburn 1.7.50.

few of the informal liaison channels with the services and the MoS than Fairey seemed to possess, and had to resort to rather uninformed, formal enquiries to gain insights into service thinking and current programmes.

Fairey were also attempting to broaden the basis of support for their GR17/45 design by offering it for a number of additional roles. The first of these, Project 44, envisaged a modified GR17/45 design, equipped with two Aden cannon and intended for long range operations. In this configuration the aircraft would have had a take off weight of 20,000 lbs., a maximum speed of 268 knots, and an endurance of 9.25 hours at a cruising speed of 125 knots.[1] They also proposed that their GR17/45 design could be used as a carrier-borne transport aircraft to carry such items as spares in cases of urgency or emergency.[2] This suggestion was rejected by the Admiralty in January 1951.[3]

No contracts were given to the firms to modify their prototypes to accommodate Pentane and implement the revised cockpit arrangements, despite the probability that both changes would be incorporated in production aircraft.[4] It had now been realised that Pentane and the new British sonobuoys would increase the maximum load of weapons and stores the GR17/45 would be required to carry in service from the 2,000 lbs. limit written into the requirement to approximately 3,000 lbs.[5] To partially compensate

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1. RAFM AC-73/30 (43/c/1) GR17/45. Correspondence July 1950 - December 1950. Note on Project 44. 14.12.50.
2. File E. Letter from Fairey to MoS 20.12.50.
3. Ibid. Letter from MoS to Fairey 21.1.51.
4. File O. Minute 19.8.50.
5. File P. Minute 25.8.50.

for this increase, Armstrong Siddeley had published a new brochure on the Double Mamba engine which gave its power as 2640 shp plus jet thrust, compared with the previous 2540 shp figure.[1]

Fairey and Blackburn also received information on two new naval projects in September. The first of these concerned the naval night fighter. The Chiefs of Staff had finally agreed that the Navy could have such an aircraft and a new requirement had been drawn up. An unofficial copy of this was given to Fairey, and they realised that a performance far superior to their existing N14/49 design study was now required, and that they would have to start work on a completely new design.[2] Blackburn also seem to have received similar information, for they started work on such a design in late September.[3]

The second project was initiated by a letter from the Assistant Director of Research and Development for the Navy in the MoS (AD/RD N) to the Ministry of Supply's Resident Technical Officer (RTO) at Fairey's Hayes works. This stated that the Naval Staff had asked for a preliminary investigation into the practicability of installing the United States AN/APS 20B early warning radar into the GR17/45 aircraft, and wanted a report from both the airframe firms on what was involved in such an installation.[4] Design investigations of this variant were

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1. File F. Brochure referred to in Minutes of 5th Progress Meeting on Gannet ASMK1 30.10.52.
2. RAFM AC-73/30 (41/c/1). 114T 1951. Fairey Project 42 and Brochure to N114T, 26.7.51.
3. Jackson, <u>op.cit.</u>, p. 529.
4. RAFM AC-73/30 (43/c/1). GR17/45 Correspondence July 1950-December 1950. Letter from AD/RDN to Fairey's RTO 16.9.50.

started by both Fairey and Blackburn before the end of September, and Fairey submitted a preliminary design brochure for such an aircraft during October. It showed a simple grafting of the AN/APS 20B radar scanner onto the underside of the Fairey design between the undercarriage main wheels. The rest of the aircraft was standard, with two crew members in front-facing cockpits, and the third in an aft facing rear cockpit.[1] Blackburn also submitted a brochure on the modifications that would be required before their aircraft could carry this radar equipment.[2]

The new arrangement of the crew in the Fairey aircraft appears to have been finally agreed by the Admiralty during September, for in early October, their General Manager (Engineering) circulated a Memorandum stating that

> 'Authority has now been given for design and manufacture to proceed to convert the present three seater WE488[3] to the proposed scheme, having only one crew in the rear cockpit, the other crew member being positioned just aft of the pilot's cockpit.
>
> This redesign to also include rearrangement of equipment to last known requirements.'[4]

The final link with the original weapon/search equipment combination intended for the GR17/45 in 1945 was broken during October when DAW sought approval to abandon production of the ASV15 radar set. This was already in production and 100 had been made at a cost of £225,000, but it had reluctantly been

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1. File C. Brochure received by MoS 27.10.50.
2. Jackson, op.cit., p. 529.
3. This was Fairey's third prototype, and the first three-seat version.
4. RAFM AC-73/30 (43/c/1) GR17/45 Correspondence July 1950-December 1950. Memorandum from General Manager (Engineering) 5.10.50.

decided it was unacceptable for service use.[1]

A further item of equipment common to both firm's designs that was giving problems was the turbo-starter for the Double Mamba engines. This had been one of the few items of equipment for which a parallel development strategy had been used, both the Rotax and B.T.H. companies having been given contracts to design competing units. Both units had experienced development problems and unless they could be resolved, it would not be possible to predict accurately a likely production date for the aircraft.[2] Fairey also had an additional problem with the engine accessories of their prototypes. In mid-November, they complained to the MoS that they had few spare constant speed units or feathering pumps.[3] The latter deficiency was a product of ROTOLS contract for these pumps only specifying that they should be capable of operating for 10 minutes. Since engines were rarely stopped in flight, this was adequate for normal purposes. By contrast, this was the standard procedure to extend the endurance of the Double Mamba GR17/45 and the existing stock of pumps was being used up rapidly. Fairey asked for the contract to be altered to cover an increased number of pumps.[4]

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1. File D. Minute 13.10.50.
2. File F. Minute placed at 10.50 in file.
3. A feathering pump is a device for halting a propeller in flight and changing the angle of the propeller blades so that it produces minimum drag, and thus has little adverse effect on the performance of an aircraft.
4. File F. Letter from Fairey to MoS 10.11.50.

iii. The Production Decision.

The first indication that pressures were building up for an early decision to be taken on which GR17/45 variant to put into production came in June 1950. Details had been received by the MoS of the modifications needed to enable the competing designs to carry Pentane and to fulfil the new requirements for crew accommodation, while Fairey had supplied details of their current proposals for a Griffon engined version. CNR decided to hold a meeting in July to review the position of the aircraft in the light of these proposals and the results of the preliminary deck-landing trials which were to take place in late June. A note was circulated requesting submissions for consideration by this meeting and stating that there were two reasons which it was necessary to rapidly reach a production decision. The first was that it was desirable to tell the firms involved as soon as possible which of them would produce the aircraft. The second was that the economic situation demanded that development of one of the types be swiftly terminated, in order to reduce expenditure.[1]

In the period between the decision to call this meeting, and the meeting itself, the international situation changed rapidly. On the 25th June, North Korean forces crossed into South Korea and the Korean war commenced. British aircraft carriers were sent to Korean waters, and on 1st July, the first air strikes were launched from them against North Korean forces.

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1. File D. Summary Minute requesting appreciations of the GR17/45 position for the meeting on 20.7.50, circulated 13.6.50.

By the end of August, British ground troops had also been committed to the fighting.[1]

When the meeting convened on the 20th July, CNR stated that its purpose was to try to arrive at a decision on which GR17/45 design to order into production.[2] DAW indicated that despite recent events, there was no reason why this decision should be affected by considerations arising out of the international situation. A number of varied viewpoints were then put forward on which design should be chosen. It was argued that the June deck landing trials had demonstrated that the Blackburn Griffon prototype was far more satisfactory from a handling viewpoint than the Fairey Double Mamba, as the latter had experienced control problems. It was also stated that it was going to be substantially cheaper to modify Blackburn's design to take Pentane than the Fairey design. A further line of argument that was developed was to postpone any decision on production until trials had been carried out with Pentane. This was based on the belief that one of the designs might prove to be incapable of carrying and dropping the torpedo. A fourth viewpoint expressed was that the Fairey Griffon engined design would probably be better than the Blackburn design. In contrast to this, it was argued that a fully developed engine such as the Griffon should not be used in a new aircraft, and that both Griffon engined designs should be given no further consideration.

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1. Bartlett, <u>op.cit.</u>, pp. 54 and 55.
2. Files D & E. Minutes of meeting to discuss aircraft built to specification GR17/45 20.7.50.

A further argument was that the Fairey Double Mamba possessed major and unambiguous advantages over the Blackburn Double Mamba design. It was stated to be doubtful if the latter had sufficient tankage to achieve the $4\frac{1}{2}$ hours overload endurance specified in the Staff Requirement.

CS(A), who chaired the meeting, indicated that after listening to these arguments, he felt that work on the Blackburn Griffon aircraft should be terminated, as it did not meet the Staff Requirements. This initiated a lengthy discussion on whether this was in fact the case, especially as its poor take-off performance was no longer relevant as the Requirement allowed the use of RATOG. Both CNR and DMARD indicated that in their opinion it just met the requirements. It was also argued that the majority of the shortcomings that the Blackburn Double Mamba was alleged to possess were based on estimates, as the third Blackburn Double Mamba prototype had only flown for the first time the previous day. The Chairman then stated that in view of the preceding discussion, he felt that any decision taken would be determined by the urgency of the situation. If the Admiralty wanted to move into immediate production, then they should choose the Blackburn Griffon version. If they were prepared to delay their decision, their best long term choice was probably the Fairey Double Mamba, modified to take Pentane. DAW then revealed that his interim advice to the Admiralty Board had been to accept any delay incurred by carrying out comprehensive competitive trials on all three GR17/45 variants, unless a consensus emerged from the current meeting which enabled the MoS to recommend that development of one or more of the aircraft should be terminated. CS(A) responded by reiterating that he felt the Blackburn Mamba was hardly worth considering. DMARD argued that although the current performance estimates appeared to support this view, they were not necessarily correct, and generally the Blackburn aircraft had proved the better one to date. The argument then descended to the level of reputations and beliefs, with DG/TD(A) implying that Fairey had a better reputation than Blackburn, and that on this basis their design should be adopted.

A more constructive approach to the problem was then initiated with the suggestion that one method of correcting the deficiencies of the Blackburn Mamba would be to allow Blackburn to redesign the wing to give it increased span and area and therefore lift. CS(A), while not dissenting from this suggestion, stated that to obtain the best possible aircraft it would be necessary either to completely redesign the Blackburn Mamba, or allow an extensive redesign of the Fairey Mamba. Even if this was to occur, he still felt the Fairey design would emerge as the better aircraft.

In an attempt to obtain at least one positive decision from the meeting, DMARD then suggested that the Fairey Griffon project should be terminated. Even this was opposed, it being argued that this version offered greater endurance than the other three, and that the only real criticism that could be levelled against it was the limited power of its engine.

CS(A) then indicated that he felt the choice of powerplant for the aircraft was a matter for the Admiralty, not the MoS.

Strong views were then expressed that unless the Admiralty wanted an immediate, short term aircraft, the Griffon engined versions should be terminated immediately. It was also felt that if a Griffon engined version was adopted by the Navy, it was likely that a turbine powered variant would rapidly supplant it. DAW stated that to choose the Blackburn Griffon for production would inevitably mean a later change to the Double Mamba as its power-plant. AD/RDN supplemented this comment by pointing out that it would be fairly simple to change over from the Griffon to the Double Mamba with the Blackburn design and then even to revert back to the Griffon if the engine supply position made this necessary. The Fairey design, on the other hand, would have to be very extensively modified before such interchangeability of power-plants could be achieved. DMARD, who had throughout the meeting visibly favoured the Blackburn designs, expanded this argument further by suggesting that if a Double Mamba powered aircraft was required, Blackburn's design should be chosen because of the ease with which it could be converted from Griffon to Double Mamba power, and that to assist this process the position of the Double Mamba accessories should be altered. He again stressed that the main criticisms of the Blackburn Double Mamba were based upon paper estimates and the firm's previously poor reputation compared to Fairey, though DG/TD(A) forced him to agree that paper estimates were usually fairly accurate. DAW, who seemed to cautiously favour the Fairey design, responded by stressing that the major points favourable to the Fairey Double Mamba design were its shorter take-off and slower landing speed.

The Chairman concluded the discussion by observing that no generally acceptable decision on which aircraft to recommend for production appeared likely to emerge from the meeting. He now felt it was the responsibility of the Admiralty to consider the factors and arguments discussed during it, and to inform the MoS of their decisions so that development and production could be suitably directed.

The Admiralty Board responded to reports of the substance of this meeting by asking the MoS to give them information on four items. These were:

a. the endurance of the Mamba engined Blackburn aircraft.

b. the maximum weight at which it could maintain height on one engine.

c. (i) an assurance that the Blackburn Griffon had good control qualities, and

(ii) these could be reproduced in the Mamba version, and that the change of engine would not induce the control difficulties being experienced with the Fairey prototype.

d. Information on Fairey's proposals for improving the control of their aircraft, with particular reference to whether a two position tailplane was essential. The Admiralty indicated they did not favour this latter complication.[1]

The MoS responded to the Admiralty Board's questions by initiating a special investigation into them.[2] It was then decided to extend the investigation to include a further series of carrier and flying trials, plus tactical and weapon delivery trials. These latter trials were to be conducted by the anti-

1. File D. Minute placed in file. August, 1950.

2. Ibid.

submarine school at Londonderry, using the three seat Blackburn and Fairey prototypes, and were scheduled to start on the 1st December.

Although no decisions had been taken on the production version of the GR17/45, it is probable that the Navy's questions reflected a tendency on the part of the Admiralty Board to look more favourably upon the Blackburn design than the Fairey one. It offered three major advantages over the latter design at this time. First, the Blackburn arrangement of the crew sitting together under a continuous cockpit canopy both enabled them to be in physical touch with each other, and to perform visual search tasks. Fairey's uncertain arrangement of two crew in front and one at the back, or one in the front and two in the back failed to offer this dual capability. Second, the Fairey aircraft was known to be experiencing difficulties with its elevators which adversely affected its control characteristics under certain conditions, while the Blackburn design was apparently free of such faults. Since having an aircraft which was safe to fly was of paramount importance to the Admiralty Board, this defect probably outweighed the lack of endurance possessed by the Blackburn Mamba design. Finally, the Blackburn design offered the inherent flexibility of being able to switch from the piston engine to the gas-turbine and back again as cost and circumstances demanded. This could serve as an insurance against the untried gas-turbine power-plant proving unsuitable for service use.

It is probable that information on the major criticisms made of the Blackburn Double Mamba design during the July meeting had been transmitted to the firm by MoS officials, for during August they asked the Ministry for permission to increase the wing span and wing area of their third, Double Mamba powered, prototype. They hoped that this would increase its endurance and enhance its take-off performance and ability to cruise on one engine. The firm estimated that it would take about six weeks to complete this work, enabling them to have the aircraft ready for flying by mid-October, and able to take part in the series of carrier trials which had been scheduled for early November.[1] Modification work on this third prototype started when the aircraft returned from the SBAC show on the 11th September.[2]

The deficiencies in the Blackburn design appeared to be purely technical in nature, but the control problems being experienced by the Fairey design masked a major breakdown of co-ordination within the Fairey organisation. The lack of an effective centralised project management system had been commented on unfavourably by a MoS official in January 1950, when he noted that it had been necessary to consult six people to find out what was being done to resolve the handling problems of the Fairey GR17/45.[3] Fairey's flight test department was situated at White Waltham, while the design department

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1. Ibid. Letter from Blackburn to MoS 14.8.50.
2. Jackson, op.cit., p. 460.
3. File C. Minute 21.1.50.

was at Hayes, and this physical separation added to the problems of co-ordination. In addition, Fairey had run down their experimental section and used its facilities to build production aircraft. This meant that no part of the Fairey organisation had the specific responsibility of manufacturing ad hoc modifications for prototype aircraft.[1]

The control difficulties culminated in a heavy landing by one of the prototypes at White Waltham on 23rd August, in the course of which the aircraft's nose wheel collapsed.[2] This confirmed the test pilot's opinion that until effective modifications were made to the elevators, the aircraft was unfit for service use and very dangerous to fly.[3] At approximately the same time, Sir Richard Fairey was told informally by a senior officer in the Admiralty that Fairey would lose the GR17/45 production contract unless they took rapid steps to retrieve the situation.[4]

Sir Richard Fairey's response was to ask Mr. G.W. Hall to accept the responsibility of making the Fairey GR17/45 aircraft fit for service flying. Hall, the head of the company's Research and Armament Development Division, had been a Fairey director since November, 1949.[5] He was now appointed Technical Director of the company, and made responsible for all the

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1. Interview with Mr. G.W.Hall, C.Eng., FRAeS., former Managing Director, Fairey Aviation Co. Ltd.
2. RAFM AC-73/30 (41/c/1) GR17/45. Correspondence July 1950-December 1950. Report dated 23.8.50.
3. Interview with Hall, <u>op.cit.</u>
4. <u>Ibid.</u>
5. <u>The Aeroplane</u>, 4th November, 1949, p. 604.

engineering aspects of the company's work. Under his leadership, the flight testing and experimental design and production sections of the firm were reorganised, and co-operation and co-ordination between them was improved. A swift appreciation was made of the elevator troubles afflicting the prototypes, and a temporary modification was made to the position of the elevator hinges, pending a definitive redesign of these components. This restored the effectiveness of the elevators, and the flight test programme was resumed. A change was also made to the communication system between Fairey and the MoS and Admiralty, with Hall being designated as the person within the Fairey organisation through which all requests for information and modifications to the GR17/45 aircraft should be channelled.[1] In consequence, by mid-September, Fairey had started to operate as a coherent and centrally directed development organisation.

The start of the Korean war at the end of June 1950 was followed by perceptions that the general international situation was deteriorating. The British government started to take measures to improve its military capabilities by increasing its Defence Budget. On the 26th July 1950 it announced that an extra £100 million would be added to the existing 1950/51 budget to fulfil the urgent equipment needs of the armed forces.[2] On the 4th August it was decided that during the following three years £3,400 million would be spent on defence. When Parliament was informed of the details of this in mid-September this amount

1. Interview with Hall, op.cit.
2. Bartlett, op.cit., p. 60.

had increased to £3,600 million.[1] A final increase came at the end of January 1951, when the figure was revised to £4,700 million, giving a level of yearly expenditure almost double that envisaged early in 1950.[2] By mid-September 1950 the financial restraints upon production expenditure had been removed and the dominant problem had become one of finding equipment to purchase.

MoS personnel maintained a close watch on the activities of both GR17/45 design firms from August onwards, and it was reported that Blackburn was proving much more responsive to the wishes of the Admiralty and MoS than Fairey. DMARD was informed in October that Blackburn were making every effort to put forward an aircraft which would be acceptable to the Navy. They had both a two-seat and three-seat Griffon prototype available for immediate evaluation, while work was proceeding rapidly on the modifications to the three-seat Double Mamba prototype which were intended to improve its performance.

Progress with the Fairey project was regarded as much less satisfactory by the MoS officials. Both two-seat prototypes had flown, but it was unclear when the firm would be able to complete the third, three-seat prototype. This was due largely to indecision over the preferred cockpit arrangements. The issue was eventually resolved by direct discussions between Fairey and MoS representatives, and it was stated at an internal policy meeting of Fairey executives on 4th October that 'it should be known that we are now preparing to complete the third

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1. Ibid.
2. Ibid., p. 61.

prototype with the revised 3 seat arrangement, i.e. pilot and observer forward and crewman aft, in accordance with the Form 555[1] prepared as a result of Commander Harrison's visit on this subject. Further discussions should be held with Commander Harrison to make sure that our interpretation of the requirements was up to date.'[2] At the same meeting it was also agreed that the General Manager (Engineering) should inform CNR that they would try to have this modified aircraft available for the Londonderry tactical trials.

Fairey's General Manager (Engineering) issued instructions after this meeting for design and manufacturing work to start to convert the uncompleted third prototype to the new cockpit arrangements.[3] Simultaneously instructions were given that all design work on the Griffon engined GR17/45 was to be suspended until further notice.[4] No evidence is available to indicate whether this had resulted from the receipt of information that the Admiralty was now no longer interested in such an aircraft, or was merely a decision to assign greater temporary priority to design work on the new crew arrangement.

The MoS officials dealing with the GR17/45 project appear to have been unaware of these developments, for they believed that the central problem was that Fairey were unprepared to

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1. Form 555 was the standard method of reporting the minutes of technical meetings held to discuss modifications to an aircraft design.

2. RAFM AC-73/30 (43/c/1) GR17/45. Correspondence July 1950-December 1950. Notes of meeting 4.10.50.

3. Ibid. Internal Memorandum from General Manager (Engineering) 5.10.50.

4. Ibid. 6.10.50.

spend any more of their own money on altering the third prototype to meet the new cockpit requirements.[1] They feared that this would make it impossible to hold effective competitive tactical trials at Eglinton[2] in December. A meeting was arranged between AD/RDN and Fairey's Chief Designer and General Manager (Engineering) on 12th October to discuss this issue. The latter's perception of this meeting was that AD/RDN 'explained ... (that) ... the Eglinton assessment trials ... (were) ... due to start on the 1st December, and be completed by the 31st December on a definite ruling by the Admiralty .... He stressed that there was no latitude in these dates, but I believe he did this with his tongue in his cheek.'[3] The Fairey representatives had told AD/RDN that they would attempt to comply with this, but that they felt there should be 'no disruption of the proposal to modify and equip the third aircraft in accordance with the advice of Commander Harrison (RD/QN) and he was handed a copy of Mr. Spinks' notes of Commander Harrison's visit of 10th October ....'[4] This document suggests that Fairey had been told by their Admiralty contacts that it was more important to proceed with redesigning and rebuilding the aircraft to the new configuration than having it ready for trials on the 1st December. This would explain why the Fairey representatives

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1. File E. Minute from DGRD(A) to DMARD 5.10.50.
2. Eglinton was an airfield outside Londonderry, Northern Ireland, which housed the Fleet Air Arm Component of the Joint Anti-Submarine School.
3. RAFM AC-73/30 (43/c/1) GR17/45 Correspondence July 1950-December 1950. Notes on meeting at MoS 12.10.50.
4. <u>Ibid</u>.

were very sceptical of AD/RDN's attempts to impress upon them the rigidity of the deadline and the need for urgency. It also suggests that Fairey regarded responsiveness to the perceived wishes of the Admiralty as more important than complying with requests from the MoS.

Blackburn were informed by letter in mid-October of the programme of trials for the GR17/45 aircraft. These were to include flying trials from HMS Illustrious and Boscombe Down in late October and November, and tactical trials at Eglinton from the 1st December. It was hoped that these trials would allow a decision to be reached by the end of the year[1] on which aircraft should go into production.

The modifications to the Blackburn Double Mamba prototype were completed by the end of October and the aircraft was able to commence deck-landing trials aboard HMS Illustrious on the 30th of that month.[2] It became clear during this and later trials that the extended wing tips, which had been intended to improve the aircraft's endurance, had had unforeseen side effects: they tended to stall at slow speeds, producing control difficulties and a marked loss of take-off performance. It was accepted by the MoS that this was a temporary problem which could be overcome by a process of trial and error. The apparently inflexible trials schedule meant that Blackburn had no time to alter these

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1. File D. Letter from MoS to Blackburn. 14.10.50.
2. Jackson, op.cit., p. 460.

wing tips and the comparative assessments of the GR17/45 variants had to be based on the existing design. This led to the view being articulated within the Ministry that it would be wrong to take such a vital decision while the Blackburn prototype was suffering from a fault which could easily be remedied if the firm was given a little time for ad hoc experimentation.[1]

The Admiralty's desire that a decision should be made by the end of December led the MoS to call a preliminary review meeting on the implications of the GR17/45 flying trials on the 22nd November. It was stated at the outset of the meeting that the Admiralty's interest in a Griffon engined version of the GR17/45 had declined. One explanation for this decline may have been the placing of large production orders for the Firefly VII interim anti-submarine aircraft.[2]

The meeting was primarily concerned with discussing the GR17/45 variants in terms of a number of technical criteria. The first of these was ease of production. It was stated that Fairey had a larger production organisation and greater facilities, and would be able to start production more rapidly than Blackburn, but extensive redesign and development work would be needed on their prototypes before production could start. The second criterion was potential for future development. Boscombe Down had reported that it would be relatively easy to modify the Blackburn aircraft, but that the Fairey

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1. File D. Summary Minute 16.11.50.
2. For details, see pp. 366 and 377 below.

design's method of construction made such changes difficult. It was also noted that the Blackburn aircraft had a much greater ability to accommodate increased weapon loads and additional radar equipment than the Fairey design. The third criterion was ease of maintenance and serviceability. It was agreed that the Blackburn design was superior in this area. The final criterion to be discussed was that of operational capabilities. The Fairey design was judged to be clearly superior in this area. It had proved to be very easy to land on a carrier's deck, and it had an exceptional pilot's view.

The Chairman's summing up was devoted almost entirely to a discussion of the flying qualities of the aircraft rather than their technical attributes. He said that if the Admiralty wanted a Griffon powered aircraft they would have to adopt the Blackburn design, but warned that this had to be regarded as an interim aircraft because no plans existed to increase the power of the Griffon engine. He judged the Fairey Mamba to be a very good aircraft which was fully up to CS(A) release standards. By comparison the Blackburn Mamba had very inferior flying qualities, and he was doubtful whether it was safe to allow service pilots to fly it in its existing configuration.[1]

Detailed instructions had meanwhile been sent to the Anti-submarine School at Londonderry concerning the trials to be carried out at Eglinton airfield during December. These were to be conducted with three aircraft:

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1. File D. Minutes of meeting on the technical implications of the choice of the GR17/45 for possible production 22.11.50.

1. The Blackburn Griffon three-seat second prototype.

2. The Blackburn Double Mamba three-seat third prototype.

3. The Fairey Double Mamba two-seat first prototype.

It was stated that the object of the trials was to evaluate the tactical qualities of each aircraft. These were defined in terms of five elements: (a) search capability; (b) patrol capability; (c) tracking ability; (d) attack characteristics; (e) crew communications and co-ordination system.[1]

These tactical trials were scheduled to start on 1st December. At the end of November, it was decided to hold a meeting of the Admiralty Board in mid-December to discuss the detailed results of the carrier flying trials. It was stated that this would clarify the future of the three designs.[2]

The official report on the carrier trials was available by 13th December. In summary form, its conclusions were:

	Fairey Mamba	Blackburn Mamba	Blackburn Griffon
Carrier operations	Extremely good	Good	Good
General handling	Very good	Unsatisfactory	Good

It was stated that the Fairey aircraft had no basic handling defects, and those that did exist were curable. It was also felt that the aircraft would accept considerable changes in configuration and increases in take-off weight, as it was able to fly comfortably at 120 knots on only one engine. It also offered the pilot an exceptional view over the nose.

1. File AE. Letter from Admiralty to Commanding Officer, Anti-submarine School, 15.11.50.

2. File F. Minute dated 29.11.50.

The Blackburn Mamba was stated to possess serious general handling defects. It was judged to have little potential for future development, as the new wing planform did not constitute an efficient lifting surface. In addition, unexplained engine stalls had been experienced with the aircraft. It was felt that it would be difficult to either change its configuration or increase its take-off weight as its performance was already marginal. The minimum patrol speed that could be sustained with the aircraft was 140 knots, and at that speed, 78% of the available engine power had to be used. This meant that the aircraft was unlikely to be able to carry the standard operational load of 2,000 lbs. of weapons and equipment under tropical conditions.

The criticisms of the handling of the Blackburn aircraft were equally applicable to the Blackburn Griffon. In addition, this variant offered a more restricted pilot's view than the Double Mamba version, and the single engine was much noisier.

The report concluded that the Fairey Mamba design was the better prospect for production and future development.[1]

The knowledge that this report was likely to be conclusive appears to have resulted in a decision to delay the tactical trials for, on the 7th December, Fairey's General Manager (Engineering) circulated an internal memorandum stating that he had been informed by telephone that it had been decided

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1. File AF. Report on A & AEE appreciation of GR17/45 aircraft. 13.12.50.

to send the personnel of the Anti-submarine School on Christmas leave and resume the trials in the New Year, with the object of completing them by 31st January.[1]

One of the major criticisms made of the Fairey design during the November preliminary review meeting had been its poor provisions for maintenance and servicing. A Fairey team visited Boscombe Down on 15th December to discuss this,[2] and the issue was raised again three days later in an informal discussion at Hayes with RDQN. He emphasised the Navy's belief that the aircraft would take an excessive time to service under operational conditions, and confirmed that the firm had to take steps to modify it. The future development of the aircraft was then discussed in terms which could be taken to indicate that Fairey were about to be awarded a production contract. RDQN indicated that although no final decision had been taken on the cockpit arrangements for production aircraft, the two forward plus one aft crew distribution would probably be favoured. He also stated that the 36 inch radar scanner might be too large for the aircraft, and that there was a possibility of a 22 or 24 inch one being introduced instead: a firm decision would be taken on this within three months. The Fairey representatives were also informed that although the plans to lengthen their bomb-bay still left it 30 cu. ft. smaller and

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1. RAFM AC-73/30 (43/c/1) GR17/45 Correspondence, July 1950-December 1950. Internal memorandum from General Manager (Engineering), 7.12.50.

2. Ibid. Report on visit to A & AEE to discuss points arising from second 30 hr. inspection by naval personnel. 15.12.50.

6 inches shorter than that possessed by the Blackburn aircraft, it had been considered acceptable in view of the superior performance offered by the Fairey aircraft. RDQN indicated that production aircraft would also have to have facilities for the stowage of arctic survival gear, and that meetings would be held early in January to officially discuss these points.[1]

The available evidence seems to suggest that the Admiralty Board finally decided early in December to place the Fairey Double Mamba GR17/45 in production. Their emphasis in the summer upon obtaining an aircraft with acceptable handling qualities makes it probable that this was the main criteria upon which they based their decision. It was certainly not maintainability, or the ability of such an aircraft to perform its full role effectively, for the tactical trials had only just commenced, and the three-seater Fairey prototype had not been completed. In view of the damning report from the A & AEE on the handling qualities of the Blackburn designs, the Board probably felt they had little option but to award the production contract to Fairey.

The final action to terminate the prototype competition occurred on the 5th January, when the Admiralty's decision to order the Fairey aircraft was communicated to the MoS. One day later, DMARD wrote to Blackburn's Chief Designer to inform him of this decision.[2]

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1. Ibid. Notes on informal discussion with RDQN held at Hayes, 18.12.50.
2. File D. Letter from DMARD to Blackburn's Chief Designer, 6.1.51.

iv. The Gannet AS Mk I Production Requirement.

It seems likely that before the production contract was officially awarded to Fairey, a detailed list of the modifications needed to bring the prototype design up to a production standard had already been drawn up. This list contained twelve major items. They were:

1. An increase in bomb-bay length.

2. A re-arrangement of the rear cockpit and its equipment.

3. The repositioning of the 36 inch radar scanner for the new ASV19B radar.

4. The repositioning of the undercarriage 6-8" aft.

5. A redesigned undercarriage to accept forces of 16 ft/second at 20,000 lbs. landing weight.

6. An improvement in access to the engine installation.

7. An increase in electrical power through the provision of a new auxiliary gearbox.

8. The installation of bomb-bay heating.

9. The provision of hydraulic brakes, a modified hydraulic system and modified electrical instruments.

10. Provision for emergency undercarriage lowering.

11. Improvements in the access to most components, particularly the variable incidence tailplane.

12. A redesign of the wing-locking mechanism.

It was stated that it would probably take about two months for the Fairey Double Mamba with these changes incorporated in it to be formally agreed as the final production standard, and in the meantime it was proposed to complete the third, three-seater, prototype as planned in order to allow the new cockpit layout and that of the existing equipment to be assessed.[1]

1. File C. Note on GR17/45 Final airframe standard, 8.1.51.

This resulted in the third prototype eventually flying for the first time on the 10th May 1951 with both a pilot and observer's position forward and a two-seat cockpit in the aft position.[1] Once this assessment had been made, it was anticipated that the aircraft would be rebuilt to the final production standard. It was estimated that this production prototype would not be completed in less than eight months from the date of the Final Production Standard Conference, and any additional alterations to armament, equipment or lay-out would mean further delaying this completion date. It was hoped to convene this Final Production Standard Conference during the first week of March.

In order to speed up development work, it was also proposed to modify externally the second, two seat prototype by fitting it with a mock-up rear cockpit canopy, so that handling trials could be conducted with it on its return from Eglinton tactical trials. This aircraft flew for the first time in this form on March 13th 1951.[2] It was also planned to build some pre-production aircraft to enable the type to complete CS(A) release trials before the first production aircraft appeared, thus enabling the latter to pass directly into naval service. On the basis of Fairey's prediction that the first production aircraft would be completed during March 1953,

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1. The Aeroplane, July 13, 1956, p. 51. It appears that at some point in the latter part of 1950 Fairey must have agreed to alter their original intention to produce the third prototype with two crew members forward and one aft.

2. Ibid.

the first pre-production aircraft would have to be available by September 1952 in order to allow six months for the CS(A) release work. As Fairey had indicated that they could produce the first pre-production aircraft by that date, and additional aircraft at a rate of one a month thereafter, it was accepted that the firm would be able to build three such aircraft for delivery in September, October and November 1952.[1]

This programme was discussed with Fairey's General Manager (Engineering), at a meeting on the 17th January. It was agreed that in practice it would be impossible to bring any of the existing Fairey prototypes up to the full production standard, and that the three pre-production aircraft would have to act as the production prototypes. This discussion led to the MoS formulating a detailed development programme for the Fairey GR17/45, which was presented to the firm in a letter from AD/RDN to Fairey's General Manager (Engineering). It proposed that one of the three existing prototypes should be used for handling trials, one for armament trials and one for radio and radar trials. The Final Conference on the aircraft would be held in September 1952, coincidental with the completion of the first pre-production aircraft, and the second and third pre-production aircraft were to be completed in October and November 1952.[2] It should be noted that no mention was made in this letter of any aircraft for engine development work,

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1. File C. Minute on Fairey GR17/45 Production Programme 8.1.51.

2. RAFM AC-73/30 (43/b/2) HFW. February, 1950-May, 1952. Letter from AD/RDN to Fairey's General Manager (Engineering) 24.1.51.

perhaps because it was believed that transferring the Blackburn Double Mamba to Armstrong Siddeley would provide them with adequate facilities for Double Mamba flight test work.[1]

In January 1951, a revised Staff Requirement, NRA9, was issued to cover the Fairey GR17 production aircraft. In contrast to previous versions, the section of the preamble specifying that the aircraft had to be capable of operating from Escort carriers was deleted, and replaced by a statement that the aircraft had to be able to operate from carriers and airfields by day or by night in all parts of the world. Endurance was specified as 3 hours on internal fuel, on one engine if necessary, plus 5 minutes at full power. Four differing roles were listed: strike, anti-submarine search, single package search/strike and training including minelaying. The difference between the strike and search roles was that in the former Pentane and sonobuoys were to be carried, and an endurance of only 2½ hours was specified. Only depth charges or small homing weapons were specified for the latter role, but endurance was increased to 4½ hours. The single package role envisaged both depth charges and sonobuoys being carried, with endurance being reduced to 3 hours.[2]

The delayed tactical trials commenced at Eglinton at the start of January 1951, but on the 9th the Commanding Officer at the Anti-submarine School was informed that the Fairey GR17/45 had been selected for production, and as a result the

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1. File D. Minute 5.1.51.
2. File C. Revised Staff Requirement NRA9, 25.1.51.

object of the trials was to be revised. Their new task was to see if there were any special features of the Blackburn design that could usefully be included in the Fairey production aircraft. In order to freeze this latter design, suggestions for major modifications had to be made by early February.[1]

Fairey became involved in a disagreement with the MoS over the Double Mamba engine position in the same month, as a result of Fairey's General Manager (Engineering) writing to AD/RDN complaining about a severe shortage of both Double Mamba engines and engine accessories. He pointed out that they had only five sets of engines for three prototypes, and argued that they required at least one more set if their development programme was to proceed smoothly.[2] In his reply AD/RDN rejected this proposition, insisting that five engines, four propellers and control units and four feathering pump motors were sufficient for the development programme.[3] This issue was to be a source of prolonged friction between Fairey and the MoS. The problems likely to be encountered with the engines during the development programme was underlined by a letter from A & AEE at Boscombe Down to the MoS received after this exchange. This pointed out that during the Boscombe Down trials programme on Double Mamba engined aircraft, five engines had failed.[4]

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1. File G. Telegram 9.1.51.
2. Ibid. Letter from Fairey's General Manager (Engineering) to AD/RDN 18.1.51.
3. RAFM AC-73/30 (43/b/2) HFW. February, 1950-May, 1952. Letter from AD/RDN to Fairey's General Manager (Engineering) 29.1.51.
4. File G. Letter from A & AEE to MoS, 1.2.51.

CNR also appears to have been aware of this problem, for when Fairey's Chief Designer (Aircraft) circulated a memorandum to other executives informing them of the results of a visit he had paid to Armstrong Siddeley on the 27th February, he reported that 'Rear-Admiral Abel-Smith has visited Armstrong-Siddeley recently, and is understood to be pressing Luby for three more Twin Mamba Units to be built forthwith. I suggest we should follow this up at Director level.'[1]

An initial order for 100 production aircraft was received by Fairey on 21st January, 1951, and during February they were told that the aim of their production programme should be to deliver 32 aircraft per month,[2] though this rapid production order was not parallelled by any equivalent urgency in agreeing the final production standard. The first major problem that arose over this was the realisation within the MoS that the operational loads specified in the revised Staff Requirement implied a substantial increase in normal take-off weight compared with previous versions of the requirement. As the original take-off weight limitations had been retained, this made it technically impossible to meet the requirement. The maximum take-off weight of the aircraft was specified as 18,500 lbs., while the basic weight of the aircraft had risen to 14,600 lbs. and the revised endurance requirements implied an increased fuel

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1. RAFM AC-73/30 (43/b/2) HFW. February, 1950-May, 1952. Memorandum from Chief Designer (Aircraft) to General Manager (Engineering) 7.3.51, para 6.

2. File X. Letter from Fairey to MoS 29.10.54.

load. It was calculated that to fulfil the Pentane strike role the aircraft would have to take-off at 19,945 lbs., comprising 14,600 lbs. basic weight, 2,450 lbs. weapon load and 2,985 lbs. fuel. This requirement was based on the need for the aircraft to make a 200 mile high speed transit on the outward journey, and a return at patrol speed to its carrier. By altering the requirement to allow the aircraft to be flown at patrol speed throughout such a sortie, the fuel requirement could be reduced to bring the take-off weight down to 19,300 lbs. These figures excluded any allowance for the strengthening of the airframe that might be necessary to allow the aircraft to operate at take-off weights in the region of 20,000 lbs.[1] Fairey had also reached similar conclusions, for on the 22nd February their General Manager (Engineering) wrote to the Deputy DMARD in the MoS on this subject. He stated that

> 'it is desired to record this Company's opinion in connection with this aircraft for your consideration in conjunction with the Admiralty.
>
> As you are aware, the aircraft has been developed from a two seater aircraft originally designed in accordance with specification No. GR17/45 dated 25.7.46 for an all up weight of 17,000 lbs. within fixed limits of span and overall length ... Spec. GR17/45 Issue II dated 24.2.49 was issued and the aircraft has been brought by the company up to a satisfactory flying standard at an all up weight of 18,500 lbs. to meet this condition ....
>
> ... NRA9 calls ... for equipment and armament which results in an all up weight of 19,500 lbs. for the main strike case ... and 20,940 lbs. for the search strike case ... (in either case omitting the autopilot). Of the increase in weight to date 75% is accounted for by increased Naval Staff and MoS requirements, and the

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1. File C. Minute 9.2.51.

significance is obvious ....

... we are strongly of the opinion that it is wrong to put the aircraft into service at the beginning of its life at 19,600 lbs ....

...(this would also) delay the introduction of the production aircraft into service.

We already have a very heavy load of modifications to deal with as a result of serious and radical changes in Admiralty requirements before production can commence e.g. cockpit, bomb bay, scanner etc....

We therefore recommend that this matter should be carefully considered and that the Admiralty should be pressed to keep the weight of the first 100 production aircraft down to 18,500 lbs. normal load .... A very early decision is essential to enable us to issue drawings for production.'[1]

A partial attempt was made to deal with this problem when the MoS issued draft specification, GR117P on the 22nd February. This stated that the maximum all-up-weight of the aircraft should not exceed 19,500 lbs.[2] This draft specification reached Fairey on the 1st March,[3] and later in the month a meeting was held between representatives of the firm, the Admiralty, and the MoS to try to find a mutually acceptable solution to the problem. In the meantime, Fairey had calculated that if the take-off weight was to be 19,500 lbs. rather than 18,500, the landing weight would increase from 16,000 lbs. to 18,000 lbs.[4] Both the Fairey and MoS representatives produced notes on the subsequent meeting. Fairey's version reported

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1. RAFM AC-73/30 (43/b/2) UFW. February 1950-May 1952. Letter from Fairey's General Manager (Engineering) to D/DMARD 22.2.51.

2. Ibid. First draft of GR117P, 26.2.51, p. 2.

3. Ibid. Letter from AD/RDN to Fairey's General Manager (Engineering). 1.3.51.

4. Ibid. Internal Memorandum from Fairey's Head of Technical Design Office to General Manager (Engineering), 12.3.51.

that the Naval representatives had turned down the firm's proposal that the first 100 aircraft should be completed to a lower weight standard, despite the fact that strength tests could take six months. The firm had agreed that if any modifications were needed to enable the aircraft to cope with the increased weight they would probably be known before the first production aircraft was delivered, and it would probably be possible to incorporate them in it, thus enabling all production aircraft to take-off at 19,600 lbs. In addition, the Fairey representatives had accepted responsibility for adapting the flying controls to cope with the increased weight, but had pointed out that considerable clarification of the detailed requirements were necessary before they could finalise the production drawings of the fuselage. Details of Pentane were still scarce, and no information had been provided on the auto-pilot and de-icing equipment.[1] The Ministry version was generally similar to the company's, but also included the information that Fairey had agreed to deliver the first six production aircraft by April, 1953.[2]

This meeting pre-empted a major outstanding issue which would normally have been discussed at the Advisory Design Conference at the end of March. As a result, the latter concentrated

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1. Ibid. Notes on meeting to discuss acceptance standards for GR117P aircraft 15.3.51. Fairey also wrote simultaneously to the MoS about these issues. File C. Letter from Fairey to MoS, 14.3.51.

2. File C. Notes on meeting held 15.3.51 to determine production standards for GR117P plus briefing Minute for this meeting, 14.3.51.

on reviewing the detailed specifications of the equipment and weapons intended for the aircraft.[1] The Fairey representatives again took the opportunity to reiterate their view that too much equipment was being put into the aircraft. They underlined their dissatisfaction with this situation by contesting the original set of Ministry minutes produced after the meeting, and asking that they be revised to include the sentence,

> 'The firm emphasised that in their opinion there was a great danger of killing a good aeroplane by overloading it at this stage in its life, and said that they considered it absolutely essential to limit the weight to 19,600 lbs. by a reduction of the loads in the specification.'[2]

The comparative tactical trials at Eglinton with the Blackburn prototypes led to the creation of further design uncertainties. Fairey became aware of the likely content of the Eglinton report at the end of February following a visit by one of their test pilots to the Anti-submarine School. He reported that two major criticisms had been made of the flying characteristics of the Fairey prototype. One was that the heaviness of its ailerons compared unfavourably with the powered ones used by the Blackburn design, and this had led to pilots experiencing difficulties in maintaining landing altitude at touch down. The second was that 'The bulkhead behind the pilot's head should be removed and replaced by a

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1. Ibid. Draft minutes of ADC for Spec. GR117P 29.3.51.
2. RAFM AC-73/30 (43/b/2) HFW. February 1950-May 1952. Memorandum from Fairey's General Manager (Engineering) to Fairey's RTO requesting revision of draft Minutes of ADC 14.4.51.

framework. This would improve the cockpit enormously and make it more favourably comparable with the Blackburn GR which is held by the naval crews to be the ideal .... The Blackburn GR rear cockpit has some very good points ... and the A/S crews here will not be entirely satisfied until something approaching it can be achieved .... A great effort must be made to meet a number of the suggestions as the aircraft will be in service for many years and must start off by being popular if it is to be a success in service.'[1] He also made two interesting observations on the relationship between the Naval Staff and operational units. 'Not much interest in maintenance has been taken to date, which is somewhat surprising after the recent Ministry and Admiralty criticism'[2] and 'It is quite obvious that little attention is paid by MoS or the Admiralty to the opinion of various operational units in naval aviation on cockpit necessities and the desirability of standardising on some new untried component.'[3]

The official report of the Eglinton trials was made available to Fairey on the 15th March. This expanded upon the earlier criticisms, by arguing that having the two members of the Blackburn's crew in one rear cockpit allowed them to co-operate closely in all the activities of the aircraft. It was noted that this advantage would not be obtained in any of the proposed

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1. Ibid. Report on visit to RNAS Eglinton to discuss tactical trials of Fairey GR17, 27.2.51.
2. Ibid.
3. Ibid.

layouts for the Fairey GR17. It also suggested that major modifications should be made to the Fairey design's observers' cockpit to improve the pilot's rear view. This would probably involve replacing the metal bulkhead between the pilot and observer with a perspex screen, and repositioning the instruments attached to it.[1] This latter issue was discussed with Fairey at a meeting in mid-April, and the firm agreed to make the necessary modifications to the cockpit bulkhead.[2] In addition a meeting had been held earlier in the month to discuss the fitting of a Sperry Autopilot to the aircraft,[3] while in May a meeting was held to discuss the ASV19B installation.[4]

The effect of all this activity was to sustain uncertainty about the detailed design of the production aircraft, and involve Fairey in an extensive programme of major modifications to their original prototype design. By mid-May eight major design changes had been agreed between Fairey and the MoS. These were:

1. The bomb-bay had been lengthened 23 inches to accommodate Pentane with air tail.
2. It had been agreed to fit the ASV19B radar, move its scanner aft by 11" compared with the ASV15 radome position, and

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1. Ibid and File C. Report on Tactical trials of GR17 aircraft dated 3.3.51, received by Fairey 15.3.51.
2. File AG. Notes on Meeting 19.4.51.
3. RAFM AC-73/30 (43/b/2) MFW. February 1950-May 1952. Minutes of meeting to discuss fitting of Sperry type E autopilot to GR117P, 3.4.51.
4. RAFM AC-73/30 (43/c/1) GR17/45. Correspondence, May 1951-April 1952. Minutes of meeting to discuss installation of ASV19B in GR117P, 3.5.51.

enable it to be lowered an additional 5% to reduce blanking in the dive.

3. The radio operator's rear cockpit was to be extended to accommodate additional equipment and to give a better view when looking forward. This would be accomplished by fitting a larger canopy.

4. A number of changes had been made to the power plant to obtain:

   (a) improved accessibility;

   (b) turbo-starting;

   (c) the 34 kilowatt alternator required for de-icing of engine intakes and intake guide vanes.

5. The undercarriage had been moved back 12 inches to eliminate a tendency for the aircraft to tip onto its tail. The first production aircraft was also to have a revised undercarriage capable of withstanding a 16½ft/second vertical velocity, while development work was proceeding to produce an undercarriage capable of withstanding 18ft/second vertical velocities.

6. Internal fuel tankage had been increased to 400 gallons to give the required endurance at the higher all-up-weight of 19,600 lbs. To provide space in the wings for this additional tankage, it had been found necessary to extend the wing leading edge forward.

7. In order to improve directional stability and improve aileron control on the approach, the fin area had been increased by adding two small fins to the tailplane.

8. To improve lateral control, the ailerons were to be interconnected and their span increased.

It was noted that these changes could affect the centre of gravity range, and that this might necessitate further design changes. Finally, the MoS took the view that Fairey's complaints over the increased take-off weight of the aircraft were irrelevant, as it would not greatly affect its flying capabilities.[1]

In accordance with traditional Naval practice, it had been decided to allocate a name to production Fairey GR17/45 aircraft. This caused a surprising amount of argument between Fairey and the Admiralty, as the Company wished to call the aircraft the Seafarer, while the Admiralty wished to call it by the name of a seabird. Eventually they ignored Fairey's suggestion, and called it the Gannet, the production aircraft becoming the Gannet AS Mk I.[2]

All the outstanding design issues had been resolved by May 1951, and in succeeding months attention became focused on the progress of the development programmes relating to them. In June it was reported that the additional tailfins had had the desired effect, but that trouble was being experienced with propeller stalls and propeller vibrations.[3] By September, disquiet was being expressed in the MoS over the reliability

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1. File C. Summary Minute 28.5.51.
2. Files AH & AI.
3. File O. Test report, 1.6.51

of the Double Mamba engine, and the need for more intensive flight trials was under consideration. There had been repeated engine failures in flight, and this was delaying efforts to investigate vibrations being experienced in the pilot's cockpit.[1] It was also noted that the engine problems, and the numerous engine changes they had produced, had delayed the programme of development flying so much that it was anticipated that two early production aircraft might have to be used if the type was to be cleared for service by early 1953.[2] The possibility of ordering a larger number of pre-production aircraft for development was also raised, but no action was taken to implement this suggestion.[3]

Fairey compiled their own internal report on the progress of development and production work in anticipation of a visit by CNR on the 4th October. This observed that production drawings were starting to be sent to the production department, and that delays in their production had been a consequence of the modifications made to the original design. The modification which had created the greatest problem had been the need to reposition the undercarriage further aft. Despite these problems, the report indicated that it was still feasible for the firm to produce six production type aircraft by April 1953.[4]

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1. File F. Minute 21.9.51
2. Ibid. Minute 3.8.51.
3. Ibid. Minute 11.10.51.
4. RAFM AC-73/30 (41/d/2) Firefly Mk. 7. FHP. Review of position of Firefly Mk 7 and GR17/45 2.10.51.

A detailed examination of Fairey's production capacity was undertaken by the MoS at the end of 1951 as part of a comprehensive review of capacity in the aircraft industry. This concluded that on the assumption that the number of man hours required for Gannet production aircraft would drop from 214,000 for the first pre-production aircraft to 52,000 for the 80th production aircraft and 35,000 by the 360th aircraft, the Fairey organisation would be unable to attain the specified production rate of 32 aircraft a month plus spares, unless it resorted to extensive subcontracting. It had been pointed out to the firm that current calculations suggested that they would have to contract out 60% of the work on the Gannet, which was 10% more than the largest measure of subcontracting achieved during the war. Fairey had responded by indicating that they proposed to delay action until March 1952, in the hope that the government would either resort to direction of labour into the aircraft industry, or accept more restricted production targets.[1]

The Admiralty seem to have maintained their interest in an AN/APS 20B equipped Early Warning version of the Gannet during this period. An informal approach was made to Fairey at Director level in May 1951 on the implications of the new production specification for the 1950 design study on this aircraft. The General Manager (Engineering) felt that it would be at least nine months before the Gannet modifications were com-

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1. File R. Notes of Meeting between Production Manager, Fairey Aviation Limited and AP3 7.12.51.

pleted and design effort could be moved to this version of the aircraft, and he asked the Director concerned with Admiralty liaison to discover the Navy's reaction to this.[1]

v. The Dual Gannet.

In mid-March 1951 the Admiralty stated a requirement for a dual control version of the Fairey GR117P aircraft. It was intended to use this aircraft both to train pilots to fly the Gannet anti-submarine aircraft and as a general turbo-prop trainer, and it was envisaged as a simple conversion of the anti-submarine aircraft. In May, DAW's target date for the dual version's entry into service was stated to be January 1954, with the 25th aircraft of the production line being scheduled as the first T2 conversion.[2]

The project did not gather any momentum until August 1951, when it was stated that although the Admiralty's Director of Aircraft Equipment would want to be informed of the cost of the dual version, it was improbable that any upper limit would be placed on it.[3] Fairey was officially informed of the situation at the end of the month as a result of a telephone conversation between their General Manager (Engineering) and AD/RDN, in which he was asked whether the first trainer conversion could be delivered by January 1954. As a consequence of this con-

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1. RAFM AC-73/30 (43/b/2) HFW. February 1950-May 1952. Memorandum from General Manager (Engineering) on GR17 with AN/APS 20B 22.6.51.
2. File N. Minute 6.5.51.
3. Ibid. Minute 21.8.51.

versation, the firm started design work on the aircraft.[1]

A Naval Staff Requirement for the aircraft, NA33 was published in mid-September.[2] As a result of the design investigations undertaken by Fairey, DG/TD(A) in the MoS reported to the Admiralty early in November that their production targets could not be met, and that June 1954 was the earliest possible date for delivery of a dual aircraft.[3]

vi. The Firefly VII interim anti-submarine aircraft.

In late 1949, three interim anti-submarine aircraft had been under active development. Only the Firefly VII survived through to the end of 1950. The converted Sturgeon was flown for the first time in August 1950, but the project was abandoned at the end of the year and both prototypes were scrapped. Only the first prototype flew and the intended operational evaluation of the crew arrangements does not appear to have been carried out. One explanation for the termination of the project was that the prototype experienced acute handling difficulties due to the effect of the jet efflux from its two single Mamba engines.[4] The remaining interim aircraft, the Blackburn Griffon was cancelled in December 1950, when it was decided to terminate development of all the Blackburn GR17/45 designs.

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1. RAFM AC-73/30 (43/b/2) HFW February, 1950-May, 1952. Internal memorandum from Fairey's General Manager (Engineering) concerning telephone conversation about dual Gannet with AD/RDN 31.8.51.
2. File N. Gannet Dual OR NA33, 17.9.51.
3. Ibid. Memorandum from DGTD(Air) to DAW, 2.11.51.
4. Barnes, op.cit., pp. 417-418.

The Firefly VII was initially regarded as a minimally modified version of the Firefly IV-VI design which Fairey had produced in relatively small numbers for the Royal Navy from 1946-1950. Decisions about this new version of the aircraft tended to be taken in an incremental manner, rather than through the process of trials and debates which characterised the GR17/45 projects. Although work on the aircraft had started early in 1949, it was January 1950 before a draft specification, F101, was issued to cover it. In this, the Griffon 57 was specified as the engine for what was described as a three seat version of the Firefly V.[1] Almost simultaneously, the Sub-Committee for Naval Aircraft Design agreed to sanction production of such an aircraft, arguing that there was a pressing need for a better anti-submarine aircraft than the existing two-seat Firefly to bridge the gap until the GR17 became available in 1952/53. The main reason given for the new requirement was that plotting the aircraft's position while it was operating in the search role could not be carried out efficiently by only one crew member.[2] It was early March, however, before copies of the specification, renumbered M101P were circulated to the aircraft industry. This was a formality, as it was unthinkable that any firm other than Fairey would produce the aircraft, given

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1. File M. Draft specification F101: 3 seat anti-submarine aircraft from Firefly V. 7.1.50.

2. File H. Meeting of Sub-Committee for Naval Aircraft Design 12.1.50 excerpt in File N.

that it had to be constructed in accordance with the agreed drawings and schedules for the design and construction of Firefly V aircraft, except where changes were necessary to meet the requirements of the new specification.[1] The MoS was instructed that the Admiralty was prepared to purchase 50 of these aircraft in 1951/52.[2] Fairey responded to the issue of the draft specification by criticising that part of the requirement which stated that the aircraft had to be able to fly comfortably at speeds as far below 150 knots as possible. They pointed out that flight trials on the converted prototype aircraft had indicated that if the aircraft was fully equipped with external drop tanks and sonobuoys, it would be very difficult to maintain a cruising speed of less than 150 knots for a long period.[3]

The specification also stated that normal take-off weight was to be 14,700 lbs., but indicated that 15,400 was acceptable if it was impossible to attain the lower figure. By the end of March, DMARD had to admit that the minimum operating weight of the aircraft was likely to be 14,800 lbs., and with a full operational load it would increase to 16,000 lbs.[4] This led to a revision of the specification, the maximum take-off weight being altered to 15,800 lbs. and maximum landing weight with one hour's fuel and a full sonobuoy load being changed to 13,500 lbs.[5]

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1. File M. Minute 4.3.50.
2. Ibid., Minute 13.3.50.
3. Ibid. Comments passed on by RTO (Fairey) to MoS 27.3.50.
4. Ibid. Note from DMARD to Director Royal Aircraft Establishment (RAE) 29.3.50.
5. Ibid. Amended draft spec. M101P. Undated.

As production planning progressed, it became clear that the factor which would determine the rate of output of this aircraft was the availability of the Griffon 57 engine which, in the form required for this aircraft, had been renumbered the Griffon 59. It was noted in March that development work on this engine was still continuing, and that a production order for it was unlikely to be placed before September 1950.[1] In May, it was accepted that the introduction of the Mk VII into the Firefly production line was totally dependent upon the availability of the Griffon 59 engines. The first production engines had been promised for June/July 1951, and it was planned to start Firefly VII deliveries in September 1951 at the rate of 5 aircraft per month, giving 35 deliveries in the financial year 1951/52. It was hoped to produce the additional 15 aircraft which had been ordered for 1951/52 during 1952/53 when it was anticipated that a maximum delivery rate of 20/22 aircraft per month could be attained.[2]

The ADC for the Firefly VII was held in April 1950. It produced no major changes to the aircraft or the specification. A consensus emerged that the maximum landing weight of the aircraft would inevitably exceed 13,000 lbs., and that the minimum comfortable cruising speed for the aircraft was likely to be above 145 knots. The Royal Aircraft Establishment representative suggested that maximum take-off weight should be restricted to 15,800 lbs. because of limitations in the aircraft's structure.

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1. Ibid. Minute 21.3.50.
2. Ibid. Minute 22.5.50.

The Admiralty representatives confirmed that only production aircraft were required, and that no prototypes were to be ordered. The Fairey representatives were also told that the soundproofing of previous marks of Firefly had been poor, and that they should improve upon this in the Mark VII.[1]

Fairey seem to have been unhappy at the Admiralty's decision to dispense with a Mk VII prototype programme, for a month later they held an internal meeting to discuss how many prototypes they would need for such a programme. It was reported that Rolls Royce and Rotols estimated that Fairey would receive the first Griffon 59 engines and propellers by September 1950. If the first production aircraft was to be delivered to the Navy in August 1951, as scheduled, flight development work would need to be completed by March 1951 to enable any necessary modifications to be made to this aircraft before its first flight. It was estimated that two prototypes would be needed for this,[2] but no official sanction could be obtained for the scheme, and as a result Fairey had to use the first two aircraft of the production line for flight development work. These did not fly until May and August 1951.[3]

It was also noted at this meeting that the MoS had yet

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1. Ibid., and RAFM AC-73/30 (41/d/2) Firefly Mk VII Aircraft FHP. Minutes of ADC on three-seat anti-submarine version of the Firefly V, 6.4.50.

2. RAFM AC-73/30 (41/d/2) Firefly Mk VII Aircraft, FHP. Notes of internal FAC meeting on Firefly Mk VII prototype programme 4.5.50.

3. RAFM AC-73/30 (41/d/1) F.H. Parker 4. Firefly Correspondence April 1951-June 1952. Prototype programme 19.10.51.

to award Fairey a production contract for the aircraft, although, through Fairey's liaison system with the MoS at Director level, they had been assured that this was only a formality.[1] Revised cockpit requirements for anti-submarine aircraft, which caused so much uncertainty over the final configuration of the Fairey GR17/45 three-seater prototype, were issued in June 1950. The prototype Firefly VII conversion was examined, and it was concluded that a better cockpit position and view for the observer was needed if these requirements were to be met.[2] A meeting was held in mid-July to consider Fairey's proposed amendments to their Firefly VII design. Their rearrangement of the rear cockpit, and their proposed redesign of the rear cockpit hood were accepted.[3] In parallel with this, a decision was taken to try to upgrade the Firefly VII's search radar capability by installing the ASV19 in this aircraft in place of the ASH radar. At the end of October it was stated that the Staff Requirement for this installation had been confirmed and it had priority A. Fairey were to fit a version of this radar into a Firefly VI, and it was hoped that flight trials could begin during December.[4] The radar scanner was to be installed in a wing mounted container.

Trials had been conducted on the night operating capabilities

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1. Letter to Sir Richard Fairey, 21.4.50. op.cit., p. 2.
2. File M. Letter from RTO (Fairey) to MoS, 3.6.50.
3. RAFM AC-73/30 (41/d/2) Firefly Mk.VII Aircraft, FHP. Memorandum from General Manager (Engineering), 24.7.50.
4. RAFM AC-73/30 (41/d/1), Firefly Aircraft FHP: Misc. correspondence on Firefly IV-VII. Memorandum from Fairey RTO to General Manager (Engineering) 3.10.50.

of the Firefly V aircraft during 1950 by a squadron operating from the aircraft carrier HMS *Vengeance*. The report of these trials contained little that had not already been discussed with the Fairey directors during their visit to the Anti-submarine School in mid-1948, yet both the MoS and the Admiralty seem to have been unaware of the type's inherent operational defects. The Firefly V had been found to possess three deficiencies when operated at night from HMS Vengeance. These were a tendency for the undercarriage to throw the aircraft back into the air on landing; an inadequate pilot's view, which meant that the aircraft had to be landed without him being able to see the deck of the carrier; and a sluggishness in all the controls of the aircraft at low speed. It was suggested in the report that the first two faults could only be cured by the use of a tricycle undercarriage, but it was noted that the third fault had not been encountered in other types of naval aircraft with tailwheel undercarriages, and appeared to be unique to the Firefly. The report concluded that the totally inadequate view rendered the aircraft unsuitable for night deck landings.[1]

This report was forwarded to Fairey on the 20th November 1950, and the next day RDQ(N) visited Hayes to discuss it with representatives of the company. Two major conclusions emerged from this meeting. The first was that the view that an aircraft had to be fitted with a tricycle undercarriage if it was

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1. *Ibid*. Note from Fairey RTO to General Manager (Engineering) plus copies of HMS *Vengeance* report on night operation of Firefly Mk.V. 20.11.50.

to be operated from an aircraft carrier at night was rejected, yet no attempt was made to contradict the findings in the report that the nature of the Firefly V undercarriage made night operations difficult. The second conclusion was that it would be impossible to correct these deficiencies without a major redesign of the aircraft. This applied to both existing Firefly V aircraft and future Firefly VII's. Indeed in the latter case, the requirement ruled out such a major redesign.[1]

This problem now became the responsibility of AD/RDN in the MoS and on the 29th November he wrote both to Fairey and to DMARD about remedial action to rectify the situation. In his letter to Fairey he requested information on the cost, and delay in production, that would be involved in raising the pilot's seat by an arbitrary amount in order to improve his forward view. He went on to warn that the Firefly VII would be assessed at A & AEE against the statement in the requirement that it had to be capable of performing its duties at night. In view of this, he asked for additional suggestions for improving the pilot's view and the slow speed control characteristics of the aircraft. He ended by asking Fairey to appreciate the undesirability of the MoS having to advise the Admiralty that anticipated faults in a new naval aircraft could not be corrected before prototype aircraft were flying.[2] Simultaneously, AD/RDN sent a note to DMARD explaining his action. He stated that the

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1. File Q. Minutes of meeting at Hayes 21.11.50 to consider HMS Vengeance Report 21.11.50.

2. Ibid and File Q. Letter from AD/RDN MoS to Fairey's General Manager (Engineering). 29.11.50.

Minutes of the Meeting on the 21st November contained a virtual admission that the aircraft would have to be accepted with the view, and possibly the controllability found unacceptable in previous marks of Firefly, and he had asked the firm to suggest measures, such as raising the pilot's seat, to alleviate this situation.[1]

Fairey's response to this letter was to start a design investigation, Basic Design Project 43. This was aimed at discovering the effects of raising the pilot's cockpit 12 inches and examining methods of improving the stability and controllability of the Firefly VII in order to make it more suitable for night deck landings.[2] Their General Manager (Engineering) replied to AD/RDN's letter in firm, but responsive, terms. He stated bluntly that he would 'like to make it clear immediately that there is no possibility of incorporating any modifications such as these in the Firefly Mk 7 from the commencement of its production.' He concluded by assuring AD/RDN that Fairey was 'anxious to supply an aircraft which meets as fully as possible the requirements of the service, and we shall therefore make these investigations as rapidly and as thoroughly as possible, and have further discussions with you on them.'[3]

This difficult situation was likely to be further complicated by a proposal circulating within the Naval Staff to

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1. File Q. Minute from AD/RDN to DMARD 29.11.50.
2. RAFM AC-73/30 (41/d/2) Firefly Mk VII aircraft FHP. Memorandum from General Manager (Engineering). 29.11.50.
3. Ibid. Letter from Fairey's General Manager (Engineering) to AD/RDN MoS 1.12.50.

revise part of the Firefly VII requirement in order to cover the case of an aircraft landing with an offensive load of small anti-submarine homing weapons or depth charges, as well as its normal load of sonobuoys and one hour's fuel. Such a revision would increase the existing figure for the maximum landing-weight by 900 lbs., yet the Staff was not prepared to accept any reduction in the standard of undercarriage performance. Indeed, it was insisting that the increased emphasis upon the night role made it imperative to improve on this. Early in December, Fairey was asked to investigate the full implications of such a change in the requirement.[1]

The investigations undertaken by Fairey into methods of improving the landing capabilities of the Firefly VII failed to produce any simple methods of alleviating the problem. Tests were carried out with an elevated pilot's seat and cockpit, but it was concluded that these made little difference to the pilot's view while landing on a carrier's deck. It was believed that increasing the tailplane span by 2 feet would improve control and stability, but it had been concluded that no effective modification to the existing undercarriage was possible, and that a new one would have to be designed for the aircraft. In consequence, Fairey asked for contract cover to enable them to proceed with work on both of these modifications.[2]

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1. RAFM AC-73/30 (41/d/1) Firefly Aircraft FHP Misc. Correspondence on Firefly IV-VII. Letter from RDN1 on behalf of DMARD to Fairey's General Manager (Engineering) 4.12.50.
2. RAFM AC-73/30 (41/d/2) Firefly Mk. VII aircraft FHP. Letter from Fairey's General Manager (Engineering) to AD/RDN 29.12.50.

AD/RDN responded by instructing the firm to proceed with work on the modified tailplane and to submit a cost estimate for the new undercarriage. He also stated that the MoS was prepared to accept the existing view from the pilot's cockpit.[1] It was quickly established that the new undercarriage would not be available before May 1952, by which time 150 Firefly VII aircraft should have been produced.[2] These facts were all passed on to D/DMARD in the middle of January 1951,[3] but no positive action was taken to discuss whether the performance of the aircraft was sufficiently unacceptable to warrant cancellation. The project therefore continued despite the known operational defects of the aircraft.

One explanation of this may have been the increasing number of Firefly VII's on order. It was paradoxical that as it slowly became established that the aircraft would have major operational limitations, the numbers on order were increased on four separate occasions. At some point in 1950, authorisation had been given to place a contract with Fairey for 54 Firefly VII aircraft. In November 1950 the Director of Contracts (Aircraft) (DC(A)) was informed that authorisation had been obtained for an additional 26 aircraft, making a total of 81 on order. These additional aircraft were to be delivered between the 1st April 1951 and the 31st March 1952, at an airframe cost of £21,000

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1. Ibid. Letter from AD/RDN to Fairey's General Manager (Engineering). 3.1.51.
2. Ibid. Internal Memorandum to Fairey's General Manager (Engineering). 4.1.51.
3. File Q. Note from AD/RDN to D/DMARD 15.1.51.

each and a total cost of £546,000.[1] During December 1950 and January 1951, the raising of the rearmament budget from the mid-September figure of £3,600 m. to £4,700 m. over three years was under active discussion. This culminated in the decision, announced on January 29th 1951 to accept the higher figure.[2] A spate of orders for the Firefly VII followed this decision, presumably because it was the only naval anti-submarine aircraft which appeared to be available for rapid production. In mid-January an additional 101 aircraft were ordered, making 181 on order. This included one aircraft to be used for CS(A) clearance trials. These additional aircraft were to be completed during the period April 1952 to March 1953, at a cost of approximately £21,000 each and a total of £2,120,000.[3] In February a further 105 aircraft were authorised, making a total of 286 on order. These were to cost £19,950 each, giving a total cost of £2,094,750. Fairey was instructed to increase their jigs and tooling to attain a maximum production rate of 21 aircraft a month, with a view to completing this additional contract by the end of March 1953.[4] Finally, early in June, an additional 51 aircraft were ordered for delivery after March 1953. This increased the total order to 337 aircraft. The last batch was to cost £19,950 each, giving a total cost of £1,017,450. However the maximum delivery rate

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1. Ibid. Note to DC(A) 17.11.50.
2. Bartlett, op.cit., p. 61.
3. File Q. Note to DC(A) 11.1.51.
4. Ibid. Note to DC(A) 23.2.51.

for these latter aircraft was to be lowered to 17 a month.[1] A total of £5,778,200 had thus been allocated for the purchase of Firefly VII aircraft by the Admiralty.

Design and development work to explore the problems of fitting the ASV19a radar set to the Firefly in place of its ASH installation had been started in late 1950. In March 1951, a Firefly VI test bed aircraft was flown with a mock-up of this installation, and it had no noticeable effect upon its handling qualities. This led Fairey to report to the MoS that there was no reason why it could not be successfully fitted to the Firefly VII.[2]

Work on the Firefly VII was forming an increasing proportion of Fairey's total activities by the middle of the year, but completion of production aircraft was being delayed by two factors. The most serious one was the late delivery of production propellers. It was reported that only five production propellers would be delivered by the end of September, leaving a large number of aircraft complete except for their propellers. Fairey was exploring the possibility that another type of propeller might be fitted to them temporarily so that production flight testing could begin.[3]

A second and more basic problem was that Fairey had not

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1. Ibid. Note to DC(A) 8.6.51.
2. RAFM AC-73/30 (41/d/1) Firefly aircraft FHP: Miscellaneous correspondence on Firefly IV-VII. Report on Firefly VI with enlarged radar nascelle. 7.3.51.
3. RAFM AC-73/30 (41/d/1) F.H. Parker 4. Firefly correspondence April 1951-June 1952. Internal memorandum from General Manager (Engineering) 15.6.51.

completed flight development work on the modifications designed to improve its flight performance. If these modifications were successful they would have to be incorporated in all production aircraft, including those which had already been substantially completed. These two factors led to the realisation in late July that full CS(A) release was not possible before the end of March 1952.[1]

Fairey had accepted that four specific aspects of the aircraft's performance needed improving. These were:

> 'Directional stability - to be made acceptable.
>
> Performance - to be improved, particularly at take-off and climb.
>
> Stalling and vibration - stalling characteristics to be improved and vibration reduced.
>
> Fin - fin tip stalling causing rudder locking. Dorsal fin fitted but not yet tested. Fin top extension may have to be fitted.'[2]

In addition it had become clear that the new engine installation was having an adverse effect upon the aircraft's performance. It was reported that 'the results of a few level speed runs indicate a deterioration compared with the original Firefly Mk. 7 mock-up which could not be accounted for by the increased AUW ... an average unstick distance of 1047 ft. in zero wind at 14,500 lbs. ... compares with 958 ft. for a Firefly 5 at 14,000 lbs.

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1. Ibid. Internal memorandum from General Manager (Engineering) reporting on meeting with CNR and AD/RDN re Firefly Mk VII. 25.7.51.

2. Ibid. Internal memorandum from General Manager (Engineering) 27.6.51.

... Preliminary results indicate a pronounced reduction in acceleration as the aircraft speed increases, and possible reasons for this are being investigated.'[1] As the power plant was supplied by the MoS to Fairey they were informed of the situation, and started their own investigation of the reasons for the deterioration in the aircraft's performance.[2]

A preliminary assessment of the Firefly VII's deck landing performance was carried out during July 1951 at A & AEE, Boscombe Down and on board HMS Vengeance. The report on these trials was completed in early September, and contained many of the faults discovered in the night landing trials with the Firefly V a year earlier. The directional and longitudinal handling behaviour of the Firefly VII, both during a deck landing approach and in the slow speed cruising configuation, were judged to be appreciably worse than had been experienced with earlier marks of the aircraft. The forward view was also slightly worse, while take-off performance was markedly inferior. Its under-carriage performance was bad by modern standards and, in combination with the poor handling characteristics and forward view, this was judged likely to produce a very high night deck landing accident rate. The pilots conducting the trials considered that the aircraft's performance would have to be considerably improved before it was acceptable for service use. The report recognised that the interim nature of the type made such funda-

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1. Ibid. Notes on Firefly AS Mk VII (WJ 215) for deck landing assessment at A & AEE and Deck Landing Trials in HMS Vengeance 12.7.51.

2. File T. Minutes of 24.8.51 and 25.9.51.

mental modifications impossible, and confronted the MoS and Naval Staff with the basic incompatibility between the limitations of the existing design and that part of the requirement which specified that no fundamental changes were to be made to it.[1]

The response of Fairey's Resident Technical Officer to this report may have postponed any positive action being taken in response to it, for he indicated that current flight development work was likely to correct the majority of the criticisms made of the aircraft's handling and performance.[2] During October, Fairey persuaded the Ministry to accept a temporary production standard for the power plants and fins of the first twenty five aircraft, thus enabling them to start flight testing completed production aircraft.[3]

CNR visited Hayes early in October to discuss the progress of the Firefly VII and Gannet programmes, and this stimulated an extensive review of them within the Fairey organisation. It was admitted that there had been a slippage of two months in the Firefly VII production programme, due to the spate of modifications which had followed the flights of the first and second production aircraft. Development work was still continuing on three components: the power-plant, the fin and rudder and the pilot's hood. Uncertainty about possible modifications to them

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1. Ibid. Letter from DMARD to RTO Fairey, 9.9.51.
2. Ibid. Letter from RTO Fairey, to MoS, 13.9.51.
3. RAFM AC-73/30 (41/d/2) Firefly Mk. VII aircraft FHP. Internal memorandum from Firefly VII Project Engineer to Production Manager, 4.10.51.

was not slowing down the main assembly lines, but it was preventing completion of production aircraft. It was agreed that the first twenty-five production aircraft should be completed with an interim power-plant arrangement, and that the revised pilot's hood could now be fitted to all production aircraft. The revised fin and rudder arrangements had produced an improvement in the aircraft's handling qualities, which the firm's pilots believed would meet the previous criticisms of these aspects of its performance, but the A & AEE pilots were reported to be insisting that further improvements were necessary. It was decided to fit this new fin and rudder to the initial production batch, and to undertake further development work to try to make the aircraft's handling qualities more acceptable to the A & AEE pilots.

Disquiet was expressed at Fairey's review meeting over the official attitude towards the Firefly VII development programme, as it was felt that the A & AEE report appeared to cast unjustified doubt upon the firm's competence. It was admitted that the longitudinal characteristics of the aircraft at slow speed were not wholly acceptable, but it was believed there was little that could be done to change them. The criticisms of the pilot's view and the undercarriage performance were regarded as grossly unfair and unjust, as AD/RDN had specifically accepted these characteristics on behalf of the MoS.[1] They increasingly felt that the main cause of the difficulties in agreeing an

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1. Ibid. Notes on internal FAC meeting 2.10.51 to review the position of Firefly Mk VII and GR17/45.

acceptable production standard with the MoS was that the aircraft was being judged against the qualities possessed by the new generation of jet aircraft. There was also a suspicion that the entry into service of new jet aircraft, with their extremely good pilot's view, had led the Navy to view the aircraft as obsolete, and one which they did not wish to operate.[1]

One of Fairey's test pilots visited the A & AEE at the end of November, and was able to give the Fairey management a rather more detailed picture of the attitude of naval pilots towards the Firefly VII. His report stated that even with the modifications to the power-plant, the fin and rudder and the pilot's hood, the 'pilot's first impression was that the aircraft was still definitely inferior to other marks of Firefly and that a higher accident rate must be expected when operating the aircraft from carriers than has been experienced on previous marks.'[2]

The report identified three specific areas of criticism:

'A. Directional Control

i. Rudder will not self-centre at 120 knots.

ii. In rough air conditions, uncomfortable directional "tail wagging" on approach.

iii. Large angle of left rudder required to trim out on approach.

B. Lateral Control - response and control are inferior on the Mk 7 to even the Mk 4 which has a low standard. It

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1. Interview with Hall, op.cit.
2. RAFM AC-73/30 (41/d/2) Firefly Mk VII aircraft FHP. Internal memorandum. Undated.

deteriorates with the addition of external stores. This makes the deck landing problem more acute, especially at night, bearing in mind that the view is inferior also.

C. View, etc.

1. The view of the batsman[1] is inferior to that of earlier marks.

2. It is necessary to yaw the aircraft to starboard to see clearly even if a short "straightway" is attempted. This method is unsatisfactory as it requires a last minute correction of yaw before landing.'[2]

Despite these criticisms, the Test Pilot reported the technical staff's attitude to be 'that unless further serious fault was found, a CS(A) release would depend only on the improvement of the self-centring characteristics during the climb ... (but this) was not necessarily the view of the pilots.'[3] A difference of opinion on the aircraft's suitability for service use clearly existed between the Naval test pilots, and the MoS personnel at A & AEE.

During November and December 1951 the MoS became increasingly concerned with the production work load being placed upon the Fairey organisation and instituted an investi-

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1. The Batsman was equipped with two illuminated batons and was positioned in a prominent position on one side of the aft part of an aircraft carrier's deck. He used the batons to signal to pilots making a deck landing approach the action they should take to make a successful landing. This human device was replaced by a number of automatic landing aids in the early 1950's.

2. RAFM AC-73/30 (41/d/2) Firefly Mk VII aircraft FHP. Internal memorandum, undated.

3. Ibid.

gation of this. It was reported that 337 Firefly VII aircraft were on order, including 30 for the RAN, plus spares and modification sets valued at £2,800,000. None had been delivered.[1] The Ministry decided that it would be quite impossible for Fairey to execute the existing Firefly VII airframe and spares programme with their existing resources, and simultaneously develop and produce the Gannet. As a result, Fairey was told to reduce their planned Firefly VII production rate to a maximum of 14 per month.[2]

vii. <u>The Light anti-submarine aircraft</u>.

It had become clear by early 1950 that the increases in the take-off and landing weights of production GR17/45 aircraft meant that they would be unable to operate with a full operational load from Escort and Merchant Aircraft Carriers. The Firefly VII appeared capable of meeting the weight limitations of the GR17/45 specification, but its take-off run was lengthy and the operational load it could carry was restricted, making it at best an interim aircraft. The Naval Staffs responded to this situation by producing a new Staff Requirement. This was for an aircraft fully capable of operating with a full operational load from small Merchant Aircraft Carriers. The idea of a new lightweight anti-submarine design had first been discussed in the latter half of 1948,[3] but it was April 1950 before a tentative Admiralty

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1. File R. Report on Fairey's production commitments, 1.11.51.

2. File R. Notes of meeting between Fairey's Production Manager and AP 3. 7.12.51.

3. File A. Minutes of meeting to consider the future policy for meeting requirements for an anti-submarine aircraft, 8.9.48.

requirement for such an aircraft was circulated to the aircraft industry for comment.[1]

The draft Admiralty 'staff target for an anti-submarine aircraft to operate from small escort carriers' called for an aircraft capable of carrying 3,200 lbs. of military load in either a search or a strike configuration with an endurance of four hours, a crew of three, an approach speed of 60 knots and a maximum take-off weight of 12-13,000 lbs.[2] The navy had thus adopted the idea of a split role anti-submarine aircraft advocated by Fairey in 1948. No action was taken over this draft staff target until the end of May 1951, when the Ministry of Supply issued a specification, M123, to cover it, and asked selected firms to prepare designs capable of meeting it. A deadline of October 1951 was set for submissions.

Blackburn, who had asked for information on this project following the decision to terminate development work on their GR17/45 designs,[3] appear to have undertaken design work on such an aircraft in February 1951, but it is unclear whether they ever submitted a formal design study to the MoS.[4] The two remaining contenders were Fairey and Short, the latter having been arguing the merits of such an aircraft for a considerable time.[5]

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1. File D. Minutes of meeting to consider naval aircraft projects to specifications N14/49, N9/47 and GR17/45, 3.4.50 and RAFM AC-73/30 (43/b/2) HFW February 1950-May 1952. Internal FAC Memorandum from Head of the Technical Office to General Manager (Engineering) 26.6.51.
2. RAFM AC-73/30 (43/b/2) HFW. February 1950-May 1952. Memorandum from Head of Technical Office to General Manager (Engineering) 26.6.51.
3. File A. Letter from Blackburn to MoS, 24.1.51.
4. Jackson, <u>op.cit.</u>, p. 531.
5. Barnes, <u>op.cit.</u>, p. 450.

Fairey made no attempt to produce a new design to this requirement, but relied on adaptions of their GR17/45 design. Their first attempt at meeting the requirement was to investigate the effect of operating the production Gannet with the military load specified in the requirement. This produced an aircraft with a normal take-off weight of 18,784 lbs., a take-off run of 430 ft. in a 22 knot wind and an approach speed of 80-85 knots. This compared with the figures of 12-13,000 lbs., 350 ft., and 60 knots called for in the requirement.[1] Having satisfied themselves they could not meet the requirement through this method, Fairey's next attempt was to adapt the basic GR17/45 layout to take a single Armstrong Siddeley Mamba gas turbine engine. This version also had the rear cockpit deleted, leaving two crew members only in the forward cockpits, while the ASV 19b radome was placed forward of the bomb bay in the nose of the aircraft. This necessitated a reduction in the length of the bomb-bay, and also gave some indication of the type of layout Fairey might have produced had the Z weapon not been included in the GR17/45 specification. With these alterations, the design had an estimated take-off weight of 16,150 lbs., a take-off run of 1,050 ft., and an approach speed of 77 knots.[2] Fairey had considered the problems of producing a prototype of this design, and indicated that by converting one of the

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1. RAFM AC-73/30 (41/b/2) HFW. February 1950-May 1952. Internal FAC Memorandum from Head of Technical Office to General Manager (Engineering) 26.6.51.

2. RAFM AC-73/30 (41/b/1) Gannet (1). Brochure on Project 45: drawings dated 4.9.51.

original two seat GR17/45 prototypes, a prototype could be produced within twelve months of a contract being let.[1]

At the end of October, Fairey's Chief Designer was informed by D/DMARD that the firm's proposal was not acceptable to the Naval Staff, because its weight and approach speed exceeded the requirements.[2] Short had produced a completely new design which met the major points in the specification, and they were eventually awarded a contract for three prototypes in April 1952, the aircraft later becoming known as the Seamew.[3]

viii. Naval Policy: The Parliamentary Dimension 1950-1951.

The 1950 statement on the Navy Estimates concentrated on explaining the economies that had had to be made within the Navy to obtain a 'proper balance of expenditure in present circumstances between personnel on the one hand and production, including research and development, on the other.'[4] It confirmed that one of the armoured carriers was to be modernised. 'The modernisation of the aircraft carrier Victorious will be started during the course of the year; this will be the first of several such vessels to be modernised to increase their fighting efficiency.'[5] This public statement indicated that

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1. RAFM AC-73/30 (43/c/1) GR17/45 correspondence May 1951-April 1952. Internal FAC Memorandum from Assistant Chief Engineer to General Manager (Engineering) 15.10.51.
2. RAFM AC-73/30 (43/b/2) HFW February 1950-May 1952. Undated letter from D/DMARD to Chief Designer, FAC placed in file late October, 1951.
3. Barnes, op.cit., p. 450.
4. Statement Explanatory of the Navy Estimates, 1950-1951, p. 2. Cmd 7897. Accounts and Papers, (2); 1950; Air, Army, Navy and Defence: XVI.
5. Ibid., p. 7.

the Navy had won a partial victory in the inter-service dispute over their plans to modernise the armoured carriers.

The 1950 Debates on the Navy Estimates in both Houses of Parliament concentrated almost entirely on the Navy's ability to combat the perceived threat from Russian submarines, in contrast to the emphasis on financial stringency which had permeated the Ministerial Statement. In the House of Commons, Mr. James Callaghan, the Parliamentary Secretary to the Admiralty, discussed the Navy's aircraft carrier programme in considerable detail, and also mentioned the GR17/45 for the first time. He described how 'HMS Eagle and HMS Ark Royal, two of the most modern and powerful fleet carriers are now moving on. HMS Ark Royal will be launched very shortly. HMS Eagle is now in the process of being fitted out and should be ready next year ... HMS Victorious, which had a hard war, is about to be modernised and is to be taken in hand almost immediately.'[1] He then went on to indicate that great changes were occurring in the equipment and layout of aircraft carriers, such as steam catapults, mirror landing sights and angled decks, and that this made it very difficult to complete new carriers, as they were already obsolescent when they arrived in service.

The Parliamentary Secretary then proceeded to reveal that 'in the experimental stage are a number of new types of homing torpedoes that may be launched from the surface, or from aircraft, or from under water.[2] This was presumably a reference to the

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1. 472 H.C. Deb. 22nd March, 1950. Col. 1973.
2. Ibid., Col. 1977.

new family of torpedoes which included 'Pentane'. He then went on to state that 'In naval aviation researches are at the moment being largely brought to bear on a probable submarine threat. A new "single packet" anti-submarine aircraft, whose initials are GR17, is now being developed for carrier operations. I say "single packet" because it includes in the same machine powers of detection and powers of destruction.'[1]

This reference to the GR17 allowed a Conservative M.P. Captain Ryder, to publicise doubts that existed in some quarters about the 'single packet' concept. He argued that 'the problem as I see it, is that there is a tendency for aircraft to get larger, more expensive, heavier and more difficult to handle, requiring larger and more up-to-date carriers to take them to sea. That may be very necessary if we are to meet the enemy in air combat, but the question I raise is how about anti-submarine aircraft? We have been told of the GR17. Are we satisfied that we can produce this aircraft and take it to sea in sufficient numbers to cover the very extensive trade routes which must be patrolled?... Is our plan for providing anti-submarine aircraft a practical plan, and have we under active consideration plans for using auxiliary aircraft carriers, or small aircraft carriers in increased numbers? I see we have only one auxiliary aircraft carrier, which has been relegated to the Festival of Britain.'[2] These queries emphasised the dichotomy that existed between the type of carrier forces needed to meet the immediate submarine

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1. Ibid.
2. Ibid., Col. 2078.

threat, and the Navy's long term aspirations to rebuild their large Fleet carriers.

The parallel debate in the House of Lords, in which Viscount Hall the First Lord of the Admiralty participated, covered very similar ground. The twin issues of the Navy's carrier policy and the GR17 were raised by Lord Teynham, a wartime anti-submarine escort vessel commander. He argued that 'in the case of escort vessels it might be wise to concentrate on the production of a large number of simple-type vessels, and the same argument might well apply in the future to the provision of naval aircraft for anti-submarine work. I believe it is true that owing to its weight the new all-purpose GR17 naval aircraft can land on the flight decks of only the largest aircraft carriers, the fleet carriers, which are, of course, large, vulnerable and expensive ships. I do not deny that a number of fleet carriers are certainly necessary, but might it not be wise to concentrate more on the production of a large number of simple-type naval aircraft, with the minimum fittings for anti-submarine work, which can land on the decks of not only fleet and light fleet carriers, but also, possibly on escort carriers. In fact, where are the escort carriers which I suggest are so vitally necessary for the protection of our convoys, and which will be required to sail with them again, as in the past? According to the Estimates there appears to be only one such vessel, and she is to be loaned to the Festival of Britain for two years.'[1]

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1. 167 H.L. Debs. 10th May, 1950. Col. 236.

In response to this speech, the First Lord argued that 'we cannot get those cheap aircraft of which he has been talking today. We have to get aircraft which will do the job, and such aircraft are very expensive. They are produced as the result, not of months, but of years of study in design and construction methods .... The new anti-submarine aircraft, the GR17, is now being developed for carrier operations. This machine, which has powers of detection and destruction, has already been deck landed successfully.'[1] Viscount Hall then went on to deal with carrier policy. 'We are therefore including in our combined Active and Reserve Fleets at present thirteen aircraft carriers, whose main function will be the protection of shipping against air and submarine attack.'[2]

This statement produced a pointed response from Lord Teynham, which highlighted the internal contradictions of existing carrier policy. '... with reference to the naval aircraft GR17. Of course, I am aware that it is a very efficient and up-to-date craft which embodies all the necessary instruments for combatting submarines, but there is still this point: that we cannot have a fleet carrier for every convoy, and, therefore we must have aircraft which can land on small aircraft carriers and escort carriers.'[3]

The inter-service aspects of the Navy's carrier policy were raised a month later during a further debate in the House

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1. Ibid. Col. 278
2. Ibid. Col. 279
3. Ibid. Col. 286

of Lords on the Royal Air Force. In the course of this, Lord Trenchard, who during this period advocated a major expansion of the RAF at the expense of the other two services, asked whether 'we are not putting too much time, manpower and energy into the big aircraft carriers ... the majority of people in the Royal Air Force hold the view that the big carrier is obsolete, and that it is a dangerous fallacy to base our defence upon it ... they are too vulnerable to be counted on as a safe means of support for the landing of airborne forces.'[1] This speech provides some indications of the nature of the inter-service debate over aircraft carriers. As Trenchard claimed to have been well informed on Air Force thinking, the implication is that the Navy were arguing for retention of a large fleet carrier force not for anti-submarine work, but as a means of supporting an opposed invasion of a hostile state by British forces before the Korean War led to British carriers being used as floating bases for air operations in support of UN ground forces.

The outbreak of the Korean war in June, 1950, led to a second Defence debate being held in mid-September. In the course of this, Lord Teynham once again returned to the theme of Escort carriers. He asked 'whether any steps are being taken to provide the auxiliary aircraft carriers which are of such vital necessity for service with our convoys.... Are we going to have any of these auxiliary aircraft carriers for service with our convoys.'[2] He received no reply.

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1. 167 H.L. Deb. 14th June, 1950. Col.676.
2. 168 H.L. Deb. 12th September, 1950. Col.989.

In 1951 there was no substantive statement on Defence, though on the 29th January the Prime Minister made a major statement on the Defence Programme in the House of Commons. He argued that 'the Forces have for the last five years lived largely on their stocks; and there is now urgent need for an increased production programme concentrated mainly on increasing their fighting strength.'[1] 'If our plan is fully achieved, expenditure on production for the services in 1951-52 will be more than double the rate for the current year; and by 1953-54 it should be more than four times as great.'[2] 'It will take time to build up defence production to the levels which we now have in mind, and expenditure on production will be on a rising curve during the next three years. If the programme is fully achieved, the total defence budget over the next three years ... may be as much as £4,700 millions. Nearly half of this will be for production.'[3]

The effect of this programme could be seen when the Navy Estimates were published on the 1st February 1951. They contained a substantial increase in the Navy's estimated expenditure on ships and their equipment during the financial year, though only a relatively minor increase in the sum to be spent on aircraft. It was also pointed out in the accompanying First Lord's Statement that the 'total provision for production and research,

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1. Defence Programme: Statement made by the Prime Minister in the House of Commons, 29th January, 1951. P.5, para. 11. Cmd. 8146. Acc. and Papers (7); 1950-1951; Misc: XXVII.
2. Ibid., para. 12
3. Ibid., p. 6, para. 15.

which I am proposing in the present Estimates is approximately £132 million as compared with nearly £73 million in the original Estimates for the current year.'[1] One immediate effect of the rearmament programme was to make more money available for starting new projects and completing development work on existing ones. The aircraft carrier programme was reported to be progressing satisfactorily while 'close attention continues to be paid to the development and evaluation of airborne anti-submarine equipment, and an air group has recently been formed to specialise in night flying .... Steps are being taken to put into production a new general reconnaissance aircraft for anti-submarine work .... New fighter and anti-submarine aircraft of high performance are being developed for the Navy.'[2]

The House of Lords debated Defence again on the 21st and 22nd February 1951, and Viscount Hall was subjected to further criticism over the Admiralty's aircraft carrier policy. Lord Winster commented that 'of the large aircraft carriers, six seem to have been unoperational, although the *Indomitable*, after a very long refit, did come into service at the end of 1950.'[3] Earl Beatty raised the issue of the lack of Escort carriers by stating that 'it is necessary for us to have escort carriers .... I noticed in the Navy estimates of this year that the three light fleet escort carriers whose construction was

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1. *Statement ... Explanatory of the Navy Estimates, 1951-1952.* P. 2, Cmd. 8160. Accounts and Papers, (3); 1950-1951; Navy, Defence, House of Commons, Housing: XXIII.
2. *Ibid.*, p. 7.
3. 170 H.L. Debs. Col. 485. 21st February, 1951.

stopped in 1946 still have a mark against them showing that work is suspended, and I presume, therefore, that work is being carried on only on four light fleet aircraft carriers .... In any event I feel that seven or eight light fleet escort carriers - if we are going on with all of them - are insufficient to go with all our convoys. I would ask the Noble Lord whether we are going to press on with the conversion of merchant ship hulls now under construction into escort carriers .... In view of the small number of light fleet escort carriers and the fact that the only escort carrier has been loaned to the Festival of Britain for two years, I hope that this suggestion will be seriously thought over.'[1] No comment was forthcoming from Viscount Hall. This speech is significant, for it was the first occasion upon which a parliamentarian had suggested that the Light Fleet carriers should have the specific task of trade protection, rather than forming part of a naval task force.

A week before the Navy Estimates for 1951-52 were debated in the House of Commons, the Parliamentary Secretary to the Admiralty was induced to make public some information on the history of the GR17/45 specification. Mr. Langford Holt asked him 'how many changes have been made to the specification for the GR17/44 aircraft since the first staff requirement was issued; and on what date this requirement was issued,'[2] to which the reply was 'Two sir. The requirement was issued in December 1945.'[3] Mr. Langford Holt then followed up with a

1. Ibid., Col. 503.
2. 485 H.C. Debs. 7th March, 1951. Oral Answers: Col.413.
3. Ibid.

supplementary question, asking for assurances 'that there has been, and there is now, no intention of altering the seating capacity of this aircraft from two to three, which would radically alter it,'[1] to which Mr. Callaghan responded 'That is one of the two major alterations that has been effected. The number of seats has already been increased from two to three.'[2] It is unclear what the purpose of this exchange was, though it did have one unintended result. From that point onwards the GR17/45 specification was often referred to in the House of Commons as the GR17/44.

The subsequent Debate on the Navy Estimates contained few of the extreme perceptions of the Russian submarine threat that had characterised the previous year's debate. A more balanced appreciation of Russian submarine capabilities was present throughout the debate, emphasis being placed on the craft allocated to each of the four Russian fleet areas, rather than total numbers. The bulk of the Ministerial presentations were given over to descriptions of the state of the rearmament programme, while the backbenchers who spoke often became entangled in the dispute over whether all anti-submarine aircraft should be under naval or air force command. In his opening presentation the Parliamentary Secretary to the Navy claimed that 'At our war-time peak we had eleven Fleet and Light Fleet carriers, and today we have twelve.'[3] 'We are up against greater problems

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1. Ibid.
2. Ibid.
3. 485 H.C. Debs. Supply: Navy Estimates; 12th March, 1951. Col. 1085 and 1086.

with the heavier and faster planes which we are now getting. They throw a greater strain on the arrester gear, on the deck, and also create a problem about the height of the hangars because of the height of some of the new planes. This will involve a process of modernisation and conversion of our existing carriers ....'[1] This seems to have been a reference to further planned modernisation of the armoured Fleet carriers. He then went on to say that 'we also attach very great importance to the GR17, an anti-submarine plane which has been specifically designed for these carriers. It is a three seater and, I believe, will be found capable of doing really important work in this field which has not been done before.'[2] In addition, he expressed the hope 'that helicopters, together with GR17's will be able to make great use of the sonobuoy.'[3]

Although too much should not be read into these public statements, it is interesting to note that they imply that the GR17 had been specially designed to operate from the Fleet carriers, rather than Escort carriers. The possible need for the latter was ignored in the Ministerial presentation. This raises an interesting point of political speculation about whether the inability of the GR17 to operate with a full load from anything other than Fleet carriers was advanced as one of the reasons for retaining such carriers. This argument would have both met criticisms that the Navy was ill-equipped to

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1. Ibid.
2. Ibid.
3. Ibid. Col. 1087.

meet the immediate threat from the Russian submarine fleet, and enabled the Fleet carriers to be retained for possible future use in more offensive roles.

In the debate which followed this speech, Surgeon Lieutenant-Commander Bennett raised the issue of the Firefly VII purchases. No information had previously been given to Parliament about this. He asked 'what is the purpose of ordering a fairly large number of Fireflies, often of a late mark. They are a very small and ancient heritage.'[1] Mr. Callaghan's reply was that 'They are not small and ancient. The new mark is a three seater. They will do the anti-submarine job exceedingly well until the GR17's are produced in large numbers. It is an interim plane, but has quite a long life in front of it - of several years, I would certainly hope.'[2]

Bennet then raised the issue of Escort carriers. He stated that 'all of us know of the existence of the light fleet carrier, but I would express my doubts ... whether it will be possible to operate the heavy anti-submarine ship-born aircraft such as the GR17, which is such an excellent aircraft, from anything but a large carrier .... It does seem that the day of the escort carrier and of the light fleet carrier may, in fact, be over even now, and that nothing but very large carriers can be used for modern aircraft.'[3]

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1. Ibid.
2. Ibid.
3. Ibid. Col. 1189.

A month later Mr. Langford Holt continued his probing of the GR17/45 project in the Commons by asking 'when it was anticipated that the GR17/44 aircraft, for which the staff requirement was issued in December 1945, will come into service?'[1] Mr. Callaghan responded by stating that 'it would not be in the public interest to disclose this information, but the House can rest assured that all practicable steps will be taken to ensure that the GR17 will come into service at the earliest possible moment.'[2] Mr. Langford Holt then raised a supplementary question by asserting that the development time of this aircraft had been inordinately long, and asking for serious consideration to be given to the holding of an inquiry into the whole question of aircraft production. Mr. Callaghan responded by offering 'to look into these matters.'[3]

A further forum in which some discussion on the Naval aircraft programme could have been expected was the Select Committee on Estimates, which in the session 1950-51 produced two reports on the rearmament programme.[4] Although the first of those investigated Naval rearmament, there was no discussion of naval aircraft or carrier policy during the course of its activities. The second report was devoted to the manpower and material supply problems that were affecting the rearmament programme.

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1. 486 H.C. Debates. 18th April, 1951. Oral Answers: Col. 1811.
2. Ibid.
3. Ibid.
4. Rearmament: Select Committee on Estimates. Third Report. Pp. 117-128. 1950-1951. (178). Reports: Committees (2). Estimates; 1950-1951: V; and Rearmament: Select Committee on Estimates. Tenth Report. 1950-1951, (260). Reports: Committees, (3). Estimates (continued): 1950-1951: VI.

In addition, the Comptroller and Auditor General did not query any item of past expenditure in these areas of naval procurement, and thus no relevant discussion occurred in the Public Accounts Committee.

Three issues stand out clearly from the Parliamentary discussions and documentation during 1950 and 1951. One is that a very small number of MP's and members of the House of Lords either acquired, or were given information on the details of the Navy's carrier and anti-submarine aircraft programme, and the arguments surrounding them. This enabled them to embark on a very restricted public dialogue with government ministers on these issues. At this distance in time it is unclear whether the initiative for this came from the people concerned, or from interested groups within the defence establishment. The second issue was that although a number of Parliamentarians had acquired some details of the history of the GR17/45, and certain of the issues surrounding it, the government publicly took little notice of their criticisms. The same applied to the Firefly VII. The third issue was the contradiction that existed between the types of aircraft carriers which seemed to be needed to meet the immediate threat from Russian submarines, and the Navy's ambitious Fleet carrier programme. No public attempt was made to explain this contradiction, although it was stated that the GR17 had been designed to operate from the Fleet carriers, and by implication could not operate from Escort carriers. The public pleas for closer attention to be paid to the need for Escort carriers seem to have had no impact upon official thinking and policy. Indeed, there were indications in the Parliamentary discussions that the Navy was already arguing in debates within the Ministry of Defence that its future carrier force should have a ground force support role.

CHAPTER 7

ANALYSIS, 1950-1951.

This chapter will continue the systematic examination of the relationship between the propositions on weapon procurement generated in Chapter 1 and the evolution of the British naval anti-submarine aircraft programme between 1945 and 1956.

Proposition i. Uncertainty is inherent in weapon procurement projects, but the types of uncertainty involved are directly related to the stage that has been reached in the evolution of the project.

Target uncertainty was the largest element of uncertainty present in the GR17/45 project up to 1950. Between 1950 and 1951 much of the controversy which had surrounded the concept of anti-submarine operations over the previous five years subsided, as attention became focused on choosing a design to place into production from among a range of available alternatives. The need to make a production decision muted the issue of what type of anti-submarine operations were to be performed, while the need for an anti-submarine aircraft was never questioned.

Major uncertainties persisted over the performance capabilities and the configuration of the anti-submarine aircraft both prior to, and following, the production decisions of 1950. The GR17/45 production decision was taken at a time when the hurried redesign of the Blackburn wing had created major aerodynamic problems. Doubt existed whether these could be corrected or were of a fundamental nature. The three seat Blackburn Mamba GR17/45 could be regarded as broadly representative of a production aircraft, in contrast to the lack of a three seat Fairey prototype, and the extensive structural changes likely to be required in any production model. Only the Blackburn Griffon GR17/45 three-seat prototype was likely to go into production in a virtually unchanged form.

Both the GR17/45 production decision and the problems encountered by the Firefly VII indicate the degree to which the ability to perform the anti-submarine role was subordinated to the more basic criteria of their flying qualities and the pilot's view when making a deck landing approach. The ability to perform the anti-submarine role was not evaluated in the GR17/45 competition, as this stage had not been reached when the production decision was made. The Firefly was known by 1948 to have fundamental limitations in the anti-submarine role, yet they were ignored.

This suggests that when production decisions were made, uncertainties over the correct operational concept to adopt and the detailed equipment needed to fulfil it were downgraded in importance to the point of irrelevance, the decision being firmly based upon reports on the flying qualities of existing prototypes. An important element of this decision-making process was the tendency to take an existing airframe, modify it so that it would be capable of carrying the latest types of equipment and weapons and then plan production on the assumption that no further technical problems remained. The risks involved in such a procedure were recognised at one point in the GR17/45 decision-making process when it was suggested that no production decision should be taken before trials had been conducted with Pentane, as it was possible that one of the designs might be incapable of successfully dropping this weapon, but this suggestion was ignored. The GR17/45 production order was thus awarded on the basis of a prototype which was known to require extensive modifications to the cockpit layout, the position of the undercarriage and the length of the bomb bay; which was to be equipped with an adaption of a radar built for another purpose; and which was to be armed with a torpedo that was still under development. The result was that the design of the production aircraft had not been completely proven at the end of 1951, while a fully representative prototype aircraft would not be available for testing until the first of the pre-production aircraft was completed.

A very similar situation existed with the Firefly VII. This was a stop-gap aircraft aimed at enabling the new sonobuoy equipment to be placed in service as rapidly as possible. Extensive modifications were proposed to the basic Firefly V design yet, despite Fairey's misgivings, no fully representative prototype aircraft was built. During 1951, as the early production aircraft became available for testing, it became clear that the modifications had had a very adverse effect upon the basic flying qualities of the aircraft, and this created a conflict between those personnel in the MoS who had committed themselves to producing this new version of the Firefly, whatever its defects might be, and the naval pilots responsible for deciding whether it was safe for service use.

In both of these projects, considerable technical uncertainty existed at the end of this period, largely because the modifications specified for the production version of the aircraft had not been fully tested. In the case of the Gannet, the technical problems inherent in the new design would not be revealed until it could be fully tested: in the case of the Firefly VII, the uncertainty revolved around whether minor design changes could be introduced to make it's handling acceptable to naval pilots, major modifications having been specifically excluded by the Requirement.

The internal workings of the weapon procurement process also formed an additional area of uncertainty during this period. Weapon projects appear to generate considerable passion among those people administering them, partly because of the prestige that is believed to accrue from having a design accepted for production; partly because of the considerable rewards of a production contract and the lack of prospects that accompany not obtaining one; and partly because of the considerable financial and personnel resources tied up in a development project seeking a production contract. The GR17/45 production decision was permeated by these issues, for until the outbreak of the Korean War the prospects were that each of the two firms involved would only survive in their existing form if they obtained the production contract. In consequence, the production decision was seen by the MoS as an industrial as well as military decision. It was initially dominated by two different, but related substantive issues. One was whether the aircraft was to have a gas-turbine or a piston engine; the second whether the contract was to go to Fairey or Blackburn. The linkage between the two issues was that Blackburn had produced the only piston engined GR17/45 prototype, and any decision to opt for a piston engined aircraft was tantamount to opting for their design.

This situation created a number of cleavages within both the MoS and the Naval Staff. Within the latter, it seems probable that differences of opinion still existed over the likely composition of the Navy's carrier fleet in the early 1950's. If the large Fleet carriers were retained, the lower powered piston engined Blackburn Griffon would be able to operate from them despite its lengthy take-off run: if they were to be scrapped, a higher powered Mamba aircraft would be needed to obtain the short take-off run necessary for operations from smaller carriers, or alternatively a completely new light anti-submarine aircraft design might be needed. This cleavage was overlain by the financial aspects of the decision, for a Griffon engined version was certain to have a lower initial cost than a Mamba version, and might even have lower running costs. In addition, if flexibility was required, only the interchangeable Griffon and Mamba power plants of the Blackburn design appeared to provide it.

The cleavages within the MoS were over rather different issues. First, there were those who sought to have the production contract awarded to either Blackburn or Fairey because for a variety of reasons they believed it right that these firms should be given the ability to survive as aircraft design and production units. Second, there was a commitment within the engine development section of the MoS to the gas-turbine as the future line of engine development, and it was believed that any reversion to a piston-engine for the GR17/45 designs would undermine this policy. In addition, the GR17/45 offered the only real prospect of a production order for the Double Mamba, and thus a return on the resources the MoS had committed to it. Third, there were those who realised that the Fairey method of airframe construction made modifications to the prototype designs both difficult and costly, and who considered it would be much cheaper and easier to prepare the Blackburn airframe for rapid production than the Fairey one.

These multiple cleavages created major uncertainty over which GR17/45 variant was to be chosen for production and it took six months from March 1950 for some of the conflicting choices to be resolved, and for a coalition to be formed to support the decision that was finally made. In the absence of clear and accepted criteria upon which to base a decision, the intermingling of substantive and organisational conflict that occurred during this period was inevitable, and its outcome inherently uncertain.

A similar nexus of substantive and organisational conflict was occurring over the Firefly VII, though here the issue was rather simpler. The civilian technical staff in the MoS had been given a requirement to produce a minimally modified three-seat version of the Firefly V. They had accepted that nothing could be done to improve the pilot's view unless a radical redesign of the aircraft took place. The Navy's test pilots regarded this variant as unacceptable for service use, with the implication that the MoS had been directly responsible for developing and producing an aircraft which was of little use to the Navy, thus squandering scarce resources. It remained uncertain at the end of 1951 how this problem was going to be resolved.

The last major element of uncertainty, the finance available for production, resolved itself rapidly once the Korean War stimulated the British government into embarking on a major re-armament programme. Until June 1950 the limited amount of finance available for aircraft production appears to have delayed orders being placed for the Firefly VII and may have stimulated some reluctance to reach a production decision on the GR17/45 designs. It certainly encouraged the Navy to think strongly of opting for a cheaper, Griffon-engined design and possibly not purchasing any GR17/45's at all. The removal of the existing financial restrictions after June 1950 led to large orders being placed for the Firefly VII and allowed the Navy to opt for a Mamba engined GR17/45, thus removing one obstacle in the path of a production decision.

The fact that the GR17/45 project had reached a point where a production decision was expected to be made had a very curious effect upon the uncertainties inherent in the programme. Target uncertainty largely disappeared, and the criteria of choice became whether the aircraft could operate safely from an aircraft carrier, especially at night. The uncertainties surrounding the production decision were inherent in the many cleavages in the organisations involved, and the diverse issues at stake. Given these elements, it would have been almost impossible to forecast at the start of 1950 which design would be chosen for production. A further uncertainty was the limited finance available, but the rearmament programme removed this as an effective restraint, and precipitated the production decision. Once the organisations involved became seized of the need to make a decision it was dominated by organisational uncertainties over which groups could coalesce to produce a majority behind one of the designs. Finally, the desire to install the best available equipment in the aircraft meant that production aircraft were markedly different from the prototypes, and this in turn generated a new range of technical uncertainties which could only be eliminated once production prototypes became available for testing. Finally, it is notable that the consensus in favour of the Fairey design emerged largely as a result of the marked technical uncertainties about the Blackburn design's flying ability created by the hurried redesign of its wing, uncertainties which the Fairey design did not appear to possess.

<u>Proposition ii. External factors dominate a weapon project at certain key points, specifically decisions on inception, production and cancellation. At other times the process operates autonomously.</u>

The key external events that impinged upon the naval anti-submarine aircraft programme between 1950 and 1951 were the start of the Korean War and the resulting British rearmament programme. Their direct consequence was a major increase in the resources available to the Navy for ship and aircraft construction and to the MoS for the development of new aircraft. More specifically, they shaped the GR17/45 production decision, the Firefly VII purchasing decisions and the decision to start work on a new light anti-submarine aircraft.

In July 1950 the GR17/45 prototype programme was approaching a point where sufficient information would be available to make a technically based choice between the competing designs, while the Navy's need for a purpose built anti-submarine aircraft appeared to be increasingly urgent. Unfortunately, the existing naval budget, coupled with the anticipated purchase price of GR17/45 aircraft, made it difficult to see how the numbers believed to be required could be purchased, especially as the fighter and strike elements of the Fleet Air Arm would have to be re-equipped at the same time. This gave rise to four major options: cancellation of the whole programme, and reliance on the Firefly VII and a future modern light anti-submarine aircraft design; purchase of one of the Mamba engined designs in very small numbers; purchase of rather greater numbers of a Griffon engined design; and continuation of one or both of the prototype programmes by letting contracts for prototypes of fully equipped production aircraft, in the hope that when they were completed money would then be available to finance a production order. A further complication was that it was difficult to see how the Navy's ambitious Fleet carrier construction and modernisation programme would be financed under existing budgetary limitations, yet it seemed unlikely that a Griffon engined GR17/45 would have sufficient power to operate from small carriers.

The decision to rearm radically altered this situation. The Navy were given the means to purchase large numbers of anti-submarine aircraft, and had no need to be influenced by the apparent cost advantages of piston engined aircraft. The way was thus opened for the decision to choose the Fairey GR17/45 for production, and to place a substantial production order for it. While the timing of the decision was heavily dependent upon the internal progress of the GR17/45 prototype development programmes, its substance was heavily influenced by the increased availability of funds for new naval equipment.

The initial Firefly VII production decision appears to have been reached with no external stimulus at all, as it was seen merely as a question of it replacing the Mark VI aircraft on the existing Firefly production line. This contrasts with the decision to proceed with development of the Mark VII, which was heavily influenced by the international situation in 1948-49 and a perceived need to place an interim anti-submarine aircraft into production. The rearmament budget, and the need to spend the money allocated to the Navy for immediate production, stimulated the decision to increase the numbers on order, despite the technical problems it had encountered. Finally, the decision to embark upon development of the light anti-submarine aircraft, a requirement first discussed in 1948, was probably related to the increased availability of development finance.

It is clear that from mid-1950 onwards the expanded defence budget had a direct impact on all three anti-submarine aircraft projects. It alone was probably responsible for the expansion of the Firefly VII order and the inception of the light anti-submarine aircraft project. The GR17/45 situation was a little more complex, however, for the internal evolution of the project had reached a point where some decision had to be made concerning production, though the actual decision was heavily influenced by the increased finance available.

Proposition iii. Governments act purposefully and as unified entities both to maintain their defence R & D base and to avoid having to make conscious choices between conflicting alternatives.

This period indicates that what appears superficially to be purposeful behaviour on the part of a unified governmental organisation is often the product of groups competing to have their viewpoint, interests or opinions accepted as governmental policy. Actions to maintain the R & D base only persisted through to June 1950, and were largely a continuation of the activities found in the 1948-49 period. After June 1950 the problem increasingly became one of the aircraft industry being given more design, development and production work than it could easily handle, and the need to sustain the R & D base temporarily disappeared.

Two sets of events can be cited as evidence of a policy of consciously attempting to sustain the R & D base up to mid-1950. One was the awarding of contracts to Fairey for the N19/49 project, despite the unsatisfactory nature of the designs offered, and the insistence by some MoS officials that this firm should be given an opportunity to produce a Griffon engined version of their GR17/45 design if it was decided to abandon the gas-turbine engined designs. The second was DMARD's strong support for the Blackburn design throughout the GR17/45 production decision process, which was consistent with his prior concern to give the company every opportunity to produce an acceptable design in the belief that their future depended upon them receiving a production contract. Both of these activities were based upon a desire to sustain specific firms in the belief that they would make a valuable future contribution to aircraft design and development, rather than any policy of maintaining an R & D base as such.

A similar picture of superficial purposefulness underpinned by a lack of organisational unity and consensus can be seen in the decision-making processes related to the GR17/45 and the Firefly VII projects. A major feature of this first decision was the way in which a final judgment was avoided until a clear-cut winner emerged from the competitive trials. It was intended to recommend the termination of development of one or two of the three existing GR17/45 variants at the July meeting, but it rapidly became clear that both the Blackburn and Fairey designs were strongly supported by specific individuals attending the meeting, and that no unanimous decision was likely to emerge from it. It was also apparent that a major disagreement existed between the MoS and the Admiralty over the choice of engine for the aircraft. The only agreement to emerge from the meeting was a recommendation for a full programme of trials, and a decision that ultimately the choice of engine was a matter for the Admiralty, although the MoS was strongly in favour of them choosing the Double Mamba gas-turbine.

In the course of the July meeting, it became clear that three criteria could be used to evaluate the performance of the aircraft in the anti-submarine role: their deck landing and low speed handling performance; their ability to carry new weapons and equipment, and their ability to perform anti-submarine search and strike missions. The available evidence suggested that the Blackburn Griffon was superior in the last two respects to the Fairey Double Mamba, but the lack of a definitive three seat version of Fairey's aircraft made it impossible to perform a comparative tactical evaluation of the two types.

The Admiralty's response to the recommendations which emerged from the July meeting, was to indicate that their interest in a Griffon powered GR17/45 was declining, and that they placed primary emphasis upon the deck landing and low speed performance of the GR17/45 variants to the apparent exclusion of other factors. The production decision thus became dependent upon the results of the deck-landing and handling trials on HMS Illustrious and at Boscombe Down. It is interesting, though not very productive, to speculate how the final decision would have been arrived at had Blackburn decided either not to alter the wing planform of their Double Mamba powered variant before the start of the deck-landing trials, or been encouraged to do this in late 1949, when it should have been clear to officials in the MoS that this variant had major endurance, low speed cruise and take-off limitations.

The Boscombe Down report on the GR17/45 deck-landing and handling trials was unequivocal in identifying the Fairey Double Mamba as the better flying machine. This conclusion was facilitated by the failure of Blackburn to effectively redesign the wing of their Double Mamba powered aircraft. Once this report was available, little thought was given to a comparative evaluation in terms of the other two criteria, despite the fact that the advantage here seemed to lie with the Blackburn design. Its contents, together with the emphasis placed on deck landing performance by the Admiralty, combined to enable a rapid decision to be reached to produce the Fairey variant before the full series of competitive trials had been completed.

The second decision was a decision not to act. There was ample evidence available from November 1950 onwards that any three seat version of the Firefly MkV was unlikely to be regarded as acceptable by naval pilots for night operations. Both the requirement and the specification stated that the Firefly VII aircraft was to be a minimally altered version of the Firefly V, yet it was clear that the aircraft would have to be extensively redesigned if it was to overcome its known deficiencies when operated at night from aircraft carriers. Such a night flying capability was increasingly viewed as an integral part of anti-submarine operations.

Two options appeared to be available to deal with this problem. One was to authorise a major redesign, the second to terminate development of the aircraft and cancel the production orders. Neither of these options was adopted, and no hard evidence exists to suggest why. Instead the MoS official involved tried to invite Fairey personnel to disagree with the HMS Vengeance report on the Firefly V's night flying capabilities, and then unilaterally stated that the two features of the aircraft which had been most adversely criticised in this report were acceptable to the MoS and, by implication, to the Admiralty. As a result the programme was allowed to continue, but these two features became the target of mounting criticism. In this case not only was a decision delayed indefinitely, but there was also an attempt to ignore the existence of a major dilemma, which had to be rapidly resolved if money was not to be wasted building production models of an aircraft which was operationally unacceptable.

The evidence from the GR17/45 decision and the Firefly VII non-decision suggests that this proposition is mis-stated. It seems clear that the source of inaction was the existence of conflicting alternatives, and a lack of consensus between the groups or individuals supporting them. A decision was only taken when an unequivocal technical recommendation appeared, and nobody chose to question the assumptions upon which it was based. Neither this aspect of policy making, nor that related to the R & D base can therefore be seen as a product of purposeful action by a unified entity.

Proposition iv. The weapon acquisition process is conducted solely through closed politics, and public debate and discussion exercises no real influence over it.

This period witnessed the start of more visible public interest in naval anti-submarine aircraft. Parliamentary investigations into the effectiveness of the re-armament budget initiated late in 1951, were partly responsible for this as was the more extensive information made available to the technical press on the naval anti-submarine aircraft projects, but this still did not result in any form of critical public debate or enquiry being initiated about them. Until the defeat of the ruling Labour government in October 1951 one political party had been in power throughout the GR17/45 gestation period, and therefore had a monopoly of detailed information on these projects. The advent of a new governing party, and the creation of a parliamentary minority having recent information on defence matters, made it likely that in future there would be more extensive discussions of detailed defence issues. In 1950 and 1951 the increased supply of information did not produce any corresponding critical public debate on these issues, and the naval anti-submarine aircraft projects remained firmly within the domain of closed politics. What Parliamentary discussion did occur on the general concept of anti-submarine operations and the equipment needed for them had no discernable influence upon government policy-making, while many of the points raised in Parliamentary debates were publicly ignored by government ministers.

Proposition v. The weapon procurement process is dominated by civilian direction and industrial and service views or problems have no influence over it.

In Chapter 5 it was concluded that the Navy's views were the dominant element in the anti-submarine aircraft procurement process, mainly as a result of the service's position as customer. The period 1950-51 provides further reinforcement for this proposition. The impact of industrial views and lobbying during this period was negligible. Only three examples have been presented in Chapter 6, and none of them provide any evidence of a direct link between industrial lobbying and the decisions taken on the anti-submarine aircraft programme. One was the promulgation by the Naval Staffs of an official requirement for a split-role light anti-submarine aircraft during 1950. This idea had first been suggested by Fairey in 1948, and was also supported by Vice Admiral Sir Mathew Slattery, the former CNR, when he became Joint Managing Director of Short Bros. The second was Fairey's active advocacy of a Double Mamba rather than Griffon powered GR17/45 during mid-1950: the third their plea to limit weight escalation in the production aircraft in early 1951.

The relationship between the civilian technical staff in the MoS and the officers of the Naval Staff was a little more complex, because in the last resort the Navy relied upon civilian technical judgments when making their procurement decisions. This produced an acute conflict in 1950 when MoS officials did their best to prevent the Admiralty choosing the Griffon piston engine to power GR17/45 production aircraft. Again, no direct evidence exists to suggest why the Navy decided to change their attitude towards this engine. It may have been as a result of the MoS arguments, technical or otherwise, or it may simply have been that the use of a piston engine had been considered in order to save money, and when that factor became irrelevant thanks to the rearmament budget, the underlying support for the Double Mamba power-plant reappeared.

In all the discussions between the MoS and Naval representatives over the production order for the GR17/45, it was recognised that in the last resort the decision was one for the Admiralty Board and not the Ministry. All the latter could do was attempt to secure a near unanimous recommendation from a joint meeting, which could be sent to the Admiralty Board, and failing that they had to rely upon the Naval Staff transmitting to the Board the arguments discussed at such meetings. Similarly, the MoS seem to have had little ability to influence the Admiralty in their actions in writing the GR17/45 production requirement, and including in it such major changes in equipment loads that the normal take-off weight was increased considerably. Indeed one of the activities that appeared to be taking place in late 1950 was that naval officers were by-passing the civilians in the MoS and giving direct guidance to Fairey on the type of changes they wished to see in the GR17/45 production aircraft.

In contrast to these events, the Firefly VII project appeared to be dominated by the civilians in the MoS. Decisions were made within the MoS on the acceptability of certain features of the design for operational use, apparently without full consultation with the Navy, and it was these decisions which produced an aircraft with grave operational limitations. This made the civilians in the MoS the dominant element in this project through to the end of 1951.

During this period, the Navy's ultimate dominance as customer was consciously recognised by the civilians in the MoS, while industrial views appeared to have little influence over either organisation. It is unclear whether the MoS's views on gas turbine engines did prevail in mid-1950 over the Navy's predeliction for adopting a piston engined aircraft, or whether the changed financial climate led to the Navy's change of attitude. The relationship of technical dependence upon the MoS was such that if MoS officials chose to make important technical decisions without consulting the Navy, there was little to stop them doing so, as the consequences of such decisions would only become known to the Navy at a later date.

Proposition vi. Governments do not act as unified entities when taking decisions on defence projects because of the conflicting interests and expertise of the bureaucratic organisations involved. This creates a lack of positive direction and control.

Two types of conflict are discernable within the bureaucratic organisations responsible for naval aircraft procurement during this period: conflicts between the two ministries involved based upon their own perceived interests, and conflicts within the ministries between different sections wishing to further or protect what they perceived to be their own interests. Thus while there existed a visible conflict between the MoS and the Admiralty in early 1950 over the type of engine to be fitted to production GR17/45's, there also existed within the MoS at least one individual in a senior position who was advocating that serious consideration be given to placing the Blackburn GR17/45 into production as it could if necessary be powered by a piston engine. The strength of this advocacy was to be an important element in ensuring that no positive production recommendation went from the joint meetings on the GR17/45 to the Admiralty Board.

In the Firefly VII case, the situation that had developed by the end of 1951 appears to have been a product of lack of consultation between the two ministries. As a result a relatively coherent policy had been pursued of developing the best aircraft that could be produced within the limitations of the specification, despite it being patently obvious after the HMS *Vengeance* report that it was unlikely to be acceptable to the Navy.

These examples support the proposition in all respects, for in the first case the consequence of the lack of unity was an inability to produce a positive recommendation, while in the second case it produced a lack of effective control over the project.

Proposition vii. Certain individuals may, through their personal or organisational position, determine whether a defence project is sustained or cancelled.

Four examples have been uncovered in this period of the major influence exerted by certain individuals upon the course of a defence project. The first was the impact of Mr. G.W. Hall upon the Fairey GR17/45 development programme in early 1950. His ability to give a clear lead in resolving the central problems that were making the prototype unsafe to fly, and his action in co-ordinating Fairey's development activities over the aircraft, both appeared to prevent the threatened cancellation of the aircraft, and make it possible to win the production order at a later date. The second, and similar, example is the design error which was made by an unknown designer or group of designers at Blackburn when they extended the Blackburn Mamba wing in the belief that this would improve its performance. Had this redesign been successful, it would have made it much more difficult to unequivocally recommend the Fairey design as the better aircraft.

The last two examples are of the influence of civil servants over a defence project. One is the way that personal advocacy and influence may well have been very important in determining the outcome of the GR17/45 production decision. This is difficult to discern directly from the minutes of meetings and is further confused by the intervening variable of organisational role. It is clear that certain individuals, such DAW, did have organisational roles which enabled them to have a powerful personal influence over this decision if they chose to relay to the Admiralty Board their own personal views, as well as or instead of those expressed at meetings. The second example is the key role AD/RDN played in the Firefly VII project. He personally appears to have decided that the pilot's view was acceptable to the Navy, and was thus directly responsible for the results which flowed from this decision.

In all these cases individuals had a major influence upon policy, and had they not acted in the way they did, it is likely that the course of the naval anti-submarine programme would have been substantially different. This period thus provides ample evidence to reinforce this proposition.

<u>Proposition viii. Time is the most flexible variable in the weapon procurement process, followed by cost and quality.</u>

This period is unique in the post-war history of naval anti-submarine aircraft projects in that the rearmament budgets, initiated in September 1950, appeared to produce a temporary relaxation of financial restraints upon the military aircraft development and production process. This meant that, in theory at least, cost could be traded for time. In practice this did not occur extensively, mainly because a new set of limitations appeared, namely design and production capacity and the supply of trained labour.

The history of the GR17/45, Gannet and Firefly VII projects seems to support the proposition that quality was a relatively inflexible factor in the weapons procurement process during those two years. New equipment was added to these aircraft irrespective of the effect upon their take-off weight and performance, or their cost and time schedules. No new requirement or modification seems to have been contested on the grounds of its impact on other factors. Indeed the only effort to do this came from Fairey and not the MoS.

The effect of this behaviour was that it was the time estimates which were not attained, rather than the quality targets. The development time of the Gannet could not be shortened appreciably, because of the difficulties of substituting expenditure for time, while there was little thought of putting into production an aircraft similar to the existing prototypes. Thus the evidence of this period seems to support this proposition.

<u>Proposition ix A weapon project comprises the following sequential phases</u>:

d. Prototype trials and selection of contractors.

e. Production development.

f. Production orders.

The GR17/45 production contract appeared to have been awarded as a consequence of competitive prototype trials, yet the committee discussions that preceded it, and the nature of the information requested by the Admiralty, suggest that the selection of appropriate criteria for evaluating the competitive prototypes was an integral part of the process of choice and largely predetermined the decision reached. The Firefly VII, Seamew and Gannet T2 represent alternative methods of initiating projects to that stated in this proposition. The former was an example of an aircraft ordered into production without the benefit of a design competition and rudimentary prototype trials. Its main recommendation for production was that it existed and appeared to be easily and cheaply adaptable to a new role. This suggests that any new military requirement can be fulfilled by either initiating the development of a completely new aircraft, or adapting an existing one. Adaption offers advantages in terms of time and expenditure, but a new development appears to offer greater quality, both because it has been designed specifically to the requirement and because it will be built on the basis of contemporary technological knowledge, rather than that of 5 to 10 years previously. A similar type of choice existed in the case of the Seamew development decision between ordering prototype production of a new design, or adapting an existing one. In this case the decision was made to produce a new design in a situation where the adaption comprehensively failed to meet the requirement. This development programme also represented an abandonment of the competitive prototype approach in favour of selecting only one aircraft for prototype production on the basis of a paper design competition. Finally, the Gannet T2 represents a common special case of adaptions made to existing designs in order to provide operational training aircraft. In these cases, no competitive element was possible as the basic design had already been chosen.

One further point illustrated by events during this period was that because of the time frames within which new military requirements and items of equipment tend to evolve, the prototype of a military aircraft will often be found to have been designed to obsolete military requirements, and around outdated or non-existent sub-systems, when it is eventually accepted for production. The resultant production model will often incorporate extensive modifications to the prototype design, and its production may commence before these modifications have been fully tested. Both the Gannet and the Firefly VII are examples of this phenomenon, as production orders for them were placed before a fully representative prototype was in existence, while the majority of the development work on the production aircraft occurred after the placing of the production order.

These case studies suggest that the sequence of phases contained in this proposition is not sufficiently comprehensive. An alternative formulation might be:

d. Determination of criteria of choice, prototype trials and contractor selection and/or search for suitable adaptions of existing weapons.

e. Production decision, placing of orders and definition of production standard.

f. Construction of production prototypes, and production development work.

g. Modification of weapons on the production line to rectify shortcomings demonstrated by production development work.

Conclusions

The start of the Korean war, and the subsequent rearmament programme initiated by the British government in September 1950 had a profound impact upon the post-war history of British weapon development. The limited resources available for both development and production activities up to that date had seriously impaired the ability of the Royal Navy to fulfil its long-range aspirations of building up a fleet of large aircraft carriers and equipping them with advanced military aircraft. Before September 1951 no decision had been taken on the shaping of the future carrier fleet because of a conflict over the best use for available resources with the other two services and the Ministry of Defence. Financial limitations also seemed to be delaying any major order for interim Firefly VII anti-submarine aircraft, while the GR17/45 programme was experiencing two sets of contradictory pressures. On the one hand, there was a desire to terminate development of at least one of the three variants in order to save money. On the other, the development of the new anti-submarine torpedo, the switch to a new radar set, and the lack of a three seater Fairey prototype inhibited comprehensive competitive trials being carried out between the GR17/45 variants. This, together with the general uncertainty about the finance likely to be made available for the purchase of new aircraft suggested that a production decision might be considerably delayed. In addition, the search for financial economies was pushing the Admiralty into considering a piston engined version of the GR17/45, because of the comparative cost advantages of the Griffon piston engine over the Double Mamba gas-turbine. Finally, although a need was seen to exist for a light anti-submarine aircraft, it was unlikely that finance would be quickly or readily made available for it. This remained a more favourable situation than that experienced with a number of other naval projects, such as the jet propelled night fighter, which had been sustained at the design study stage for a number of years because of a lack of development funds. The development plans of 1945/46 had proved to be more ambitious than development budgets would allow.

The events of the latter half of 1950 transformed this situation. They appear to have allowed the Navy to embark upon a limited programme of completing and refurbishing Fleet carriers. They made finance available for the rapid production of new equipment, which opened the way for the large orders for the Firefly VII. They also reduced the importance of the additional cost of a gas-turbine powered GR17/45, and created a desire for a rapid production decision, so that procurement could start within the three year budget period. Finally, they opened the way for a start to be made on the development of the light anti-submarine aircraft. Thus an event which occurred on the other side of the globe, and its consequences, altered the nature of British weapons procurement for the next decade, and made possible the production of a wide range of naval anti-submarine aircraft.

CHAPTER 8

PRODUCTION, 1952-1957.

i. Introduction.

It had been anticipated in early 1946 that aircraft built to the GR17/45 specification would be available for operational service by 1950. At the end of 1951, it appeared that the Royal Navy would be fortunate if they received deliveries of such aircraft before the middle of 1953, as no fully representative production standard aircraft was then in existence. This slippage appeared to be ameliorated by the imminent entry into operational service of the Firefly VII, which would also insure against further delays occurring in the Gannet production programme.

The years 1952-1956 witnessed a major change in British defence priorities. The three year rearmament budget was stretched to four years, and some orders for interim equipment were cancelled to expedite the production of aircraft and equipment started during the 1945/46/47 planning periods. Nuclear deterrence became the backbone of British defence strategy and great uncertainty existed about the role of navies in the event of nuclear war. The commissioning of the Royal Navy's new Fleet carriers was parallelled by greater doctrinal emphasis upon the Navy's ability to conduct limited amphibious assault and intervention operations, to destroy enemy warships, and to conduct air strikes against ground targets with conventional or nuclear bombs. These changes produced an evolution in the functions of naval anti-submarine aircraft. The general trade and convoy protection task was slowly superceded by the much more limited mission of naval task force defence. Although these changes had little technical effect upon the existing naval anti-submarine aircraft programme, they were of major importance in determining whether the navy would be interested in a new generation of fixed wing anti-submarine aircraft.

ii. The demise of the Firefly VII and its consequences.

At the start of 1952, development work on the Firefly VII was concentrated on trying to obtain improvements in its control characteristics by experimenting with a number of combinations of wing tips and rudders.[1] In addition, one of the prototype production aircraft was being prepared for night deck landing trials at A & AEE.[2]

DMARD visited the Fairey works at Hayes and White Waltham early in January to examine the work in progress there on the Gannet and the Firefly VII. He discussed the criticisms of the Firefly VII in detail with Fairey representatives, who indicated that in their opinion the handling characteristics of the aircraft were little different from those of earlier models. They argued that the existing criticisms of the aircraft stemmed

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1. RAFM AC-73/30 (41/d/1) F.H.Parker. 4 Firefly Correspondence, April, 1951-June, 1952. Internal Fairey Aviation Company Memorandum from Chief Technician (A) 15.1.52.

2. RAFM AC-73/30 (41/d/2) Firefly Mk. VII aircraft: FHP. Internal Fairey Aviation Company Memorandum from Chief Test Pilot 11.1.52.

from that part of the requirement which stated that the aircraft should be capable of cruising for long periods at 120 knots. Earlier marks had been designed to operate at a much higher cruising speed, and had only been flown at this lower speed for a short period prior to landing. As a consequence, their handling characteristics at this lower speed had not been regarded as something of prime importance, and were admitted by the Fairey representatives to be marginal. DMARD inspected the aircraft at White Waltham, and agreed that little could be done to improve the pilot's view. In the course of the discussions, the Fairey representatives complained about the continual stream of alterations to the aircraft which had been demanded by the Admiralty, and DMARD agreed to review these and reduce them to a minimum.[1]

Despite these assurances, members of his department noted late in January that the weights of the Firefly VII had increased beyond the limitations agreed to at the ADC. These specified a maximum landing weight of 13,500 lbs. with ten sonobuoys and one hour's fuel and a maximum take-off weight of 15,400 lbs. It was reported that the maximum take-off weight had become 16,638lbs. and landing weight 13,966 lbs. These weights were just within the limitations of the aircraft structure, and it was recommended that the aircraft should be cleared for a normal take-off weight of 15,800 lbs., an overload take-off weight of 16,650 lbs. and a landing weight of 14,000 lbs.[2]

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1. File Q. Note by DMARD on visit to Fairey's works at Hayes and White Waltham. 7.1.52.

2. Ibid. Internal Memorandum between members of Directorate of Military Aircraft Research and Development, 16.1.52.

The precise stimulus which finally led AD/RDN to force the Firefly VII issue to a decision is unclear, though it may have been the A & AEE report on the night deck landing trials they had conducted with the aircraft. The instrument he used was a summary report on the progress of the Firefly VII development programme which he prepared for DMARD early in February, and which terminated in a recommendation that the Admiralty be advised that the aircraft was unsuitable for operational use. This report listed the deficiencies uncovered by the HMS Vengeance report on the Firefly V in November 1950, and examined the degree to which the A & AEE felt that Fairey had overcome them. The latter had concluded that the Mark VII was so inferior in view and control to the earlier marks that any attempt to use it for normal night operations would result in an unacceptably high accident rate. It was felt that even if the firm improved the directional characteristics of the aircraft, it would only be possible to give the type a limited CS(A) release for deck landing during daytime in moderately calm conditions.

AD/RDN noted that the view and control deficiencies had been known for some time, and although it was acknowledged that nothing could be done about the first of these, it had been hoped that the latter could be dealt with. Six months development work on this had produced little improvement, and there was no indication that a further six months work would appreciably alter the picture. He had now reluctantly reached the conclusion that in its present form the Firefly VII was unsuitable for its role under operational conditions, and no short term experimental work was likely to alter this. Long term redesign would remove the major deficiencies, but such action would have a serious effect upon the Gannet programme. A further problem that had emerged was that the propeller had failed a strength test, and its production had been suspended pending a redesign. All of these factors represented a very unsatisfactory technical situation, and DMARD was urged to inform the Admiralty as rapidly as possible that this aircraft would not be capable of performing night operations from carrier decks.[1]

The response of the Admiralty to this recommendation was to call for a high level meeting with MoS officials. This was attended by their Director of Aircrew Operational Training, Director of Aircraft Equipment, Director of Aircraft Maintenance and Repair and DAW. It was first unanimously agreed that the Firefly VII was not suitable for front line service, and the meeting then went on to discuss what use could be made of the aircraft, in view of the resources expended in the existing production line and the large numbers of aircraft awaiting completion. In the course of the discussion, it was accepted that the aircraft's major faults were poor forward visibility and poor stability, the latter being largely a product of its excessive take-off weight when carrying operational loads. It was believed that this could be cured easily by removing the two external fuel tanks fixed beneath the wings. It was agreed that the only fore-

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1. Ibid. Summary Minute from AD/RDN to DMARD. 7.2.52.

seeable use for the aircraft was for aircrew training or, as a last resort, for target towing. A maximum of 50 would be needed to support the training establishments at St. Merryn and Eglinton during the period 1952-55, if it was found to be suitable for training purposes.[1]

In parallel with considering how the Firefly VII could be profitably used, both the MoS and Admiralty were focusing their attention on methods of providing anti-submarine aircraft to fill the gap in operational equipment that would exist until the Gannet entered service. One suggestion, originating in the Admiralty was that the Mark VII production line should be stopped and a new batch of Mark VI aircraft produced to fill the gap.[2] Another was that an attempt should be made to clear the Mark VII for night airfield landings, thus reducing the number of Mark VI aircraft needed for training purposes and enabling a substantial number of them to be transferred to operational squadrons. Another possibility was to obtain a suitable United States aircraft for use until the Gannet entered operational service.[3] Fairey was informed of the decision not to accept the Firefly VII into the Navy's front line squadrons late in February, when its representatives were requested to attend a meeting with MoS officials and naval officers to discuss the progress of Firefly VII production work. They were told that the Navy had decided that the aircraft was to be relegated to the training role, and that

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1. Ibid. Minutes of Meeting held 21.2.52 to discuss the future employment of the Firefly VII.
2. File N. Minute 15.2.52.
3. File Q. Minute to AD/RDN. 22.2.52.

the existing contracts would be cut back to either 200 or 120 aircraft. Their response was to emphasise the effect of such a decision upon the Gannet programme: they predicted that it would be affected in two ways. First, a drastic cut in the Firefly VII production programme would mean that they might have to declare production workers redundant at a time when they were planning to slowly increase their work force in order to attain the level of output demanded by the planned Gannet programme. Second, the design work involved in converting the aircraft into a trainer would lead to a diversion of design and drawing office staff from work on the Gannet. They also argued that the number of Gannets on order should be increased, and to prevent adverse psychological effects on Fairey's workforce, the announcement of such an increase should coincide with any announcement of a reduction in the Firefly VII orders. The increase in the Gannet order was necessary because of the difficulties that were being experienced in buying components and arranging sub-contract work for the existing production order of only 100 aircraft.[1]

The MoS was beset with conflicting demands from both the Admiralty and Fairey during March over the Firefly VII and Gannet programmes. Early in that month DMARD was informed that the Admiralty Board had decided to reduce the Firefly VII order to 120 aircraft. In parallel Fairey's production manager had submitted a detailed report to the MoS's Director of Aircraft Production (DAP) on the effects of reducing the Firefly VII order.

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1. File R. Minutes of meeting held at Hayes with Fairey's production staff, 28.2.52.

This report explained that it would be impossible to immediately absorb into Gannet production work all the men made redundant by the reduction in the number of Firefly VII aircraft on order, because a number of Gannet production drawings had not been completed due to information still being awaited on the dimensions of certain government supplied items such as the radar scanner. In addition, a shortage of skilled labour was slowing down the manufacture of production tools and the equipping of the production line, which was unlikely to be completed before December 1952. The report argued that sufficient Firefly VII aircraft should be retained on order to enable them to maintain their production workforce at its existing level until the end of the year, and if possible increase it.[1]

This report was sympathetically received by DAP, and CNR was informed that if the Firefly VII order was reduced to 200 aircraft this would not seriously affect the size of Fairey's labour force, and might serve as an incentive to expedite the start of Gannet production. It was felt that reducing the order to 120 aircraft might lead Fairey to reduce their labour force, and adversely affect the initial Gannet production rate. DAP also indicated that it would assist matters if the Gannet could be given a Super Priority designation.[2] This led the Admiralty to

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1. Ibid. Report dated 5.3.52 by Fairey Production Manager on the effect of cutting Firefly VII programme.

2. Ibid. Minute from DAP to CNR 12.3.52. The idea of assigning the Super Priority label to a project was part of a new scheme to try to speed up the production and entry into service of modern combat aircraft. The theory was that projects given this designation had priority in obtaining any resources which were in short supply and would not run into production bottlenecks because of the non-availability of an important item of equipment. In practice, the wide use of this designation served to defeat its original objective.

become deeply involved with the twin issues of increasing the size of the Gannet order, and having the aircraft given the Super Priority designation.

The MoS had indicated that to be nominated for Super Priority, it was necessary for the aircraft to have a planned production rate of 32 aircraft per month. Fairey had been told by the MoS to plan for a peak Gannet production rate of this magnitude in order to fulfil the requirements for naval aircraft contained in the Admiralty's 'Super Fraser'[1] plan. This envisaged 120 Gannets being produced in the financial year 1953/54, 284 in 1954/55 and 165 in 1955/56, giving a cumulative total of 569 aircraft, with a peak production rate in 1953/54 of 24 aircraft per month. It was estimated that delays in starting Gannet production would result in only 30 aircraft being completed in 1953/54, and that a production rate of 32 aircraft per month in 1954/55 would be necessary to enable the 'Super Fraser' cumulative target to be met by the end of March 1955.

Some doubt surrounded the validity of these 'Super Fraser' requirements due to the uncertain state of the Westland Wyvern turbo-prop powered strike aircraft project. The Wyvern had experienced an engine stalling problem which had not been resolved, and the aircraft's entry into operational service had been postponed pending its resolution. This led to two differing projections of the numbers of Gannets required, because it was

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1. Lord Fraser of North Cape had been First Sea Lord between 1948 and 1951, and this plan seems to have been named after him.

possible it would have to serve as a partial substitute for the Wyvern. One was based on the assumption that the Wyvern's problems would be rapidly resolved so that it could enter service and form 17½% of the total Fleet Air Arm strength. The second was that only limited numbers of Wyverns would be accepted for operational service because of their engine defects. Calculations based on these two assumptions also envisaged that by 1954/55, 100 Avenger anti-submarine aircraft and 100 Corsair strike aircraft[1] would have been received from the United States under the Mutual Defence Assistance Programme (MDAP), and that sufficient Firefly VII aircraft would be produced to sustain a training establishment of 45 aircraft up to March 1955.

The Royal Navy would require 260 Gannets up to March 1955 on the basis of the first assumption, while under the second, 320 would be needed. These totals implied production rates in 1954/55 of 20 and 27 aircraft a month respectively. A further complication was the likely requirement of the Royal Australian Navy for anti-submarine aircraft, as their Naval Board had informed the Admiralty that they had a requirement for 51 Gannet ASMK I and 6 T2 aircraft in 1955/56 and a further 163 Gannet aircraft up to 1960.

Although a long term requirement for large numbers of Gannets appeared to exist, it was decided to base calculations of the desirable increase in the Gannet order on the Admiralty's immediate needs up to March 1955. The Admiralty seems to have

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1. These United States aircraft had been in service with the Royal Navy at the end of the Second World War.

been opposed to a single very large order on the grounds that it was preferable to order less than required, and then increase that order, rather than order the maximum planned number and then discover that changed circumstances necessitated part of that order being cancelled. A further consideration was that a single large order would normally be executed through a very high annual rate of production, in order to obtain the minimum unit price. The Admiralty wished to maintain Fairey as a viable production unit into the foreseeable future, and felt that this could best be achieved by a series of smaller production orders which sustained a steady rate of Gannet production for a number of years.

In the light of all these considerations, the Director of Air Equipment (DAE) proposed to the Admiralty Board that the total Gannet order should be increased to 280 including 50 T2's. This order was believed to cover all eventualities up to April 1955. The MoS was informed that this would not be the complete order for Gannets, but that the Admiralty was reluctant to place a larger order because of uncertainties over a number of issues. These included the future of the Wyvern, the possibility of additional United States aircraft being supplied through MDAP, and the possible impact of the development and purchase of both the light anti-submarine aircraft and anti-submarine helicopters.[1]

A high level meeting chaired by the Vice-Controller (Air) in the MoS was convened between MoS and Admiralty representatives

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1. File N. Minute by DAE 25.3.52.

on the 31st March, to discuss future action over the Gannet and Firefly VII programmes in the light of DAE's recommendation. The Agenda papers for it indicated that the first question to be discussed was whether the Gannet would be a satisfactory aircraft. The Admiralty Board had demanded such an assurance in view of their Firefly VII experience.[1] DAE tabled a further memorandum at the meeting informing the MoS that the Admiralty Board had decided to reduce to 145 aircraft their order for the Firefly VII. The Board were only prepared to consider increasing this order if the MoS advised them that a reduction of this magnitude would adversely affect Gannet production.[2] The Ministry was also informed that the Admiralty Board had decided not to use the Firefly Mk VII as a front line aircraft, but that it would allocate 50 of them for the day and night training of observers.[3] The MoS representatives revealed that they would like to instruct the firm to produce 48 Gannet aircraft in 1953/54 and 256 in 1954/55. This would necessitate a peak production rate of 26 aircraft per month in 1954/55. The Admiralty representatives indicated that they wished to receive 260 aircraft up to the end of March 1955 and had a planning requirement of a further 200 in 1955/56 and 170 in 1956/57. One of the MoS representatives asserted that unless the production order for Gannets was immediately increased to approximately 300 aircraft, he would

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1. File R. Agenda papers for Meeting Chaired by Vice Controller of Supplies (Air) on Gannet and Firefly VII. Circulated 28.3.52 for meeting on 31.3.52.

2. File N. Memorandum from DAE 31.3.52.

3. File Q. Note from AD/RDN to DMARD 31.3.52.

recommend to his minister that Super Priority should not be given to the aircraft. He conceded that the peak production rate should be reduced, and suggested that 48 aircraft should be scheduled for delivery up to the end of March 1954, 215 in 1954/55 and a further 37 between April and June 1955. It was also suggested that if this production schedule were accepted, any funding problems it might create for the 1954/55 naval budget could be overcome by stretching out the delivery programme as had frequently been done in the past. The MoS was thus attempting to pressure the Admiralty into ordering more Gannet aircraft than the latter had envisaged. The Admiralty representatives eventually agreed to seek Treasury approval to order an additional 200 Gannets.

The MoS representatives were much less successful in imposing their views upon the Admiralty over Firefly VII orders. They indicated that they believed a minimum order of 200 aircraft was necessary to ensure a smooth transition to Gannet production. An Admiralty representative stated that they could only justify an order for 160 and suggested that the MoS should themselves purchase an additional batch as target vehicles for guided weapon trials. It was finally agreed that the Navy's order for Firefly VII's should be reduced from 336 to 160, despite the fact that this would lead to cancellation charges of approximately £1 million on the contract.[1]

Delays in the production programme for naval aircraft became the subject of internal political scrutiny within the

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1. File N. Minutes of Meeting on Gannet and Firefly VII. 1.4.52.

Ministry of Defence during March, and a brief was submitted to the Minister on this subject. It stated that the Firefly VII had been ordered to replace the earlier marks of Firefly pending the introduction of the Gannet, first deliveries of which were anticipated during the second half of 1953. This variant had been developed to carry a third crew member for visual search and submarine plotting tasks. 336 Firefly VII's had been ordered for delivery between January 1952 and March, 1954 at a rate of approximately 12 aircraft per month. The aircraft had not proved acceptable for operational purposes, but could be used in a training role to release Mk VI aircraft for the front line.

The second aircraft subject to production delays, the Wyvern, was described as a wartime piston engined design which had been refitted with a turbo-prop engine and was intended as a replacement for the obsolete Blackburn Firebrand, production of which had terminated. Delivery dates for the Wyvern had been put back on numerous occasions since early 1949 because the aircraft had not passed its acceptance tests, and the Navy had had to maintain the Firebrand in service longer than planned. The main fault with the Wyvern was a tendency for the engine to stall, and no cause or cure had been found for this.

It was stated that to alleviate the operational weaknesses caused by these problems, assistance had been requested from the United States. The latter had agreed to supply 100 piston engined Avengers during the first half of 1953, which would serve as a stop-gap anti-submarine aircraft and supplement the existing Firefly V and VI anti-submarine aircraft in Fleet Air Arm Squadrons.

The United States had been unable to offer a suitable strike aircraft, but had agreed to provide 100 Corsairs which would relieve some of the pressure upon the Sea Fury fighter-bombers. Both batches of aircraft were to be supplied free of charge, though the cost of overhaul and spare parts would be taken from MDAP funds earmarked for Britain.[1]

The Admiralty Board agreed to support the increase in Gannet orders recommended by the March meeting, but wished to safeguard themselves against a recurrence of the Firefly VII situation. The Permanent Under Secretary (PUS) in the Admiralty suggested that this could be achieved by making the increased order conditional upon the MoS providing a certificate guaranteeing that the Gannet would be satisfactory in operational service.[2] This produced a rapid response from the MoS. DG/TD(A) forwarded a memorandum to the Admiralty two days later in which he admitted that the Gannet differed appreciably from the Fairey GR17/45 prototypes, and that no aircraft representative of the production version had been flight tested. He asserted that if the normal take-off weight of the aircraft remained at 19,600 lbs., there was no reason why it should be unsatisfactory in operational service.[3]

The next obstacle facing the MoS in their attempts to increase the Gannet order was to gain Treasury approval for it. The Treasury were very reluctant to commit the country to large

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1. File N. Memorandum submitted to Minister of Defence, March 1952.
2. Ibid. Minute 2.4.52.
3. Ibid. Memorandum from DG/TD(A) 4.4.52.

forward orders for military equipment in view of the uncertainty over the country's future economic and military policies. Consequently, they were only prepared to agree to an order for an additional 140 Gannets, because this would not involve any financial commitment beyond March 1954. The Ministry appear to have had no option but to accept this decision, but they stated that they reserved the right to re-open the issue at a later date if this was necessary to keep Fairey happy and production flowing. It was decided that 24 of these additional aircraft were to be trainers. The Treasury also accepted the reduction in the Admiralty's order for the Firefly VII.[1]

Additional reasons for the Treasury's financial caution were contained in the Navy's planned aircraft purchasing budget up to 1955. Omitting the standard 15% shadow cut for unspent planned expenditure, this envisaged expenditures on Naval aircraft of £13.7 million in 1952/53, £14.8 million in 1953/54 and £26.0 million in 1954/55. These figures excluded the cost of spare parts.[2] The cost of 140 Gannets plus engines was estimated at approximately £10 million,[3] and would absorb a substantial part of this budget. If economy measures forced a reduction in the major jump in expenditure planned for 1954/55, the number of Gannets delivered during that year would have to be substantially reduced. The Firefly VII cancellations would have no impact upon this situation, as it had been envisaged that this contract would be completed during the financial year 1953/54. The Joint Weapons

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1. Ibid. Minute 10.4.52.
2. Ibid. Minute placed at 4.52.
3. Ibid. Minute 10.4.52.

Production Committee (JWPC) of the Ministry of Defence had agreed earlier in 1952 that it was desirable for expenditure on naval aircraft and stores to rise from £27.8 million in 1952/53 to £34.7 million in 1953/54 and £45.1 million in 1954/55. They had been unable to confirm the details of this and other production programmes at their meeting on the 26th March, because the Treasury had been unable to provide forecasts of the finance that would be available in the long term. The central problem was that long term financial commitments were inherent in the Super Priority idea and these clashed with accepted Treasury principles of Government financing. The Navy could plan its expenditure programmes on the basis of a 4 or 5 year rolling budget, but were precluded from ordering equipment that could not be delivered within the next two years. A final complication was that on 31st March it had been agreed at Ministerial level that a new, comprehensive review of Defence Policy was to be initiated, and this would take two months to complete. It had been suggested that any increase in the Gannet order should be delayed until this review was complete, but given the interdependence of the Firefly VII and Gannet orders this was judged to be impossible.[1]

The revised orders for the Firefly VII and Gannet appear to have taken almost two months to be officially confirmed by the Government, for it was not until the end of April that Fairey was officially informed of them. The process was initiated by Fairey's Chief Engineer and Chief Test Pilot being summoned to

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1. Ibid. Minute from PUS (Finance), 1.4.52.

a meeting with four MoS and Admiralty representatives and six people from A & AEE nominally to discuss the results of the A & AEE trials with the Firefly VII. They were told that despite improvements in its control characteristics, it had not been possible to recommend the aircraft to the Admiralty for use in the anti-submarine role. This provoked a hostile response from Fairey's Chief Engineer, who complained that the firm had neither been kept in touch with the progress of the A & AEE trials, nor given a written report on them in advance of the meeting. An A & AEE representative stated that they remained convinced that the aircraft would have a very high deck landing accident rate, and that this would lead to a disastrous loss of morale in operational squadrons. He indicated that in their opinion, the main problem with the aircraft was the inferior view, which was even worse than in previous marks of Firefly because the aircraft had a greater nose-up angle on the approach to land than in earlier versions. It was only possible to land on a carrier by using a turning approach, because the deck became obscured by the nose of the aircraft when 200 feet from touch down. This type of landing was a difficult day operation, and an impractical night one. Fairey's Chief Engineer refuted these contentions, stating that the firm considered that the pilot's view of the Mark VII was not inferior to that from the Mark VI.

The A & AEE representatives then listed further deficiencies in the performance of the Mark VII, but emphasised that these were minor compared with the inadequate view. These included the slow response of the aircraft after full power had been applied and the difficulty of flying the aircraft on instruments due to its heavy controls and tendency towards instability. It was accepted that the firm had been able to modify the aircraft to correct other deficiencies, such as lateral instability. AD/RDN re-emphasised that the pilot's view was the major deficiency, but with this fault the other deficiencies increased in importance. The meeting then concluded with the Fairey representatives being informed by D/DMARD that the aircraft was to be used as a day and night trainer for Gannet aircrew, and that the aircraft would be modified for this role by removing from it a number of items of operational equipment.[1]

This meeting was quickly followed by a further meeting with representatives of Fairey's production department at Hayes on the 2nd May. In the course of this meeting it was stated that the Gannet order had been raised to 240, that it had been designated a Super Priority project and that further orders would be forthcoming. It was confirmed that the Firefly VII order for the Navy had been reduced to 160, but the firm was told that Treasury approval was being sought for a further 71 aircraft for the MoS's guided weapons department. The meeting also discussed the difficulties being experienced in starting Gannet production. Fairey's production manager highlighted their shortage of labour and the absence of a complete set of production drawings. Another of the Fairey representatives complained that the Ministry and Admiralty had no single channel of communication with them. DAP stated

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1. RAFM AC-73/30 (41/d/2) Firefly MK VII aircraft. FHP. Minutes of Meeting on Firefly AS MK VII, 30.4.52.

that in future all enquiries would be directed through his department, and that a resident project engineer to deal solely with Gannet questions was about to be appointed. Finally, a Fairey representative emphasised that the major delay in the Gannet production programme stemmed from the differences between the Gannet and the GR17/45 specifications, but stated that the firm still hoped to fly the first pre-production aircraft before the end of the year.[1]

A further meeting was held at Hayes on the 7th May, to decide which items of equipment were to be deleted to produce the trainer version of the Firefly VII. DAW explained that the aircraft was to be used for the training of observers and flight telegraphists in preparation for the introduction of the Gannet into Royal Naval service, and this meant that the specification to which the aircraft had been built could be substantially modified. It now stated that the aircraft should only be capable of performing anti-submarine navigational and reconnaissance training duties in temperate climates.[2] The meeting then proceeded to decide which items of equipment could be removed from the aircraft, and the deck-landing hook was included in this list.[3] Its deletion produced a heated response from Fairey's Chief Engineer who had not attended the meeting.

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1. File R. Minutes of meeting held at Fairey's works, Hayes, 2.5.52.
2. File S. Minutes of meeting held at Fairey's works, Hayes, 7.5.52. Minutes dated 13.5.52.
3. RAFM AC-73/30 (41/d/2) Firefly MK VII aircraft. FHP. Internal Fairey Aviation Company memorandum from Firefly VII designer to General Manager (Engineering) reporting on meeting on 7.5.52.

He stated that he did

> 'not wish it to be considered that any version of the Mk VII will operate only from airfields. It is the policy of the firm that the Mk VII shall be delivered as we know it now, and modified to any other requirements subsequently. No work is to be done on the altered requirement ... until ... contract action to cover our work is taken.
>
> It is to be remembered that at all times it is the firm's feeling that the Mk VII is a better aircraft than the Mk VI and that we ourselves are not in agreement with the desire to convert it to a trainer aircraft.'[1]

Whether this objection was related to anticipated disputes over payments on the Mk VII contracts, or was merely an expression of anger at what he regarded as the responsibility of others for this whole debacle is unclear. He carried his protest further by instructing that an objection should be made to the wording of the official minutes of the 7th May meeting, and insisting that the sentence 'The firm emphasised the need for retaining the hooks in case the aircraft were ever used for deck landings' be included in them.[2]

A further meeting on the Firefly VII was held at the end of June. The Fairey representatives used this to complain about the numbers of Mk VII aircraft awaiting acceptance, which they argued were creating storage problems and hindering Gannet production. They also complained about the lack of payments for Mk VII aircraft awaiting clearance, which was leading to their

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1. Ibid. Internal Fairey Aviation Company memorandum from General Manager (Engineering) 8.5.52.
2. Ibid. Letter from Fairey's General Manager (Engineering) to Fairey's RTO, 20.5.52.

Board of Directors becoming seriously worried about the firm's overdraft situation.[1]

The order for Firefly VII aircraft was subject to a further revision in September 1952 when it was altered to cover 164 T Mk 7 trainers, and 40 Mk VII's equipped with remote control equipment for guided weapon trials. The latter were known as the Mk VIII and specification D140P was drawn up to cover them.[2] Finally, the order for T Mk 7's was further reduced in December, due to economies forced upon the Admiralty by reductions in the defence budget.[3]

iii. The Gannet ASMk 1 Development Programme, 1952-57.

DMARD visited the Fairey factory at Hayes in January 1952 to discuss the progress of the Gannet AS Mk 1 development programme, and was told that production was likely to start five months later than the original target date. This was attributed by the firm to two main factors. One was the difference between the prototype and production designs and the continued lack of detailed information on certain items of equipment. The second was the short life of the prototype engines which was restricting the flying test programme. These engines had an average life of 25 hours running before malfunctioning and having to be replaced.[4]

A major development problem had also arisen for which no cause or solution was visible. Vibration was occurring in the

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1. File T. Minutes of meeting at Hayes to discuss Firefly T7 26.6.52.
2. File U. Minute 9.9.52.
3. Ibid. Minute to DC(A) 5.12.52.
4. File Q. Note from DMARD on visit to Hayes and White Waltham, 7.1.52.

pilot's cockpit at a speed very close to the aircraft's cruising speed. It appeared to be caused by the aircraft's propellers, though there were also some indications that the engines were attempting to rotate in the fuselage. The flexibility of the engine mountings had been increased to cure this, and for a time this modification appeared to have been successful, but in January the vibrations recurred. A full investigation of the problem had been initiated, but it was imposing delays upon other aspects of the flight development programme.[1]

These unresolved development problems started to generate considerable official concern about the state of the Gannet development programme, and this was reinforced by the parallel demise of the Firefly VII programme. A detailed report was prepared by the MoS on the programme, and it was discovered that since May, 1951, each of the three prototype aircraft had only flown an average of 3 hours per month. 27 aircraft months had been available and only 8 had been lost due to the need to modify the airframes and maintain and inspect them. 400 hours of test flying could have occurred during the remaining period, but only 80 had been flown. The major reason for this low figure was problems with the engines, which included difficulty of calibrating the engine controls correctly, the non-standard nature of the engine pipe lines, which meant that they often had to be altered when a new engine was fitted, and oil leaks and propeller

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1. File G. Minute 31.1.52.

vibrations. These problems were compounded by the limited number of engines available, which often meant that when an engine had to be changed, no replacement existed. Fairey had been protesting about this situation since 1951, but nothing had been done to alleviate the situation.[1] In February a further development problem arose over propeller delivery dates. Fairey had asked for delivery of the propellers for the pre-production aircraft in July, August and September 1952 but Rotols, the propeller contractors, had reported that the earliest they could fulfil this contract was October, November and December 1952. Progress with these aircraft was so far behind schedule that it was not envisaged that this particular problem would have a major impact upon the overall development timescale.[2]

The MoS inaugurated a new, more formal, monitoring and liaison system with Fairey in the early part of 1952 by instituting regular production meetings. The second of these was held in April 1952, and was chaired by AD/RDN.[3] This meeting was told that an additional engine problem had arisen, as the second engine in the Double Mamba could not be relied upon to relight in flight once it had been stopped. This threw doubts on both the aircraft's claim to twin engined reliability and its central operating concept of using only one engine on patrol in order to extend its endurance.[4]

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1. File F. Minute 19.2.52.
2. File G. Minute 6.2.52.
3. RAFM AC-73/30 (43/c/1), GR17/45 Correspondence May 1951 - April 1952. Letter giving date of 2nd AD/RDN progress meeting as 9.4.52.
4. File O. Minute 5.4.52.

The Gannet development programme was then delayed further by two new events. The first was an engine fire in one of the three GR17/45 prototypes in June, 1952 which led to this aircraft needing extensive repairs, which were not completed until early October.[1] The second was a strike at Fairey's Stockport and Ringway works. This started on the 23rd June and did not end until the 2nd September.[2]

A further Gannet production progress meeting was held during this strike at which it was stated that almost all the production drawings had been completed, together with one set of production jigs. The strike was reported to be delaying production of machine shop fixtures and tools, and four to five months work remaining to be done on these. It was also noted that 20% of the Gannet production work had been sub-contracted, and that delivery of many of these components was behind schedule, while slow development progress with certain embodiment loan items[3] made it likely that they would also delay production. It was estimated that due to all these factors, no production deliveries could be made before December 1953.[4] A further production progress meeting was held the following month, at which it was reported that the strike had produced a further two month delay in the production programme. This

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1. File F. Minute placed in file at June, 1952.
2. File R. Minutes 24.6.52 and 4.9.52.
3. These were standardised components such as instruments and switches supplied by the MoS to a firm for inclusion in an aircraft.
4. File R. Minutes of 2nd Gannet Production Meeting 26.8.52.

meant that the first pre-production aircraft was unlikely to fly before April 1953.[1] This date had receded still further when TD (Plans) visited Fairey at the end of October, for he was told that May, August and September 1953 were the likely first flight dates for these three pre-production aircraft.[2]

No solution had meanwhile been found to the propeller vibration problems,[3] and a major uncertainty had arisen over the power of the Double Mamba engine. It had been accepted that a single Mamba engine had insufficient power to enable the aircraft to fly safely on one engine at high weight, and it was hoped to replace the existing engine with a higher powered version of the Mamba, the ASM 6, which was under development for the Seamew. It was estimated that it would take 3-4 years to develope this new engine and place it into production.[4] At the 5th Gannet Production Progress Meeting at the end of October, it was stated that the engine to be installed in production Gannets, the ASMD1, would produce 2,540 shp, and not 2,640 shp as stated in Armstrong Siddeley's brochure of August 1950. The MoS had known about this since May 1951, but the Fairey representatives protested that the firm had only recently been informed of it. They had approached Armstrong Siddeley for a Double Mamba with increased power and, on the basis of these inter-firm discussions, had planned to introduce this modified

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1. Ibid. Minutes of 3rd Gannet Production Progress Meeting 9.9.52.
2. Ibid. Minute 28.10.52.
3. File G. Minute 13.10.52.
4. File F. Minute 30.8.52.

engine, the ASMD 3, into the 101st and subsequent production aircraft. This was solely an arrangement between the two firms, and the engine was not in DERD's programme as there was no official requirement for it.

It was accepted at this meeting that the performance of a Gannet powered by the ASMDI would be marginal at 19,600 lbs. take-off weight, though the maximum take-off weight could be increased to 20,000 lbs. with the ASMD 3. This would allow for some increase in equipment and fuel weights while the aircraft was in service. It was agreed that the ASMD 3 should be developed for eventual fitment to all Gannet aircraft, but it was recognised that even with this engine the aircraft still had little ability to accommodate substantial quantities of additional equipment once it was in operational service. Preliminary discussions of a Series II Gannet aircraft powered by the ASMD 4 engine, the double version of the ASM6, were placed on the agenda of the next production progress meeting.[1]

A further Gannet production progress meeting was held in November,[2] at which it was reported that no new problems had been encountered by the production programme. The appointment of the MoS Gannet Project Engineer was discussed,[3] and this seems to have led to rapid action, as Fairey's staff were informed of his appointment at the end of December.[4]

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1. Ibid. F. 5th Gannet Production Progress Meeting 30.10.52.
2. File R. Minutes of 4th AD/RDN Gannet Production Progress Meeting 25.11.52.
3. Ibid. Minutes of meeting on production of Firefly 7 and Gannet, 2.5.52.
4. RAFM AC-73/30 (41/d/4). Mr. Scott's correspondence 1950-53. Memorandum from Fairey's Chief Engineer, 30.12.52.

The Gannet development programme continued to be dominated by engine problems during 1953. One of these was the unreliability of the Double Mamba engines supplied to Fairey: another the level of cockpit vibration produced by the propellers. In the middle of February 1953 Fairey wrote to the MoS renewing their complaints about the unreliability of the Double Mamba engine. The implication of this letter was that it was the responsibility of the MoS to take steps to correct this situation, as the engines for the Gannet were produced under a direct contract between it and Armstrong Siddeley Motors.[1] No positive action appears to have been taken in response to this letter. DMARD wrote to Fairey at the end of April complaining about the limited amount of Gannet development flying that had occurred since the start of the year and the firm's failure to complete the aircraft's catapult trials. He asked Fairey to document their engine problems fully, so that he could try to resolve them.[2] This met with a slow response from Fairey and he wrote a further letter to the firm in mid-June urging them to supply him with an engine failure report.[3]

This stimulated Fairey to send him a nine point report on the engine situation. It started by emphasising that in any development programme, airframe and engine development should proceed simultaneously. There were two reasons why this had not occurred with the Gannet. First, there had been a major

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1. File F. Letter from Fairey's Chief Engineer to AD/RDN, 18.2.53.
2. Ibid. Letter from DMARD to Fairey's Chief Engineer, 20.4.53.
3. Ibid. Letter from DMARD to Fairey's Chief Engineer, 17.6.53.

shortage of engine accessories, which meant that when an engine failed it had been necessary to move its accessories to the replacement engine if development work was to continue. This engine then had to be recalibrated and tuned before it could power one of the prototype aircraft, with consequent delays in development flying. The second major reason for delay was the limited life of the engines, which had been averaging only 49 hours. It was stated that during the previous 12 months there had been 13 engine failures. Feathering pumps also failed frequently, and were in very short supply as only 12 pumps had been ordered for 10 engines. A more general complaint was that none of the engines supplied to Fairey for development work had attained its brochure power, many had operated in a totally inconsistent fashion, and they had all proved unreliable when attempts had been made to relight them in flight. The report concluded by stating flatly that in the firm's view the engine needed extensive development before it could be placed in operational service.[1]

This report led the MoS to institute its own investigation of the situation. By mid-August it had been discovered that the problems with the feathering pumps stemmed from the fact that when they were originally ordered no attention had been paid to the special nature of the Double Mamba installation, it being assumed that they would be used with propellers which were rarely feathered. With their regular and lengthy use in the GR17/45 prototypes, the feathering motors had frequently burned

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1. Ibid. Letter from Fairey's Chief Engineer to DMARD, 24.6.53.

out and when the cause of this had been discovered, an order had been placed for a new, heavy duty feathering motor. Pending its development and production it had been decided not to order further standard units for the Gannet development programme.[1]

DMARD's correspondence with Fairey over the amount of development flying that had occurred encouraged the firm to make greater efforts to complete this programme. They established improved working arrangements and liaison with Armstrong Siddeley and asked them for an increase in support staff for the Gannet development programme early in September 1953. This was now directed towards the rapid completion of the aircraft's CS(A) clearance trials.[2] Fairey also arranged a meeting towards the end of September with Armstrong Siddeley to discuss the progress of the latter's Double Mamba engine development programme.[3] This acceleration in Fairey's development work was recognised at the beginning of October in a letter to the firm from CNR. It congratulated the firm on the progress they had been making with the Gannet flight trials, but hinted obliquely at the unfortunate consequences that might befall them should this progress not be sustained.[4] This letter was a product of information reaching the Ministry at the end of September that Fairey had drawn up a firm programme for the Gannet CS(A) trials, and had guaranteed that all the aircraft earmarked for this work would be delivered

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1. Ibid. Minute 13.8.53.
2. RAFM AC-73/30 (41/d/3). Gannet Correspondence 1952-53 (Mr. Parker). Memorandum to ASM and Fairey's Production Manager, 9.9.53.
3. Ibid. Notes of meeting 23.9.53.
4. Ibid. Letter from Rear Admiral C.John (CNR) to Fairey's Chief Engineer, 1.10.53.

by the end of October 1953. It was also reported that the amount of Gannet development flying done by Fairey had increased substantially, and that there was evidence of more energetic direction and coordination of this work by the firm.[1]

Little progress had been made with the attempts to trace and eliminate the source of the propeller/cockpit vibrations. A meeting was called in late February 1953 to discuss this problem, at which it was recognised that no acceptable theory had been produced to explain the source of these vibrations.[2] Four months later it was reported that after two years work based on the belief that propeller eccentricity was the major source of these vibrations, a new explanation was starting to gain ground. This was that the vibrations were a result of the pitch change mechanism in the rear propeller not conforming to that in the front propeller. If this diagnosis was correct, altering the pitch change mechanism of the rear propeller to make it more closely resemble that of the front propeller might eliminate the vibrations.[3]

This problem was discussed in mid-July at the 7th AD/RDN Gannet Production Progress Meeting. Fairey's representatives stated that they had received preliminary reports on the tests to determine the causes of the propeller vibration, and that they felt that ROTOLS, the propeller manufacturers, were making abnormally slow progress in resolving this problem.[4] A meeting of all

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1. File O. Loose Minute 25.9.53.
2. File G. Minutes of Meeting 23.2.53.
3. Ibid. Minute 23.6.53.
4. RAFM AC-73/30 (41/d/3) Gannet I 5/53-2/54.

interested parties was arranged for the 18th September 1953 to try to rapidly resolve this issue. It achieved a consensus on the cause of the vibration and agreed on a number of possible methods of eliminating it.[1]

Other major problems which concerned both Fairey and the MoS during 1953 were the escalating weight of the Gannet and the power of its engine. By the end of April, it was accepted that the aircraft might reach service approximately 2,000 lbs. overweight. This would mean that if it took off at 19,600 lbs. with fuel sufficient for 3 hours endurance, it would only be able to carry a weapon load of 1,125 lbs., rather than the 2,388 lbs. specified in the requirement. It was suggested that the aircraft's weight could be reduced by removing from the specification the requirement for Automatic Jet Pipe Temperature control equipment.[2] This suggestion was vetoed at the end of May.[3] Fairey's own weight saving programme was rather more successful, and in mid-July they were able to report that this reduced the aircraft's weight by approximately 350 lbs.[4]

Fairey had also been investigating the ability of the production aircraft to cruise on one engine. At the end of October 1953 the Head of their Technical office reported that at the maximum weight for a single engined cruise at 6,000 ft., which

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1. Ibid. Minutes of meeting between representatives of the MoS, Fairey, ROTOL and Armstrong Siddeley to discuss Gannet propeller vibrations. 18.9.53.
2. File F. Minute 30.4.53.
3. Ibid. Minute 23.5.53.
4. Ibid. Minutes of 7th AD/RDN Gannet Production Progress Meeting held 13.7.53, para 5. Minutes dated 16.7.53.

was 19,400 lbs. with the ASMK I engine, and 20,500 lbs with the ASMD 3, '... after jettisoning stores, it is possible to maintain single engine flight on the maximum intermediate rating on either engine.'[1] It was then discovered early in November that the production Gannet appeared to possess greater drag than had been anticipated,[2] and further performance trials were instituted to remedy this.[3] The problem ceased to be of crucial importance in early January 1954 when it was reported that production engines were delivering 100 shp more than their brochure power.[4]

Six production standard aircraft were completed in time for the Gannet's CS(A) trials in the latter part of 1953, and during the early part of 1954, the Gannet development programme continued at a rapid rate, and encountered no new problems. By the end of February 1954 a CS(A) release for the type had been secured as a result of 340 hours of flying by the six aircraft engaged in the trials programme. No major engine problems had been encountered, though some surging and lack of power had been experienced.[5] It had also been discovered in January that under certain weather conditions, an engine had to be allowed to wind-

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1. RAFM AC-73/30 (41/d/3) Gannet I 5/53-2/54. Internal Fairey Aviation Company Memorandum from Head of Technical Office to Chief Engineer, 28.10.53.
2. Ibid. Internal Fairey Aviation Company Memorandum to Head of Technical Office, 2.11.53.
3. Ibid. Internal Fairey Aviation Company Memorandum on items to be measured in performance trials, 27.11.53.
4. Ibid. Internal Fairey Aviation Company Memorandum from Gannet Project Engineer to Gannet Manager (Engineering), 20.1.54.
5. File V. Minute on Double Mamba Grounding. 17.9.54.

mill[1] for a time before it could be restarted in flight. This posed a risk of complete power plant failure should a defect occur while the aircraft was cruising on only one engine. A modification programme was put in hand to overcome this, but it was envisaged that it would be several months before it could be completed.[2]

It had been decided that before Gannets were introduced into squadron service, the Navy should conduct intensive flying trials with them under operational conditions. A special squadron, 703X was formed at the Royal Naval Air Station at Ford in Sussex for this purpose, and the flying trials started in mid-March 1954. In mid-June these trials uncovered a new engine problem. In the first 10 weeks of operations, the squadron had completed 800 hours flying. During this period only one engine stall had been reported and this had been traced to a faulty Jet Pipe Temperature Control Unit.[3] The engines of four of the aircraft hadthen been changed, and stalling started to occur whenever rapid throttle movements were made. This was initially attributed to inaccurate calibration of the control units on production engines. Accurate tuning of these units was carried out, but the engine stalls persisted. On one occasion both engines of an aircraft stalled after take-off, fortunately without fatal results, but this resulted in all Gannet aircraft being grounded

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1. Windmilling implies unfeathering a propeller and allowing it to rotate freely in flight.
2. File F. Minute placed at 1.54.
3. File V. Minute on Double Mamba Grounding, 17.9.54.

for a short period.[1] Stalling, loss of power and general instability of engine operations persisted, and the squadron reported that major improvements were necessary before the engine could be considered suitable for squadron service.[2] This situation culminated in a fatal crash at the end of August, when an aircraft was lost following an engine stall immediately after taking off from an aircraft carrier. All Gannets were then grounded until appropriate modifications had been made to the engine controls.[3] The Admiralty, MoS and Fairey were now unanimously agreed that the outstanding problems with the Gannet were all Armstrong Siddeley's responsibility, and that this firm had to be pressured into remedying the situation.[4]

These events were especially disturbing to the Admiralty because they had seen very similar problems continue for over three years with the Westland Wyvern before it was eventually cleared for operational use. The Firefly VII episode was a further example of this type of situation. The MoS sought to allay their fears by offering an explanation for the engine stalls.[5] They believed the main reason for them was variations in the standard of performance of the Double Mamba production engines, which had been exaggerated by a decision to increase the fuel flow of the engine in order to give as great a margin of horsepower as possible over the minimum laid down in the

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1. Ibid.
2. Ibid.
3. Ibid. Minute 7.8.54.
4. Ibid.
5. Ibid. Minute on Double Mamba Grounding, 17.9.54.

engine technical certificate. This technical explanation of the stalling was closely related to the factors which had led Armstrong Siddeley to abandon design of a coupled Mamba engine in 1947 in favour of the co-axial arrangement.[1] The development work on the aircraft and engines had been carried out by test pilots who had been well aware of the cost to the project of losing a prototype aircraft through clumsy power plant handling techniques. The 703X squadron pilots had had little experience with turbo-prop engines, and it was inevitable that they should subject these engines to some harsh handling. This in turn had led to the engine stalling problem emerging.

Armstrong Siddeley rapidly produced a solution to this problem. The time sequence of the engine and propeller control equipment was altered, and the rpm of the engine was increased to 15,500 for take-off and 15,000 for climb.[2] The stalling problem appeared to have been overcome by these modifications

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1. In any gas turbine, there is for a given number of revolutions per minute (rpm) a maximum amount of fuel that can be burned in the combustion chambers before the compressor will stall, and the nearer this point is reached in operating conditions, the more efficient the engine will be. In the Double Mamba at take-off the amount of fuel being fed into the engine at 15,000 rpm was just below this maximum level. If, for some reason, the engine were to slow down slightly while the fuel flow remained constant, the engine would stall. What was happening under operational conditions was that stalls were occurring when the throttle was moved from the take-off to the climb power positions. This action involved a reduction in engine rpm from 15,000 to 14,500, and any inaccuracies in the control units which led to the rpm underswinging this climb power figure would produce a stall. The units concerned in this were the propeller control unit and the anticipator, which were intended to function in such a way that when the throttle was closed, the fuel flow was diminished <u>before</u> the engine slowed down.

2. File V. Summary Minute 17.9.54.

though the firm were still experiencing major problems of quality control with production engines.

Engine stalling was not to be the only problem to affect Gannet production aircraft. Doubts were thrown on the power of the ASMD3 engine during 1956, while during 1957 the propeller vibration problem reappeared. It had been accepted by the end of 1954 that weight escalation, plus the decreased engine power available from the ASMD 1 (Mk 100) engine, meant that the Gannet production aircraft would be unable to fly on one engine in the Mediterranean or tropics after a take-off at maximum weight. Fairey had recommended that under these conditions the aircraft should be flown on both engines for an hour to reduce the weight to a point where sustained single engined cruise was possible. The Navy pressed for the substitution of the ASMD3 (Mk 101) engine in production Gannets as rapidly as possible in order to overcome this limitation.[1]

This modified engine was in production by early 1956, but two technical uncertainties remained unresolved, both involving the engine's performance under tropical conditions. The first was a tendency for the oil temperature to rise above the previously acceptable levels. Approximately 4 months of investigations were needed before it could be confirmed that this would not lead to engine failures. The second problem was that the power of the ASMD 3 engine had been observed to degrade more

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1. Ibid. Minutes of meeting on Gannet and Double Mamba production, 19.11.54.

rapidly in the tropics than in that of the ASMD 1. Armstrong Siddeley claimed that this was unique to the prototype engine, and argued that since the power of each ASMD 3 engine unit exceeded the brochure figure of 1315 shp by 55 shp, any increased power loss would not affect the ability of the re-engined Gannet to cruise on one engine under such conditions.[1]

DMARD became very concerned with this issue in June, as he considered that such a degradation in power would negate the advantages which had appeared to justify re-engining the aircraft. He ruled that the new engine should only be fitted into production Gannets if its value could be conclusively proved.[2] In response to DMARD's ruling, Armstrong Siddeley produced a report on the performance of the ASMD 3 power plant. This indicated that in temperate conditions each engine developed 1,400 shp though in tropical conditions this degraded to 985 shp. This meant that the engine offered a considerable increase in power over the ASMD 1 in temperate conditions, but only a limited increase under tropical ones. This report was received with some scepticism in the MoS when it was realised that these figures were based upon performance trials with the prototype engine. It was decided that the only way to resolve this issue was to conduct tropical trials with a production engine. It was also noted that Armstrong Siddeley appeared to be aware that the Admiralty had major reservations about changing to the revised engine, and it was hoped this would spur them to greater efforts

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1. Ibid. Minutes of meeting on Double Mamba engines, 29.2.56.
2. Ibid. Minute from DMARD placed at 6.56 in file.

to improve its performance.[1]

The tropical trials were conducted at Idris, Libya during July and August 1956. Armstrong Siddeley submitted an interim report on them to the MoS in mid-August. This stated that the performance of the production engine differed little from that set out in the brochure, and that the new engine provided more power under all conditions than the ASMD 1. The firm also suggested that if they were allowed to fabricate the engine's turbine blades out of a new type of metal capable of withstanding higher engine operating temperatures, it would be possible to obtain a further 100 shp from each engine. These findings were confirmed in Armstrong Siddeley's final report on the trials in October 1956.[2] This indicated that in tropical conditions, both output and fuel consumption figures showed a 4% improvement on the brochure figures. The main source of past uncertainty was identified as an over-estimation of jet thrust decay in such conditions. The revised figure for this counteracted the slight reduction in shaft horsepower over the brochure figure.[3]

In October 1956 the MoS became aware that a propeller/cockpit vibration problem was being encountered with Gannet production aircraft.[4] A preliminary investigation was made of it and it

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1. Ibid. Report and Minute, 26.6.56.

2. Ibid. Armstrong Siddeley interim report on tropical trials of Mk 101, 21.8.56.

3. Ibid. Armstrong Siddeley final report on tropical trials of Mk 101 placed in file at 10.56. A turbo-prop engine has one major, and one minor source of motive power: the major one is the propeller, the minor one, the jet thrust from the exhaust pipes.

4. File G. Minute 21.10.56.

was discovered that there had been approximately 130 reports of bad vibration levels in the pilot's cockpit.[1] A disagreement then developed over the source of the problem, with ROTOL, the propeller firm, arguing it was produced by an engine/fuselage interaction, while Fairey felt it was solely an inter-propeller one.[2] In mid-December, when a further 17 reports of vibrations sufficiently severe to render the aircraft unserviceable in service use had been received, the MoS decided to mount an integrated research effort to discover the source of the problem. Stimulus to institute this research programme was also provided by other maintenance problems being experienced with the aircraft, such as cracking of the heat shield and aircraft skin, which it was believed were related to the vibration problem.[3]

This integrated research effort was co-ordinated by the Royal Aircraft Establishment, who produced a preliminary report on the problem in early January 1957. This stated that the causes of the interaction seemed very complex, and were believed to be partly a propeller/fuselage relationship and partly an inter-propeller one. These interactions could be removed by very accurate calibration of the propeller balance and blade angles, but such accurate settings were unobtainable under service conditions. Another method of curing them was to alter the structural characteristics of the fuselage, and increase its thickness, but this was impossible. All that was left

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1. Ibid. Minute 2.11.56.
2. Ibid. Minute 21.10.56.
3. Ibid. Minute 12.12.56.

was a palliative solution such as the provision of a spring seat to insulate the pilot from the vibrations, a device employed previously with a number of other aircraft subject to the same problem. It was recommended that this latter solution be implemented unless the vibrations were having an unacceptable effect upon the aircraft's radar equipment and instruments.[1]

This recommendation does not seem to have been accepted, for the search continued to find the source of the problem. Agreement was eventually reached in April 1957 that the vibrations were a product of an inter-propeller interaction rather than a fuselage/propeller one. This could be resolved by accurate calibration of the propellers, but, as had previously been accepted, such accuracy was impossible to achieve under service conditions.[2] By July the problem was giving rise to major production difficulties, as Fairey was now being supplied with reconditioned propellers for new production aircraft. These seemed to be very prone to vibration, and it was becoming increasingly difficult to clear new aircraft fitted with them for service use, thus creating a major production bottleneck. This threw doubt upon the thesis that inter-propeller interactions were the basic cause of the vibration, as it had been found that a propeller unacceptable in one airframe produced no vibration when fitted to another.[3]

The final report on this problem was produced in August 1957 and identified the basic cause of the vibrations as eccentricity

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1. Ibid. Report from RAE on Gannet cockpit vibration. 2.1.57.
2. Ibid. Minute 18.4.57.
3. Ibid. Letter from Fairey's Chief Engineer to AD/RDN. 23.7.57.

of the rear propeller. It was accepted that since it was not feasible to redesign the propellers or shafts to eliminate this defect a certain amount of vibration would always be present in the aircraft. Three modifications aimed at reducing the rear propeller eccentricity had been evolved, and it was hoped they would reduce the vibrations to an acceptable level.[1]

iv. The Gannet Production Programme, 1953-56.

At the start of 1953 Fairey were planning to produce Gannet aircraft at a peak completion rate of 26 aircraft a month, in order to satisfy the yearly delivery targets they had been given. In February, the MoS reached agreement with the firm to reduce this figure to 18 aircraft a month,[2] and in June a detailed production schedule was drawn up for the aircraft. This laid down monthly production figures for Gannet ASMk1 and T2 aircraft from April 1953 to August 1955. 8 pre-production and production aircraft were scheduled to be completed by the end of 1953, and production would terminate in August 1955. The peak production rate of 18 aircraft per month would be achieved between December 1954 and April 1955.[3] It had originally been planned to replace the ASMD1 engines with the ASMD3 as rapidly as possible, but development of the ASMD3 took longer than planned, and in August 1953 Armstrong Siddeley had to inform the Ministry that they would have to produce 218 ASMD1 engines before they were able to switch

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1. Ibid. Minute 1.8.57.
2. File W. Minute 10.6.53.
3. File X. Figures contained in letter from Fairey's Chief Engineer to AD/RDN, 29.10.54.

to the ASMD3.[1]

Between 1954 and 1957 there was a significant stretching out of the Gannet production programme. In mid-March 1954 the total order of 217 ASMk1 and 23 TMk2 aircraft was increased by a further 47 ASMk's and 45 TMk2's. This increase was based upon contemporary Admiralty plans for the numbers and types of aircraft carriers that were to be retained in commission. These carrier plans were under review at the time the order was increased, and it was anticipated that any reduction in carrier strength resulting from it would also reduce the total numbers of aircraft required by the Fleet Air Arm. Consequently, the Minister of Defence had only agreed to the additional order on condition that little or no expenditure would be incurred if it was reduced or cancelled within three months.[2] In mid-June this restriction was removed, and in July a contract was signed for the additional 69 aircraft.[3] At the same time, it was decided to amend the delivery programme, to take account of the fact that only 31 ASMk1's had been produced up to June 1954 rather than the 40 originally planned. The programme was stretched out to October 1955 instead of terminating in August as originally envisaged, with the peak production period moving from February to April 1955.[4] The additional 69 Gannet aircraft were to be delivered between October 1955 and September 1956.[5]

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1. File F. Minute 10.8.53.
2. File W. Minute 17.3.54.
3. Ibid. Minutes of 22.6.54 and 7.7.54.
4. Ibid. Minute 19.6.54.
5. Ibid, Minute 7.7.54.

In October 1954 the MoS informed Fairey that the Admiralty wished to stretch out the delivery period still further, and limit peak production to a rate of 8 aircraft per month. Fairey's response was to send an irate letter to the Ministry cataloguing the changes in their Gannet production instructions since January 1951. It pointed out that in that month they had been instructed to set up two production lines, one at Hayes and the other at Stockport and Ringway, in order to attain an output of 32 aircraft a month. This figure had been changed to 26 a month in April 1952, 18 a month in February 1953 and the Ministry was currently proposing to reduce it to 8 a month.[1]

The Admiralty's reasons for requesting this reduction was that they wished to maintain continuity of production in at least part of the Fairey organisation. It had been realised that if the existing production programme was adhered to, a 12-15 month break in production would occur between the completion of the existing orders and the date at which production of the AEW3 and Mark II Gannets was likely to start.[2]

A detailed report on the future Gannet production programme was drawn up early in November in preparation for a meeting on the subject attended by MoS and Admiralty representatives. This recorded that 47 Gannets had been delivered to the Navy, but because of the difficulties with the Double Mamba engine, it had not

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1. File X. Letter from Fairey's Chief Engineer to AD/RDN, 29.10.54.
2. Ibid. Minute 6.11.54.

entered squadron service.[1] A new review of Defence Policy was in progress which might result in no more Gannet ASMkl or T2 aircraft being required by the Navy, though any decision to terminate the existing 60 aircraft Seamew contract would produce a requirement for an additional 35 Gannets. It was calculated in the report that a completion rate of 8 aircraft per month would allow Gannet production to be stretched out to November 1957, by which time Fairey might either have received a further order for small numbers of the later Marks of Gannet, or have obtained the contract for one of the new generation of naval aircraft such as the NA39 twin jet strike aircraft.[2] It was accepted that a production rate of 8 aircraft per month meant that one of the two Fairey production lines would have to be closed down, and that there would inevitably be an increase in unit costs. There was also no guarantee that Mark II anti-submarine Gannets would be required by the Navy, which had recently decided to equip about half its future anti-submarine aircraft force with a version of the Bristol 191 twin rotor helicopter equipped with a dunking sonar.[3]

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1. The first Gannet Squadron formed on January, 17th, 1955, more than nine years after the aircraft's inception. The Aeroplane, July 13, 1958, p. 42.

2. Fairey submitted a brochure to the MoS specification M148T which corresponded to this requirement, on 30.9.54. By April, 1955 a Blackburn design had been chosen to meet it in preference to the Fairey design - see RAFM AC-73/30 (41/b/2). Spec. M148T. Two seat Naval Strike Aircraft.

3. A dunking sonar consisted of a hydrophone which was lowered into the water on the end of a cable, and a receiving set mounted in the helicopter. Such a sonar set was likely to be much more effective than an air-dropped sonobuoy, which worked on the same principles, but was much smaller, less powerful, and had to use a radio, rather than direct cable link, back to the parent aircraft. File X. Minute 6.11.54.

At the subsequent meeting, it was stated that the total Gannet requirement was estimated as 342 aircraft, of which 309 were already on order. This estimate was regarded as accurate to within plus or minus 15%, which meant that between 290 and 390 Gannets would be required. It was anticipated that 190 of these aircraft would be produced by December 1955, if the existing production rate and programme was adhered to. At this point the new ASMD3 engine was likely to be available, but due to orders having been placed for sufficient ASMD1 engines to power 240 aircraft, it would be July 1956 before it could be fitted into production aircraft. DAW indicated that the Navy was anxious to operate ASMD3 powered aircraft as soon as possible, because the existing aircraft could not cruise on one engine at maximum take-off weight under tropical conditions. The meeting agreed that the target rate for Gannet production should be cut to 8 aircraft per month; that attempts should be made to introduce the ASMD3 engine into the production line by December 1955; and that, if necessary, the contract for ASMD1 engines should be reduced in size.[1]

The December target date for the change to the ASMD3 engine was not attained, but in January 1956 it was reported that the engine would be fitted from the 173rd ASMk1 onwards and the 27th TMk 2.[2] The Gannet contract was amended in late March to take

1. File V. Minutes of Meeting to discuss Gannet and Double Mamba Production policy, 19.11.54.

2. Ibid. Minute 6.1.56.

account both of this change and a decision that the re-engined Gannets were to be known as the ASMk4 and TMk5. 95 aircraft were removed from the ASMk1 order and transferred to the ASMk4, while 9 were removed from the TMk2 order and transferred to the TMk5.[1] This contract was altered again in June, after it had been pointed out to the Director of Contracts that more than 169 Gannet ASMk1's had already been delivered.[2] The new contract covered the production of 183 ASMk1 aircraft and 87 ASMk4's.[3]

The RAN indicated in June 1956 that they wished deliveries of their aircraft to start in July, and it was planned to transfer them to the RAN at the rate of approximately two a month, the last transfer to take place in March 1958.[4] The final change in the delivery programme occurred in mid-February 1957, and resulted from the economy drive which preceded the 1957 Defence White Paper. This produced three major changes in the Naval anti-submarine aircraft programme. The first was that the contract for 65 Bristol 191 anti-submarine helicopters was cancelled, and replaced by one for a licence built version of the Sikorsky S.58 helicopter, the Westland Wessex.[5] The second was that the contract for 60 Short Seamews was cancelled, following both the abolition of the RNVR for whom they had been intended, and the abandonment

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1. Ibid. Minute 6.1.56.
2. File W. Minute to DC(A), 30.5.56.
3. Ibid. Minute from DC(A), 13.6.56.
4. Ibid. Minutes 5.6.56, and 24.11.56.
5. C.H. Barnes - Bristol Aircraft Since 1910, Putnams, 2nd ed. 1970, pp. 367-368

of the last remnants of plans for an extensive convoy protection capability.[1] The third was that it was proposed to reduce the existing order for ASMk4 Gannets by 25 aircraft. It was hoped, that components already produced for them would be diverted to a West German order for 15 Gannets in order to reduce cancellation costs.[2] Fairey made vigorous representations to the Admiralty over this cancellation, pointing out that they would still have to pay the full cost of the 25 aircraft as all the components had been produced for them, and arguing that the Navy had nothing to lose by reinstating the order.[3] The Admiralty remained unconvinced by these arguments, and the total number on order was reduced to 277 aircraft, including 36 for the RAN. Production had slowed to one aircraft a month by October 1957, and it terminated completely in February 1958.[4]

v. New Versions of the Gannet, 1952-56.

The idea of fitting a more powerful engine to the Gannet to improve its operational capabilities seems to have been first examined in detail in October 1952, during a joint Fairey/MoS progress meeting. It was accepted that to operate the aircraft at weights above 20,000 lbs. it would have to be fitted with a more powerful engine such as the Double Mamba ASMD4, a projected double version of the Mamba ASM6 being developed for the Seamew.

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1. C.H. Barnes - Shorts Aircraft since 1900, op.cit., p. 454; and interview with Sir Matthew Slattery, op.cit.
2. File W. Minute to DC(A), 15.2.57.
3. Ibid. Letter from Fairey's Chief Engineer to DC(A), 28.2.57.
4. Ibid. Minutes 28.3.57, and 6.6.57.

If aircraft fitted with such an engine were to follow the Gannet ASMk1 and TMk2 orders off the production line, a major policy decision would have to be taken in the near future to initiate design work on them.[1]

The Admiralty appears to have given first priority in developing these Series II Gannets to a version equipped with the AN/APS20 early-warning radar set. This aircraft was needed to replace similarly equipped piston engined Skyraiders supplied by the United States government under MDAP. Detailed discussions on this version took place during May 1953, the main arguments advanced to support its development being that it would save dollars and enable the very volatile aviation spirit used by piston engined aircraft to be eliminated from British aircraft carriers. It had also been calculated that the anticipated supplies of Skyraiders from the United States and the likely attrition rate would not allow a full establishment of them to be sustained after 1957. Provision had been made in the 'Radical Review' budgeting exercise for a British built early-warning aircraft (AEW) to be developed, and it was planned that it would enter service during the financial year 1957-58. It was assumed that the Gannet could be adapted to carry the Skyraider's radar, and that the placing of a production order for such a Gannet AEW aircraft in mid-1954 would enable the first production aircraft to be completed by mid-1956. It was anticipated that the United States would be prepared to supply the necessary radar equipment for the aircraft.[2]

1. Ibid. Minute 3.5.57.

2. File Y. Minute 20.5.53.

Fairey started project work on the Series II Gannets early in June, 1953,[1] this work including analyses of the possible benefits of fitting engines other than the ASMD4 to the aircraft.[2] A discussion between the firm and the Ministry on the Series II Gannets took place during the 7th AD/RDN Gannet progress meeting on the 13th July. In the course of this it was pointed out by DMARD (RN) that the ASMD4 engine was a paper project, and that no contract for its development had been given to Armstrong-Siddeley. Fairey's Chief Engineer indicated that his firm considered the ASMD4 engine essential if new Marks of the Gannet were to be developed, as it would enable them to take off at weights of just over 22,000 lbs. This led DMARD to agree to discuss placing an immediate contract for this engine.[3]

Fairey's project work on an AN/APS20 equipped version of the Series II Gannets enabled them to produce a set of preliminary performance statistics for it in late July. These indicated that the aircraft would have a maximum take-off weight of 24,000 lbs., and a mission duration of 5 hours at a cruising height of 15,000 ft.[4] The work culminated in the production of a brochure on the full range of Series II Gannets at the end of October 1953. This listed three separate variants of this aircraft. The first

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1. RAFM AC-73/30 (41/d/3) Gannet I 5/53 - 2/54. Internal Fairey Aviation Company Memorandum from Chief Engineer, 10.6.53.
2. See for example the memorandum from the Head of Fairey's Technical Department to his Chief Engineer comparing the performance of the Gannet with D4 Mamba and Eland engines. Ibid. 12.6.53.
3. Ibid. Minutes of 7th AD/RDN Gannet Progress Meeting, 16.7.53.
4. Ibid. Internal Fairey Aviation Company Memorandum, 23.7.53.

was an ASMD4 powered version of the ASMk1. The second was an adaption of this aircraft, intended for use in an anti-shipping role, manned by a pilot and observer and fitted with a special 3,500 lb. guided bomb. In this configuration the aircraft was capable of attaining a maximum altitude of 20,000 ft., and of carrying sufficient fuel for take-off, climb, cruise for 150 nautical miles, loiter for 20 minutes, and then return to the carrier. The third variant was the AEW version, which was stated to be capable of patrolling at 5,000 ft. for 4 hours. The drawings accompanying this version indicated that two of the three crew members were to be positioned in an enlarged rear cockpit, with the radar scanner in a long smooth housing under the fuselage, in contrast to the short bulbous one of the later production version. It was noted in the brochure that the air-frames of the three Series II Gannet variants differed from the ASMk1 in only three areas. On all variants the fuselage length was increased by approximately 1 ft. to compensate for the additional weight of the ASMD4 engine, and the undercarriage units were moved outwards 7½ inches. The AEW version also had a different fuselage structure to the ASMk1.[1]

Discussions on the Series II Gannets increased in intensity during the last two months of 1953. At the end of November, a series of Design Progress Meetings between Fairey and MoS representatives was initiated by DMARD(RN). The agenda for the first DMARD(RN) Fairey/MoS Gannet Design Progress

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1. RAFM AC-73/30 (41/b/1) Gannet (3). Brochure dated 21.10.53.

meeting in November included an item on the installation of additional radar equipment in the Mk II anti-submarine variant, and the engine requirements for all the variants. In the course of the meeting, it was stated that the new radar equipment would be mounted in an underwing container, and that trials of this installation were underway. It was also explained that the 3,500 lb. guided bomb for the strike version was in a very early stage of development, and that no dimensions were available for it, and no guarantee could be given that it would not increase in weight.

The bulk of this meeting was given over to a discussion on the power-plant for the Series II Gannets. Although the ASMD4 provided sufficient power for all variants, and enabled the aircraft to cruise on a single engine, it was felt that its take-off power might be insufficient for the strike version, especially if the weight of the guided bomb was to increase in the course of development. It was finally agreed that the ASMD4 seemed to be the best engine available, given the lack of a suitable alternative in the Ministry's engine development programme.[1]

In January 1954 the Admiralty issued Naval Staff Requirement NA46 to cover the AEW variant. This stated that the aircraft was needed to replace the Skyraider and its functions were described as giving early warning of approaching enemy aircraft at sea, particularly at low altitude; assisting in the direction of friendly fighters; detecting schnorkelling

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1. RAFM AC-73/30 (41/d/3) Gannet I. Minutes of 1st DMARD (RN) Design Progress Meeting 25.11.53, para 8.

submarines; conducting surface reconnaissance and directing offensive air strikes. It was specified that the aircraft was to embody as many standard Gannet components as possible, and was to be in service by 1958. The major aims of the requirement were stated to be to reduce the number of types of aircraft and aero-engines in use with the front line squadrons of the Royal Navy; to confine future MDAP or dollar expenditure on AEW aircraft to the provision of the AN/APS20 radar sets only, and to eliminate the need to carry high octane aviation fuel in British carriers. The hope was expressed that prototype development of this variant could be completed during 1955.[1] Immediately prior to issuing this requirement, the Admiralty indicated that they were uncertain about the total number of AEW aircraft that would be required, as they were still unclear how many Skyraiders were to be supplied to the Royal Navy under MDAP.[2]

A further discussion on the Series II Gannets was held during the 2nd DMARD(RN) Design Progress Meeting on the 11th March 1954. The morning session of the meeting was devoted to future Gannet developments,[3] and as a consequence of this meeting, Fairey's Chief Designer (Aircraft) ordered detailed design work to commence on the three Series II Gannet variants, all powered by the ASMD4 engine.[4] These variants were now

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1. File Y. NSR NA46 22.1.54.
2. Ibid. Minute 6.1.54.
3. RAFM AC-73/30 (41/d/3) Gannet II. Agenda for 2nd DMARD(RN) Design Progress Meeting, 11.3.54.
4. Ibid. Internal Memorandum from Fairey's Chief Designer (Aircraft) 17.3.54.

identified as the Mk3 AEW aircraft, the Mk4 Strike aircraft and the Mk5 Anti-submarine aircraft. A target towing version of the Gannet was also on the agenda of this meeting, and during May 1954 the firm collected information for a brochure on such an aircraft.[1]

Design work was in progress on all three Series II Gannet designs in June 1954, but some doubt still seems to have persisted on the appropriate engine for these aircraft, as studies were in progress on a Gannet with a single Rolls Royce RB 109 engine as an alternative to the ASMD4.[2] In addition, the Canadian government had stated a requirement for a multi-role Gannet which would require a redesigned and deeper fuselage than the planned ASMk5.[3]

Design work on the Series II Gannets seems to have continued from June through to October 1954, though little substantive progress was reported back to the MoS. A third DMARD(RN) progress meeting was held in mid-October, and in preparation for this, a technical briefing paper was circulated within the MoS on possible engines for future Gannet developments beyond the Series II versions. This stated that with the ASMD1 engine, the Series I Gannets should be able to cruise on one engine if their take-off weight was below 20,600 lbs. The later ASMD3 engine would

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1. Ibid. Internal Fairey Aviation Company Memorandum setting out weights and performance of target-towing aircraft 27.5.54.
2. Ibid. Internal Fairey Aviation Company Memorandum from Head of Technical Office to Chief Engineer 2.6.54.
3. Ibid. Internal Fairey Aviation Company Memoranda from Assistant Designer to Chief Engineer 2 and 4.6.54.

increase this figure to 21,000 lbs. The Gannet AEW3 and Mk4 operational requirements could not be met with an ASMD3 powered aircraft as it was estimated that they would require a maximum take-off weight of at least 22,500 lbs., but with the ASMD4 engine it was estimated that single engined cruise would be possible at a maximum take-off weight of 24,000 lbs. This higher figure still imposed an important limit on the amount of fuel that the aircraft could carry, and had made it impossible to obtain the desired endurance with the AEW version. This had resulted in DAW reducing the endurance specified in the original staff requirement so that it would conform to the anticipated capabilities of the ASMD4 engine. In making this revision, he had made it clear that the Naval Staffs wished to extend the Mk II Gannet endurance requirement to six hours flight under temperate conditions,[1] yet the planned ASMD4 engined version could not provide this capability. Only a new engine with increased maximum power could allow the Gannet to take off at the increased weights necessary to increase its endurance.

The briefing paper went on to report that studies by Fairey and the engine firms had indicated that to give the desired endurance under tropical conditions a dual engine offering

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1. This corresponds to the figure given to the Fairey directors in July, 1948 by Staff of the Anti-submarine School at Londonderry. See Summary of discussion with the Staff of the Anti-submarine School, Londonderry, 22nd July, 1948. op.cit.

a total of 3,840 shp was required. To allow some margin for development problems it had been agreed to start design studies on a new engine comprising two 2,000 shp units. The situation had been made more complex by an agreement drawn up between the MoS and Armstrong Siddeley at the start of development work on the ASMD4 engine. This had specified that Armstrong Siddeley were to make provision for the installation of more powerful engine units than the single Mamba 6 in the design of the ASMD4 power plant. This had resulted in gearing and output shafts of the ASMD4 being designed to accommodate single engine units of up to 2,000 shp. The ASMD4 with the Mamba 6 was thus an interim installation until more powerful engine units could be developed for it, but its capabilities dictated that such units would have to be fully interchangeable with the Mamba 6 used in the ASMD4 installation.

These considerations led the writer of the briefing paper to conclude that three alternative power plants were available to power the Series II Gannets at weights above 24,000 lbs. These were the single Rolls Royce RB109 and Napier Eland engines and the ASMD4 power-plant fitted with two new Armstrong Siddeley engines known as the P156. This new engine was similar to the Mamba 6, but was claimed to offer a 25% decrease in fuel consumption.[1]

The third DMARD(RN) design progress meeting on the Gannet had a very extensive agenda as a result of the attention which

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1. File V. Minute on Engines for Gannet Developments, 12.10.54.

was now being focused upon the new Gannet variants. It was envisaged that the opportunity would be taken to provide Fairey with DAW's detailed requirements for the Gannet Target Tug, while the firm would report on their work on laying out the rear observer's cockpit of the AEW3 design and their investigation of the possible use of blown flaps to reduce its approach speed. Fairey had also been examining the problems involved in carrying the anti-ship guided bomb, now code named Green Cheese, in the Mk 4 Strike aircraft, while DAW was to provide information on the radio and radar requirements of the Mk 5 anti-submarine version.[1]

In November 1954 the annual task of drawing up the Naval Budget for the next financial year led to a review of the existing development programmes. In the course of this it was stated that the Admiralty was not too interested in further marks of Gannet aircraft as they planned to use the Bristol 191 helicopter to meet about half their anti-submarine aircraft requirements.[2] This implied a drastic alteration in the priorities assigned to fixed wing anti-submarine aircraft compared to the position during the late 1940s. Meanwhile, development work continued on the AEW Mk3, which was to spearhead the development of the Series II Gannets, despite the uncertainties that existed over the future role of fixed wing anti-submarine aircraft in the Navy. It was agreed in December 1954 that prototype develop-

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1. RAFM AC-73/30 (41/d/3) Gannet II. Memorandum from Fairey's RTO to Chief Engineer, 15.10.54, re agenda for Design Progress Meeting on Gannet aircraft, 18.10.54.

2. File X. Summary of Gannet position placed in file at November, 1954.

ment work could start on this AEW variant,[1] while Armstrong Siddeley produced a favourable report on the possibility of fitting shortened jet pipes to it.[2] These were needed both to reduce power losses and to release more space in the fuselage for additional equipment. In addition, it had been decided to investigate the aerodynamic effects of fitting the AN/APS20 radar to the Gannet fuselage by producing a mock up of the underside of the Gannet and fitting it to an existing Skyraider AEW aircraft.[3] Flight trials with this modified aircraft were successfully completed by mid-February 1955.[4]

The development of the Gannet Mks 4 and 5 remained a possibility throughout the early part of 1955, and in mid-February 1955 the Naval Staff Requirement for the AEW3 Gannet, NA46 was amended to include specific reference to these variants. It was stated that a requirement existed for a variant of the AEW3 to serve as a replacement for the Gannet AS Mk1 and it specified that it would incorporate three major changes compared to the latter aircraft. These were to be an endurance of six hours, the ability to carry Green Cheese as an alternative to the normal anti-submarine weapons load, and the replacement

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1. File Z. Summary Minute of Gannet position, 30.6.55.

2. RAFM AC-73/30 (41/d/3) Gannet III 1954-55: Report on shortened jet pipes for Gannet aircraft by Armstrong Siddeley Motors, 7.12.54.

3. Ibid. Report on progress of development work on AEW Gannet contained in Minutes of 4th DMARD(RN) Design Progress Meeting 4.2.55.

4. Ibid. Test pilot's report on Skyraider fitted with Gannet under fuselage. 15.2.55.

of the ASV 19B radar with the ASV 21.[1]

A further DMARD(RN) Design Progress Meeting on the Gannet was held early in February 1955, at which the three series II Gannets and the Target Towing Gannet were again discussed. It was stated that no contract or instructions to proceed had been given to Fairey for the latter variant as the MoS were waiting for a decision from the Admiralty's Directorate of Aircraft Equipment on whether the Navy needed such an aircraft. It was reported that the MoS had not yet issued a specification for the AEW Mk 3 aircraft, but their representatives stated that they hoped to do this before the ADC, which had been provisionally fixed for early March. Finally, DMARD indicated that he considered the ASMD3 engined version of the ASMk1 should be known as the ASMk 4, leaving further Series II Gannets to be assigned higher mark numbers at a later date.[2] An informal meeting was held with Fairey later in the month to discuss the feasibility of fitting all the units that comprised the ASV21 into the existing Gannet ASMk 1 aircraft. In the course of it, the Fairey representatives obtained confirmation that this radar would only be fitted into the Series II Gannet and would not be retrospectively fitted into Series I aircraft.[3]

Discussions on the new anti-submarine version of the Gannet

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1. File Y. Revised version of NA 46; issued 14.2.55.
2. RAFM AC-73/30 (41/d/3) Gannet III 1954-55. Minutes of 4th DMARD(RN) Design Progress Meeting, 4.2.55.
3. RAFM AC-73/30 (43/b/3). C.61: Mr. W.C.Scott, Misc. correspondence, 1954-55; No. 2. Notes on informal meeting to review ASV 21 units in relation to their fitment into Gannet aircraft, 15.2.55.

continued to be focused on the availability of a new engine to power it. This was regarded as crucial because a new concept of trade protection was emerging within the Admiralty centred upon anti-submarine aircraft capable of attacking surface raiders with the anti-ship homing bomb 'Green Cheese.' It was hoped to deploy this aircraft in trade protection carriers between 1958 and 1964. This concept seems to have been aimed at combatting the twin threats of the Russian submarine and cruiser fleets, and was based upon the idea that the light Fleet carriers would be assigned to trade protection duties, rather than be used as part of an offensive naval task force.[1] It had also been accepted that the radar equipment carried by the Gannet ASMk1 was becoming obsolete, and that new equipment would have to be incorporated in it. It was felt that it would be better to install this in a new series of aircraft with increased engine power, rather than in a modified version of the existing aircraft.[2]

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1. Navy International, Vol. 77; No. 5; May, 1972; p. 26. This concept had emerged from a far reaching review of Naval Policy conducted within the Admiralty. It had been concluded that only those carriers equipped with steam catapults and angled decks would be able to operate the new generation of fighter and strike aircraft. The majority of the newer carriers had been in the final stages of construction when these developments had materialised, and to enable the three recently commissioned light Fleet carriers of the Hermes class to operate such aircraft would require an extensive and expensive modernisation programme. In addition, these carriers would only be capable of carrying and operating a very limited number of the new generation of aircraft. In consequence, it seems to have been decided to utilise these carriers in a trade protection role, and equip them with first generation gas turbine aircraft such as the Sea Hawk and the Gannet. It was intended that these aircraft would also equip the RNVR squadrons, thus enabling the carriers held in reserve to operate these squadrons in the trade protection role in the event of hostilities.

2. File Y. Minute 15.4.55.

The issue of whether a development contract should be let for the P156 engine reached a climax in April 1955. It was now planned to design this power-plant around two 2,200 shp units. A number of arguments had been advanced in favour of this new engine. The additional operational equipment being carried by the ASMk1 aircraft had reduced its endurance to less than 4 hours, while the weight of 'Green Cheese' had increased to 4,000 lbs. Both these factors suggested that an engine of increased power and efficiency was required for further versions of the Gannet. In addition the Skyraider AEW aircraft, which the Mk3 Gannet was intended to supplant, had an endurance of six hours, but this could only be attained if the Mk3 was fitted with the P156 engine. These arguments seem to have been accepted, for it was recommended that development of the P156 engine should commence, though it was recognised that the tight replacement time schedule of the Mk3 AEW project meant that the initial production aircraft would have to be fitted with the ASMD4 engine. This power plant had recently been renumbered ASMD8, although it still consisted of two of the Mamba 6 engine units which had been developed for the Seamew.[1] Fairey continued to undertake basic project studies on a Rolls Royce RB109 engined Mk3, though this option does not appear to have been seriously considered by either the MoS or the Admiralty.[2]

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1. Ibid.

2. See RAFM AC-73/30 (41/b/1) Gannet (1) and RAFM AC-73/30 (41/b/1) Gannet (4). Brochure and drawings related to RB109 powered Gannet Mk3, 20.4.55.

A further issue facing the Admiralty at this time was the need to place a production order for the AEW3 aircraft. The pressure for this had arisen because the United States government had refused to supply airborne radar or sonar equipment to Britain unless a production order existed for the aircraft which was to carry it. They had adopted this posture after they had supplied scarce dunking sonar equipment to the Royal Navy, and then discovered at a later date that the Fleet Air Arm had no helicopters capable of carrying it. This left the Admiralty in a dilemma, as a production order for the Gannet Mk3 would have to be placed almost immediately to guarantee that the necessary AN/APS20 radars would be supplied on time, yet the AEW prototype aircraft was only in a preliminary stage of development, and it might prove to have such great deficiencies that it would be unacceptable for operational use.

The Admiralty Board had approved a five year rolling budget for the Fleet Air Arm, known as FAA2, earlier in 1955. This stretched through to the financial year 1960-61, and contained provision for the purchase of 80 Gannet AEW aircraft between 1958 and 1960. This figure had been based on a front line strength of 22 aircraft and a training establishment of 7 aircraft. It assumed that the Navy would maintain an operational fleet of two light Fleet and two Fleet carriers throughout this period, the former having 4 AEW aircraft and the latter having 6, with an extra air group in reserve in the United Kingdom. Contemporary calculations of maintenance, repair and attrition figures for the type indicated a total production requirement of 76 aircraft.[1]

The existence of FAA2 provided the justification for the Admiralty placing an initial production order for the Gannet AEW3. An agreement was reached in June whereby the United States government was to supply 31 AN/APS 20E radar sets and their associated equipment to the Royal Navy as part of the MDAP arrangements, on condition that an immediate production order would be placed with Fairey for 31 Gannet AEW3 aircraft. These were to be delivered during the financial year 1958/59, and to meet this production schedule, they would be powered by the ASMD8 power-plant, rather than the P156. Finally, the United States government stipulated that the existing Skyraider AEW aircraft were to be returned on a one for one basis as each of these Gannet AEW 3's became operational. The figure of 31 Gannet AEW 3's and AN/APS 20E radar sets was a product of the fact that 20 Skyraiders had been delivered to Britain, with a further 11 expected under MDAP.[2]

This order was placed at a time when detailed design work on the Mk3 Gannet was still incomplete. There was a major meeting

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1. It should be remembered that these figures assumed a relatively high annual attrition rate. This was because angle-decked carriers were only just arriving in service, and any aircraft landing on a normal deck and missing the arrester wires would crash into the barrier. On an angled deck, the pilot of such an aircraft could take-off again and make a further landing attempt. The introduction of the angled deck produced a marked reduction in naval aircraft attrition rates and made it unnecessary to procure two or three times as many aircraft as were needed for the front line squadrons.

2. File Z. Minute 30.6.55.

between Fairey, the MoS and the Admiralty in April to discuss the layout of the pilot's cockpit,[1] while in late May and early June, a number of Fairey representatives visited the United States to discuss the characteristics of the AN/APS 20E radar equipment with the manufacturers and United States naval personnel.[2] The requirement was then amended at the end of June by an arbitrary increase in the endurance figure from four to five hours, which forced the firm to increase the estimated take-off and landing weights of the aircraft, and made it doubtful whether the existing undercarriage would be capable of coping with the impact of landing on a carrier's deck. Fairey proposed to overcome this problem by using blown flaps to reduce both approach speed and landing reaction weight.[3] Despite these design uncertainties, a production order for 31 Gannet AEW Mk3 aircraft was issued to Fairey in August. This stated that the aircraft were to be built to specification AEW 154D, and the accompanying cost estimates only included a nominal figure for tooling as it was assumed that the airframe of the AEW3 would be similar to that of the ASMk1.[4]

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1. RAFM AC-73/30 (43/b/3) C.61: Mr. W.C. Scott, Misc. correspondence 1954-55; No. 2. Notes on meeting held 13th April 1955 to discuss Gannet Mk3 Pilot's Cockpit layout.

2. Ibid. Report dated 13.7.55 on visit of UK Mission to the United States.

3. File Y. Minute 27.6.55. This technique involved taking air from the engine and expelling it at high velocity over the wings to increase lift.

4. File Z. Minute placed in file August 1955.

Limited development work continued on the remaining Series II Gannets while the AEW3 production order was being finalised. At a meeting in mid-April 1955 it was confirmed that they should be designed around a common fuselage and be capable of undertaking alternative anti-submarine and surface ship strike roles.[1] A design study had been undertaken by Fairey of a possible trial installation of ASV21 equipment in an ASMk1 Gannet, and at a meeting in early May it was agreed that a non-representative trials installation was possible, but that the existing ASV19B equipment and the sonobuoy receivers would have to be removed to provide the necessary space.[2] This investigation had been initiated by NSR 1240, which called for a trial installation of ASV21 in order to assess its potential as a replacement for the ASV19B.[3] In early July, the MoS ear-marked one of their Gannet development aircraft for this task,[4] and Fairey were given instructions to proceed with the installation.

The Admiralty appear to have decided not to proceed with the development of the remaining series II Gannets soon after this date for neither the ASV21 equipment nor the aircraft arrived at the Fairey works. It was eventually confirmed in

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1. RAFM AC-73/30 (43/b/3): C61: Mr. W.C.Scott, Misc. Correspondence 1954-55; No. 2. Notes of meeting held 13.4.55.
2. Ibid. Notes on meeting held 3.5.55 to discuss trial installation of ASV21 in Gannet.
3. File AA. Minute from RDN3 to DMARD (RN) 8.6.55.
4. Ibid. Note dated 13.7.55.

January 1957 that the Admiralty had no further interest in such a trial installation.[1] The guided bomb Green Cheese was cancelled in March 1956 after £0.9 million had been spent on it,[2] and this marked the end of official interest in the strike version of the Series II Gannet.

Design and development work on the AEW Mk3 continued throughout 1956 and 1957. It was gradually realised that the ASMk1 fuselage would have to be completely redesigned in order to accommodate the two crew members in a cabin within the fuselage, with the result that the production schedule slipped and costs increased.[3] By October 1956 it was envisaged that the prototype aircraft would fly in November or December 1957, with the first production aircraft following in January 1958.[4] In November 1956 the design of the production aircraft was frozen, and a revised specification, AEW 154P was issued to cover it.[5] The ASMD8 power plant also experienced major development difficulties, culminating in the inclusion of an extra stage in the compresser.[6]

The prototype aircraft eventually flew on August 20th 1958 with the first production aircraft following on December 2nd 1958.[7]

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1. Ibid. Letters from RTO (Fairey) to DMARD(RN) 2.11.56 and DMARD(RN) to RTO (Fairey) 4.1.57.
2. 679 H.C. Debs., 17th June 1963; Written Answers: Cols. 7 & 8.
3. RAFM AC-73/30 (43/b/3). C61: Mr. W.C. Scott, Misc. Correspondence 1954-55; No. 2. Minutes of Advisory Meeting on Gannet AEW3 Rear Cockpit, 9.3.56.
4. Ibid. Notes on AEW coordinating meeting at Admiralty, 30.10.56.
5. RAFM AC-73/30 (41/b/1) Gannet (3) Specification AEW 154P dated 30.11.56.
6. File AB. Minute 1.59.
7. H.A.Taylor, Fairey Aircraft Since 1915, Putnam: London, 1974., p. 375.

By January 1959 the contemporary Naval five year rolling budget, FAA4, only envisaged a total production run of 38 Gannet AEW aircraft, and assumed that a replacement would come into service in 1965.[1] Late in 1959, 9 additional aircraft were ordered to cover the period up to 1965, followed in March 1961 by an order for a further 3 aircraft to cover the period up to 1971.[2] The aircraft entered operational service with the Fleet in March 1960. The limited number of AEW 3s purchased and the major design changes that occurred during development made the aircraft much more expensive than the ASMk1.[3]

The last attempt at producing a new version of the Gannet occurred in December 1960, when Fairey, who had by then been taken over by Westland, were asked to investigate the possibility of converting a number of ASMk4 Gannets into deck-landing transport aircraft.[4] A Staff Requirement was issued for this aircraft in July 1961, which specified that a cabin should be built into the rear fuselage of an ASMk4 Gannet capable of accommodating either five people or a stretcher and medical orderly. In addition, the bomb-bay was to be modified to enable it to carry a Blackburn Palouste engine or a similar freight load.[5] This requirement does not seem to have been actively pursued, and it was eventually cancelled in April 1963.[6]

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1. File AB. Minute 1.59.
2. Ibid. Minutes dated 17.8.59 and 8.3.61. and File AC. Minute 8.3.61.
3. File AB. See Minute 14.9.49 for a detailed breakdown of cost increases.
4. File AD. Request for design investigation, 2.12.60.
5. Ibid. Staff Requirement 1691B, 28.7.61.
6. Ibid. Minute 8.4.63.

vi. Parliament and Naval Anti-submarine Aircraft, 1952-57.

Parliamentary discussion of naval aircraft carrier policy and the supply of naval aircraft prior to 1952 had been confined to the annual Statements on the Service Estimates, and the subsequent debates in both Houses of Parliament. In 1952 both the Select Committee on Estimates and the Public Accounts Committee of the House of Commons became involved with these issues, and this provided an opportunity for some MP's to question civil servants and serving officers on them. The Public Accounts Committee was the first to become involved with anti-submarine aircraft, when it examined the circumstances surrounding the cancellation of the ASV15 radar set.

The Navy's Appropriation Account for the financial year 1950-51 was published at the end of January 1952. Attached to it was a report from the Comptroller and Auditor General which highlighted the fact that the Admiralty had had to make provision for 'certain radar equipment costing approximately £253,000 which has proved unsatisfactory for the purpose intended.'[1] The report contained an extensive history of this equipment. It stated that '(in October, 1945) the order was reduced to 100 to match expected deliveries up to the end of 1946 of two types of aircraft, although it was confidently expected that other types of aircraft then in production or under development would require to be equipped with the set. By the spring of

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1. Navy: Appropriation Account, 1950-51: Report of Comptroller and Auditor General; Para 12, 1951-52, (74). Accounts and Papers, (3); 1951-52; Navy, Defence, House of Commons, Housing: XXI.

1947, however, the order for one type of aircraft had been cancelled and it had been decided to use the other only for target towing .... It was still considered that the set would be required for future aircraft ... the results of the trials of the first production models were not available to the Admiralty until ... February 1950.'[1]

The report was considered by the Committee of Public Accounts in February 1952 and Sir John Lang, the Permanent Secretary to the Admiralty was allowed to make a statement on this item. He explained that

> 'In two years leading up to the completion of the main outline design which is roughly speaking the end of hostilities there was every reason to expect that the device would be successful ... we felt we could not wait for prototypes to be tested ... we should lose our place in the queue for production ... that would have been a serious disadvantage with new aircraft that we then expected to come into service and which depended on this equipment if they were to achieve their proper function.'[2]

Unfortunately, there had been a

> 'lack of appreciation ... of the way in which the several departures which were made gradually from the original outline design were likely to prejudice the performance of the ultimate equipment. When later we dealt with the placing of a second order in 1948 the need for the set was even more urgent and the scientific promise was still high .... Actually, the equipment, when in tune, does give the results desired. The whole trouble is that it cannot be kept in tune long enough to be acceptable as a piece of service equipment.'[3]

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1. Ibid., Para 13. The two aircraft referred to were the Fairey Spearfish and the Short Sturgeon.

2. First, Second and Third Reports from the Committee of Public Accounts; p. 291, para. 3298; 1951-52, (85-1). Reports; Committees, (1); 1951-52; Accounts, Public to City of London (Guild Churches) Bill: IV.

3. Ibid., para. 3299.

Sir John was then closely questioned by the Chairman of the Committee on the impact of this cancellation on the Navy's procurement programme. He stated that the Navy had had 'to swing over to an alternative which takes the form of an adaption for naval purposes of something that was designed in the intervening years for civil aviation purposes.'[1] A member of the Committee, Sir Ralph Glyn, then asked Sir John whether 'in the high priority plan now agreed by the Government in regard to the Gannet ... you have got all the backing for the electronic equipment for (this) machine.'[2] Sir John replied 'Undoubtedly,'[3]

This dialogue over the Gannet was continued in another forum a little later in the year, when problems associated with the supply of naval aircraft were being investigated by the Select Committee on Estimates. Sir John Lang informed this Committee that

> 'It is quite true that some of the aircraft which we were expecting to see in Naval Aviation over the next twelve months or two years have been suffering from teething troubles of one sort and another, and we are not at all certain whether we shall achieve the forward programmes or not.'[4]

In response to a question about progress with the Gannet from Sir Ralph Glyn, he stated that

> 'The Gannet is an aircraft which, until roughly twelve months ago, was in the experimental stage. At that time, two firms were building "Gannet" prototypes; one was

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1. <u>Ibid</u>., Para. 3301.
2. <u>Ibid</u>., p. 297, Para. 3344.
3. <u>Ibid</u>.
4. <u>Rearmament: Tenth Report from the Select Committee on Estimates</u>. p. 44, para. 533, 1951-52; (288). Reports; Committees, (3); 1951-52; Estimates, (Cont.); VI.

> the Fairey Aviation Company Limited, and the other was the Blackburn Company. Roughly 12 months ago we decided in favour of the Fairey machine and we placed a production order for that machine. It is quite true that as the production order has got into its stride there have been certain modifications; this is absolutely inevitable as one goes ahead to a production machine as contrasted with a prototype machine.'[1]

In parallel with these Committee deliberations, the Defence Statements and Estimates for 1952-53 had been published, and debates occurred on them in both Houses of Parliament. These debates were rather more informed than in previous years as the Ministers of the 1945-51 Labour administration were now in opposition.

The Statement on Defence for 1952 identified the main objectives of the naval rearmament programme as the strengthening of anti-submarine and anti-mine forces.[2] A major section of the Statement was devoted to the problems that had affected the defence production programme. 'The £4,700 million programme included £2,000 million for production at the price level at the end of 1950 .... It was made clear at the outset that such a programme could be achieved in three years only if the labour, raw materials, machine tools and other manufacturing capacity were available as and where they were needed. It is now clear that these conditions cannot be satisfied.'[3] Stress was laid on the fact that 'The aircraft programme in particular, which includes several new production lines for jet aeroengines, requires the building up of a large labour force. Before the

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1. Ibid. Para. 544.
2. Statement on Defence, 1952. P.2, Para. 1. 1951-52. Cmd. 8475. Accounts and Papers, (3); 1951-52; Navy, Defence, House of Commons, Housing; XXI.
3. Ibid. P. 9, Para. 38.

programme started, the labour force in the aircraft industry was about 150,000; it is now 177,000 and a further 50,000 will be required by March 1953.'[1]

The Statement on the Navy Estimates for 1952-1953 reported that 'new types of anti-submarine aircraft with improved radar and sonobuoy equipment are under development. Another anti-submarine weapon which is being developed for use by aircraft as well as by ships is a torpedo which will seek out and destroy its target whatever the evasive measures taken.'[2] In the ensuing Debate on Defence in the House of Commons the new Prime Minister, Sir Winston Churchill, stated firmly that 'the Royal Navy has three main threats to meet, each of which, if successful, would affect our survival in this island. I will state them in their order of gravity as they affect us - the mine; the U-boat ... and the threat from the air.'[3] Mr. Thomas, the new First Lord of the Admiralty, reinforced these points in the Debate on the Navy Estimates which occurred the next day. He stated that 'the main purpose of the past Government and the present one has been the build up of our naval strength, including our naval aircraft, to meet the underwater menace in all its forms.'[4] He then proceeded to describe the current state of the carrier programme. 'The fleet carrier _Eagle_ has completed and is now in commission, while her sister ship, _Ark Royal_ is fitting out and

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1. _Ibid._, p. 10, para. 41.
2. _Statement ... Explanatory of the Navy Estimates, 1952-53._ p. 9, 1951-52. Cmd. 8476. Accounts and Papers, (3); 1951-52; Navy, Defence, House of Commons, Housing: XXI.
3. 497 H.C. Debs., 5th March 1952. Col. 440
4. 497 H.C. Debs., 6th March 1952. Col. 666.

is expected to be completed in 1954.'[1] 'The *Hermes* class of light Fleet carriers, ... are urgently required in service to match the production of modern high performance aircraft ... sea trials of *Centaur* ... are expected to begin early next year, and will be followed by those of *Albion* in the spring of 1953.'[2]

Mr. Thomas next went on to discuss the Fleet Air Arm, stating that 'for anti-submarine work we have the "Firefly" Marks V and VI in service.'[3] In addition 'not only are we looking for the best aircraft for attack and defence, but we are not overlooking the potentialities of the helicopter for anti-submarine work.'[4] At this point he was interrupted by Mr. Callaghan, the former Parliamentary Secretary to the Admiralty, who asked whether Mr. Thomas could tell the House 'how the GR17 is coming along, and when it is likely to be in service? .... I told the House last year that it was expected this would be in service at the end of this year. Has the programme dropped back, if so, will not the Hon. Gentleman tell us by how much? That was not a secret last year, so presumably it is not a secret now.'[5] Mr. Thomas refused to provide any information on these points, claiming that there were 'reasons why I cannot tell the House today even as much as the Hon. Member told the House last year. If I could give him a date, I certainly would, but it is quite impossible.'[6]

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1. *Ibid.* Col. 668.
2. *Ibid.* Col. 669.
3. *Ibid.* Col. 675.
4. *Ibid.* Col. 676.
5. *Ibid.*
6. *Ibid.*

Mr. Callaghan took an early opportunity to return to this issue and that of carrier policy in his opening speech for the Opposition. 'I ... would ask ... what is his policy about the modernisation of aircraft carriers. I have great doubts about this, and always have had. I am not at all sure it would not be better to leave these ships, the "Victorious", "Illustrious", "Indomitable", "Formidable" and the rest of them, as they are, with the addition of the steam catapults the Right Hon. Gentleman should be able to put into them, let them fly off such planes as they can, and when the GR17 comes along that should certainly be a possibility .... If these carriers can continue flying off Mark VII and other aircraft used for anti-submarine work they will be doing useful work.'[1]

A Conservative back bencher, Mr. Langford Holt, then asked a number of questions about the GR17. He stated that 'the full reference number of the GR17 is GR17/44, which seems to indicate that the aircraft started its career in 1944 ....[2] It is not in service now ... (and) I am prepared to bet it will not be in service by the end of next year .... The Admiralty ... produce a staff requirement for an aircraft which will be required to perform certain functions. After the requirement has gone to the aircraft manufacturer, the Admiralty change the requirement from a two-seater to a three-seater. That leads to an intolerable and impossible situation for the manufacturer, however hard he may try.[3]

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1. Ibid. Col. 691.
2. Ibid. Col. 746.
3. Ibid. Col. 747.

In winding up the debate, Commander Noble, the Parliamentary and Financial Secretary to the Admiralty, indicated that carrier policy was under review. He stated that 'of the carriers, only the "Victorious" at the moment is committed to modernisation. What the future policy will be, both for the carriers on which work is going on at present and the carriers that would be suitable for modernisation is based on a comprehensive plan. We have to have balanced carrier forces; we have to have task forces of Fleet carriers and trade protection carriers. Whether we go on modernising, as with the "Victorious" or proceed quickly with the others depends on the balance of our carrier forces at the time.'[1] It was noticeable that no indication was given of the role the 'task forces of Fleet carriers' were expected to perform.

The anticipated delivery date for the Gannet was raised later in March during the Debate on the Navy Estimates in the House of Lords. The Earl of Birkenhead stated that 'It is true that deliveries of the Gannet are expected to be behind schedule. I can assure the House, however, that all possible steps have been taken to accelerate deliveries of this aircraft, which is being given the same special priority that is being accorded to new types of fighters for the RAF.'[2]

During the remainder of 1952 and the early part of 1953, a number of Parliamentary Questions were addressed to Ministers about both the Gannet and general carrier policy. In May 1952,

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1. Ibid. Col. 865.
2. 175 H.L. Debs., 27th March 1952. Col. 1091.

in response to a question from a Conservative member, the Civil Lord of the Admiralty informed the House of Commons that 'it was recently decided to accord super-priority to the production of the Gannet anti-submarine aircraft.'[1] Two months later, Mr. Langford Holt asked the First Lord of the Admiralty about the future of the armoured carrier 'Formidable'. He was told that it was in reserve, and its future was under consideration.[2] Three months after this exchange, Mr. Callaghan asked whether 'HMS Formidable is able to operate the Gannet anti-submarine aircraft without modification.'[3] A negative reply was given to this question, and it enabled Mr. Dugdale to introduce a supplementary question asking why it had been decided to scrap HMS Formidable.'[4] He was told that the 'considerable expense of modernising her to operate up-to-date aircraft would not be justified now that Her Majesty's ship "Eagle" has joined the Fleet and Her Majesty's ship "Ark Royal" has reached the fitting out stage.'[5]

Three weeks after this exchange, Mr. Callaghan raised the issue of Gannet delivery dates once again by asking the Minister of Supply 'what effect the super-priority given to Gannet is having on production; and when the Royal Navy can expect a

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1. 501 H.C. Debs., 28th May 1952. Oral Answers: Col. 1355.
2. 504 H.C. Debs., 30th July 1952. Oral Answers: Col. 1466.
3. 505 H.C. Debs., 22nd October 1952. Written Answers: Col. 121.
4. Ibid. Col. 122.
5. Ibid.

reasonable flow of these aircraft.'[1] Mr. Sandys responded by stating that 'super-priority has proved most helpful, particularly in regard to materials supplies. It would not be in the public interest to publish forecasts of deliveries.'[2] Upon being informed by Mr. Callaghan that 'there is widespread criticism that the super-priority is creating more confusion than aeroplanes'[3] Mr. Sandys counter-attacked by arguing that 'the reason for this plane taking so long to get into production is that under his administration at the Admiralty it was entirely redesigned.'[4]

The unproductive nature of this interchange appears to have stimulated Mr. Langford Holt to ask a further detailed question on the Gannet five weeks later. This requested information on 'when the staff requirement for the Gannet aircraft was first issued; why this requirement was subsequently altered; and what is the estimated lapse of time between this staff requirement and the equipping of the first Fleet Air Arm squadron with this aircraft.'[5] He was told by the First Lord of the Admiralty that 'the original conception of the aircraft now known as the Gannet (not then intended for primarily an anti-submarine role) was the subject of a Staff Requirement issued in December 1945. The Staff Requirement was later altered to

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1. 507 H.C. Debs., 10th November 1952. Oral Answers: Col. 571.
2. Ibid.
3. Ibid.
4. Ibid.
5. 509 H.C. Debs., 17th December 1952. Oral Answers: Col. 1366.

make an anti-submarine role its primary purpose and to enable the aircraft to carry a third crew member and newly developed weapons and equipment. This altered and final Staff Requirement was issued in January 1951. I regret that it is not in the public interest to answer the last part of the question.'[1] In the course of the subsequent dialogue the First Lord re-iterated that 'in the case of the Gannet there was a change of policy in that the aircraft was converted from a reconnaissance aircraft to an aircraft which ... must be used primarily for anti-submarine work.'[2]

Mr. Langford Holt's inquiries into the Navy's carrier and anti-submarine aircraft programmes were widened early in 1953 by questions to ministers on Escort Carriers and the supply of Avenger aircraft to Britain by the United States Government. In response to a question on the future of HMS Campania, Britain's sole surviving Escort Carrier, he was told that she was 'being laid up at Sheerness.'[3] His inquiry as to why it had been necessary to reintroduce Avenger aircraft into the Royal Navy, after they had been 'withdrawn from general use in April 1946'[4] and a supplementary comment that 'its reintroduction is a severe condemnation of the procedure by which the Admiralty acquires its aircraft for the Fleet Air Arm,'[5] produced an evasive reply

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1. Ibid.
2. Ibid.
3. 511 H.C. Debs., 28th February 1953. Written Answers: Col.238.
4. 515 H.C. Debs., 6th May 1953. Oral Answers: Col. 380
5. Ibid.

from the First Lord of the Admiralty. He stated he 'did not agree with that at all. The Avenger was used as a torpedo-bomber in 1947 but was modified for anti-submarine work. It was discarded in 1947 because there was a great drain in dollars in buying spare parts, but we have now received a supply of these aircraft from America under the Mutual Security arrangements to help us until the Gannet comes along.'[1]

A further question on naval anti-submarine aircraft was tabled early in March 1953, when Mr. Baldock asked the First Lord of the Admiralty about the use of helicopters for anti-submarine duties. He received the unusually informative reply that 'a naval staff requirement has been stated for the development of a helicopter suitable for employment afloat in an anti-submarine role. This is now being examined by the Ministry of Supply. Investigations are in hand to determine the possibility of adapting existing helicopter designs for anti-submarine duties.'[2]

In the latter part of 1952, a major inquiry into the provision of aircraft for the Navy was conducted by one of the sub-committees of the Select Committee on Estimates. This had been prompted by a visit paid by the Committee to HMS *Eagle* during which some Members had become convinced that the Navy was not obtaining satisfactory supplies of modern aircraft.[3] The sub-committee

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1. *Ibid*.
2. 512 H.C. Debs., 11th March, 1953. Oral Answers: Col.1263.
3. *Rearmament: Seventh Report from the Select Committee on Estimates*. P. xi, 1952-53. (178). Reports; Committees, (2); 1952-53; Coastal Flooding (Emergency Provisions) Bill to Estimates: IV.

took evidence on this subject in late November and early December 1952, and its Report was published in May, 1953. The majority of its hearings were dominated by attempts to identify those parts of the Defence establishment which were responsible for the supply of naval aircraft. The remainder of its time was spent in trying to determine why the aircraft ordered for the Fleet Air Arm were either still not in service, or had arrived in service late. Much of this latter investigation centred around information obtained by the members of the committee when they had visited HMS Eagle. This seems to have included a simplified account of the anti-submarine aircraft situation.

One of the Committee Members, in the course of questioning witnesses, alleged that 'there are three types of aircraft, A, B and C. A is quite an old model which they are now in fact actually using; B is one of the improved models which they had hoped to get but so far the supply has not come forward satisfactorily; and C is a still newer type, and again, they have a prototype and that is about all ... in view of the regretted delays it might be felt that the right thing to do was to suppress type B altogether and concentrate the productive resources on type C.'[1]

The issue of types A, B and C was not referred to in detail when the Fifth Sea Lord, the Vice-Controller (Air), the Director of Naval Air Warfare and the Director of Naval Aircraft Development and Production were called to give evidence,

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1. Ibid. P. 4, Para. 34.

but a detailed discussion took place on the naval anti-submarine aircraft programme. After an interchange on the role of United States aid in filling the gap that existed before the Gannet came into service,[1] Mr. Donner alleged that 'the principal reason for the delays in delivery of these aircraft is that when you reach the stage where they are being produced, you get on the one hand the Radar people, and on the other hand the Armaments people, both coming with new ideas and new demands; and ... the manufacturers are delayed in their production because what is asked for in fact unbalances the aircraft or adds unduly to its weight.'[2] He went on to claim that 'Mr. Winterbottom and I have both had private information (the source of which we cannot divulge) of a particular case affecting Naval aircraft where a particular demand for a new form of equipment came as an unpleasant surprise in the sense that it upset the whole of the design.'[3] Mr. Winterbottom then stated that 'it was a case, in fact, where a new piece of radar equipment was installed in a machine which I believe was 24 inches longer than the radar equipment for which the thing was originally designed. That moved the centre of gravity back 12 inches and, of course, upset the whole basic design of the aircraft.'[4] This allegation was not challenged by the Naval officers present,

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1. Ibid. Paras. 106-108, p. 12.
2. Ibid. Para. 108, pp. 12 and 13.
3. Ibid. Para. 109, p. 13.
4. Ibid. Para. 110, p. 13.

and no discussion took place on it. Mr. Donner then asked about the effect of Super Priority on the Gannet programme and the reasons for the slippage in service dates. He was told that there had not 'been a very great delay ... caused by modifications.'[1] Mr. Winterbottom enquired whether he was right 'in thinking that the specification of the "Gannet" was 1945'.[2] He was told that 'the specification for the family of aircraft was 1945, but it was not a Gannet but an aircraft called the GR17 which was demonstrated in 1950. I think the manufacturers might say, if they were asked, that at that stage the Admiralty insisted on a lot of modifications before it went into production, but that would be falsifying the true position because in 1950 the thoughts of 1945 no longer really applied. It was not possible, for a number of reasons, to go into production any earlier. So in 1951 the staff thoughts had to be brought up to date and the version put into production is the aircraft we now know as the "Gannet".'[3]

A week later the Controller of Supplies (Air) and the Under Secretary (Air) in the Ministry of Supply were questioned by the Committee on the detailed reasons for the delays in the supply of naval aircraft. Most of this questioning centred on the Westland Wyvern strike aircraft, but CS(A) was also asked to explain the meaning of the Gannet Specification number, GR17/45. He told the Committee that it was 'General Reconnaissance No. 17, issued in 1945; and it goes into production next year,

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1. Ibid. Para. 156, p. 16.
2. Ibid. Para. 162, p. 16.
3. Ibid.

so that is 8 years. But when it was required it was not the aeroplane which is coming into production next year. In 1945, it was just a general reconnaissance aeroplane, and at the time the only submarine force in the world worth thinking about was the American force, and the Navy did not ask for anti-submarine aircraft. But in the course of the political changes since then the submarine menace from Russia became more important and the Navy changed their requirement and converted it into an anti-submarine aircraft. That comes into production next year, and there is no reason why it should be late. Any lateness will be due to the strike at Stockport.'[1] Mr. Winterbottom then put to CS(A) the question he had asked the Admiralty representatives. 'Am I right in thinking that, in constructing the "Gannet", when the armaments and radar equipment were being fitted into the airframe, certain technical difficulties arose because the radar equipment did not actually match up with the aircraft, and that several modifications had to be made.'[2] He was told that 'it was a two-seater to start with; now it is a three-seater, and the different type of anti-submarine radar now required has involved a "rehash" inside.' Mr. Winterbottom then pursued the matter further by asking whether 'the armament of the "Gannet" changed also.'[3] He was told that 'they have got two equipments. There is practically no armament in the

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1. Ibid. Para. 371, p. 32.
2. Ibid. Para. 376, p. 32.
3. Ibid.

general reconnaissance machine, but now it has got weapons to deal with submarines as well as radar equipment.'[1]

The MP's on this committee, although they seem to have been in possession of some of the relevant facts, were unable to obtain a conclusive explanation for the delays in the naval aircraft programme. In addition, they were not in a position to uncover the rationalisations, evasions and half-truths contained in some of the evidence given to them on the naval anti-submarine programme. As a result, the Committee report contained no substantive recommendations or observations on that programme.

Towards the end of 1952, the Conservative Government decided to try to reduce the impact the rearmament programme was having upon the British economy. The Minister of Defence announced that 'we shall somewhat reduce the production of types now in service, but we shall continue to press forward as rapidly as possible with the introduction of the newer and still more advanced types.'[2]

These cuts had only a limited impact on the Navy Estimates for 1953-54 for the 'total provision for production and research in these estimates (was) approximately £157,600,000. The comparable figure in the original estimate for the current year was £163,000,000.[3] The remainder of the Statement on the Navy

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1. Ibid. Para. 378, p. 32.
2. 179 H.L. Debs., 4th December 1952. Col. 780. Statement on Defence Production Programme by Earl Alexander of Tunis (Minister of Defence).
3. Statement ... Explanatory of the Navy Estimates, 1953-54. P. 2. 1952-53. Cmd. 8769. Accounts and Papers, (3); 1952-53; Navy, Defence, House of Commons: XX.

Estimates was remarkably non-informative, merely repeating information contained in the previous years Estimates.

The debates upon the 1953 Defence and Naval Estimates in both the House of Lords and the House of Commons were dominated by disquiet at the apparent inability of the Royal Navy to obtain modern aircraft. In the House of Lords, a debate was held on the Supply of Aircraft in mid-February in which Lord Pakenham, a former Labour First Lord of the Admiralty, discussing responsibility for this state of affairs said 'some blame the aircraft industry: they feel that the industry has not taken enough interest in the Navy. The industry blame the Navy: they say that what the Navy want is a kind of Christmas tree upon which to keep on hanging things until the point is reached when the aircraft will not fly.'[1] As this debate progressed, it became clear that what was now causing most concern was the threat of air attack upon convoys, and the absence of a modern carrierborne fighter aircraft in the Navy's current inventory. Lord Teynham pointed out that 'the Navy has no operational jet fighter aircraft of high performance, and unless they are added to the super priority list there will be no chance of getting them for a very long time .... There is only one weapon that can be really effective in ... an attack in the middle of the Atlantic ... that is the high performance carrierborne naval fighter, operating in task forces from light fleet carriers or from auxiliaries operating within the convoys themselves.'[2]

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1. 180 H.L. Debs., 17th February 1953. Col. 471
2. Ibid. Col. 476.

These issues were also discussed in the Debate on the Navy Estimates in the House of Commons in mid-March. In his opering speech Mr. Thomas, the First Lord of the Admiralty, admitted 'that naval aviation is not being re-equipped with modern types of aircraft as quickly as any of us would like.'[1] The remainder of the debate centred around the reasons for delay, and also criticisms of the qualities of the aircraft in the programme. Among the latter was a claim by Captain Ryder that the Gannet was 'too late and too heavy. It can only operate from carriers and can, therefore, be used only in small numbers.'[2]

In his speech winding up the debate, the Parliamentary and Financial Secretary to the Admiralty tried to offer an explanation of the causes of delay in the supply of naval aircraft. He claimed that he had 'studied the comparisons between the production of naval and other aircraft, and I think that the periods of production through most of their states compares very favourably; but one point at which the Navy have special difficulty is during the period between the construction of the prototype and going into production.'[3] He also discussed in some detail the Admiralty's attitude towards anti-submarine helicopters. 'We attach full importance to the potentialities of helicopters in anti-submarine warfare, and there is considerable research going on both here and in the United States .... I think it will be found that it is not an easy problem, because

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1. 512 H.C. Debs., 16th March 1953. Col. 1836.
2. Ibid. Col. 1979. Ryder presumably meant Fleet carriers.
3. Ibid. Col. 2009.

modern anti-submarine equipment is very heavy and there have to be considerable periods of hovering by day and night for its use.'[1]

The debate in the House of Lords on the Navy Estimates allowed Lord Teynham to make a further plea for the construction of auxiliary aircraft carriers,[2] but in his closing speech the Earl of Birkenhead indicated that official thinking on the role of carriers was starting to move away from exclusive emphasis on trade protection and anti-submarine warfare. He stated that 'we must have carrier-borne fighter protection immediately available in direct support of the Fleet and Convoys. Let me stress, too, that there can be no question of having only small carriers. The essential advantage of sea power is its mobility and the ability to strike at the enemy at any point in the oceans or near his coastline. To maintain this traditional advantage, carrierborne fighters must be available; and fleet carriers which are armed and can carry the necessary number of aircraft are necessarily required for this purpose.'[3]

The Statement on Defence for 1954 contained for the first time a lengthy discussion on the nature of any future war which involved nuclear weapons. It was suggested that 'such a war would begin with a period of intense atomic attacks lasting a relatively short time, but inflicting great destruction and damage. If no decisive result was reached in this opening phase,

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1. _Ibid_. Col. 2010.
2. _Ibid_. Col. 498.
3. _Ibid_. Col. 506.

hostilities would decline in intensity, though perhaps less at sea than elsewhere, and a period of 'broken backed' warfare would follow.'[1] This suggested that a short, initial nuclear exchange would be followed by a period of conventional naval warfare. As a result 'the necessity for the proper defence of our sea communications makes it unlikely that expenditure on the Royal Navy can be reduced much below present level.'[2] In substantive terms, this meant that the Navy 'will continue to concentrate on building up and modernising its anti-submarine and anti-mine forces and on the completion of aircraft carriers now under construction. The carriers will be fitted with the angled deck which will enable them to operate efficiently high performance aircraft.'[3] In addition 'there will be substantial provision of aircraft for the Fleet Air Arm. The development and introduction of helicopters for naval work is proceeding.'[4]

These points were enlarged upon in the Statement on the Navy Estimates. It was reported that 'the fleet carrier Ark Royal and two light fleet carriers of the Hermes class, Albion and Bulwark, will be completed during 1954-55. As Centaur, another Hermes class carrier, is about to join the fleet, only

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1. Statement on Defence, 1954. P. 5, para 13. Cmd. 9075. Accounts and Papers, (3); 1953-54; Navy, Defence, House of Commons: XXII.
2. Ibid. P. 6, para. 16.
3. Ibid. P. 7, para. 17.
4. Ibid. P. 14, para. 49.

one carrier should still be under construction by the end of the year. All these new carriers will have angled decks.'[1] In addition 'the re-equipping of the Fleet Air Arm with jet and turbo-jet aircraft has made progress and Sea Hawk day fighters and Wyvern strike aircraft are in service. From America, we have received a number of Avenger anti-submarine aircraft to bridge the gap until Gannets are in service, and further deliveries of aircraft fitted with airborne - early-warning radar, which are proving of great value to the Fleet.'[2]

Prior to the 1954 debates on Defence and the Navy, Mr. Callaghan had once again raised the question of the future of the remaining armoured fleet carriers through the medium of a Parliamentary question. He asked the First Lord 'what his policy is about the modernisation of further Fleet carriers apart from HMS Victorious.'[3] He was told that the Navy was 'not prepared to modernise any more of the Fleet carriers, at any rate for the time being.'[4]

The 1954 Debate on the Navy Estimates enabled the First Lord of the Admiralty to put forward a much more positive view of naval developments than had been possible at any time since the war. He reported that the Navy 'have already rearmed several of our day fighter squadrons with Sea Hawks, and a strike squadron with Wyvern aircraft. In the coming year we

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1. Statement ... Explanatory of the Navy Estimates, 1954-55. p. 7. Cmd. 9079. Accounts and Papers, (3); 1954-55; Navy, Defence, House of Commons: XXII.
2. Ibid.
3. 523 H.C. Debs., 4th February 1954. Written Answers: Col. 76.
4. Ibid.

expect the delivery of further large orders of Sea Hawks, Sea Venoms and Gannets. The result will be that by this time next year the Sea Fury and Firefly, which have both served their generation well, will have been virtually eliminated from the front line. The Gannet, which will be the first specialised naval anti-submarine aircraft, will come into squadron service this year.

We will also start on the production of a lighter anti-submarine aircraft, the Seamew, the prototype of which hon-members may have seen at Farnborough last year. In this aircraft a resolute attempt is being made to halt the trend towards large and complicated aircraft. It has been specifically designed for rapid production and ease of operation from the trade protection carriers.'[1]

He also revealed that 'our anti-submarine aircraft will be fitted with improved radar for snort detection and will carry buoys which can be dropped for detecting submerged U boats. Greatly improved homing weapons for destroying the U boats when located will shortly be coming into service. Here I come back to the question of helicopters, because there are great possibilities in the use of helicopters in anti-submarine warfare. Their ability to hover with a locating device suspended in the sea promises us a great improvement in the accuracy with which a submerged submarine can be fixed.

An order has been placed for a twin-engined helicopter -

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1. 524 H.C. Debs., 9th March 1954. Col. 1951.

the Bristol 173 - for use as an anti-submarine helicopter for the Navy. Until this is available we are using American helicopters and equipments, and have already formed our first anti-submarine helicopter squadron to evolve and develop the necessary techniques.'[1] Mr. Thomas made no attempt to explain the roles the Gannet, the Seamew and the anti-submarine helicopter would fulfil.

Mr. Callaghan ignored these issues of equipment policy in his opening speech for the Opposition in this debate, preferring to 'ask the First Lord to note that, at the moment, the aircraft carrier itself is under challenge and under very heavy fire from a great many senior officers in the Royal Air Force - mostly retired, but nevertheless officers of very great weight and experience.'[2] He then went on to demonstrate the changed perceptions of the Russian naval threat by asking for assurances that 'the weapons carried by (naval) aircraft are capable of sinking ships of the "Sverdlov"class.'[3] He then concluded by pointing out that the First Lord had to rebutt 'the argument ... that anything that an aircraft can do when operating from a carrier can be done very much better by a land based aircraft.'[4]

In the course of the ensuing debate a number of further questions were raised about the Navy's aircraft carrier fleet. Mr. G.R. Howard observed that 'the First Lord today mentioned

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1. Ibid. Cols 1952-1953.
2. Ibid. Col. 1958.
3. Ibid. The 'Sverdlov' was a recently completed Russian heavy cruiser.
4. Ibid.

trade protection carriers. Are they the kind of ships which we used to know as "MAC" ships or are they light carriers or what is their official description.'[1] Similarly, Mr. E.Shackleton commented that 'we ought to know what type of vessel is intended to provide the anti-submarine escort for the convoys. Quite clearly something smaller and a good deal less expensive than even the light Fleet carrier is adequate for the job, but what, then, are the major capital ships for?'[2]

The Parliamentary and Financial Secretary to the Admiralty, Commander Noble, dealt with these points in his winding up speech. He affirmed that 'we attach great importance to our carriers, both today and in the future. They provide, with their aircraft, what we might call the main armament of the Fleet today.'[3] He then observed that 'one Hon. Member has asked my right Hon. Friend what exactly he meant by escort carrier. He meant that to cover the light fleet carrier, the "Mac" ships, the converted ships and what may be the helicopter ship of the future. It was a comprehensive term.'[4] Finally, he commented that he 'had been asked about the weapons which the carriers' aircraft will carry. I would say that I should think they would be able to sink a fair sized cruiser.'

The Debate on the Navy Estimates in the Lords was delayed until the end of July 1954 and in consequence a number of

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1. Ibid. Col. 1958.
2. Ibid. Col. 2084.
3. Ibid. Col. 2169.
4. Ibid.

developments which had occurred since the early part of the year could be discussed. Lord Gifford used the debate to criticise the Navy's system of aircraft procurement, especially as it had affected the Gannet. He stated that he was 'sorry that the progress with the anti-submarine aircraft has been s l o w and I think that everything possible should be done to speed up the production of the Gannet .... The Gannet was originally designed for an all-up weight of 16,500 lbs. and it has ended up with an all-up weight of 21,000 lbs. I feel that those on the production side really must stand up to the Naval Staffs. Obviously, the Naval Staff will always ask for more and more, if possible, but those on the production side must be given a fair run, and the Staffs must accept a reasonable compromise, or we shall have our aircraft festooned with gadgets like a Christmas tree.'[1]

The Earl of Birkenhead informed the House in winding up the debate for the government, that 'production is to be started on an economical anti-submarine aircraft, the Seamew, and I think that no one can accuse the Royal Navy of being backward in the matter of helicopters. Guided missiles have also been occupying our very close attention, and I am glad to say that steady progress is being made by the Ministry of Supply in the development of a large guided missile for Fleet and convoy protection.'[2]

The Public Accounts Committee of the House of Commons

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1. 189 H.L. Debs., 27th July 1954. Col. 161.
2. Ibid. Col. 177.

investigated the financial repercussions of the Firefly VII cancellation during 1954. They had been informed of this by the Report of the Comptroller and Auditor General on the Navy's 1952-53 Appropriations Account, published in January 1954.[1] This explained that 'a note on page 20 of the Account records a payment of £500,000 to the Ministry of Supply in respect of charges arising from the partial cancellation of an order for certain naval aircraft. The total amount of these charges is expected to be approximately £800,000. The aircraft, which were ordered in 1950, represented a redesigned version of an existing model and were expected to be satisfactory for operational purposes until a later type could be proved and put into production. It was considered that certain deficiencies of the redesign could be overcome in the course of production and, as the requirement was urgent, no prototypes were obtained. The machines were, however, found on delivery to fall short of requirements and it was decided early in 1952 to reduce the order to numbers sufficient for training and certain other purposes, and to expedite production of the later type. The reduction of the order cut the estimated outlay on these machines by some £6 million, after taking into account the charges arising from the partial cancellation of the contract.'[2]

The Public Accounts Committee looked into this issue on

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1. Navy Appropriation Account, 1952-53: Report of Comptroller and Auditor General. Pvii, para. 24. 1953-54. (62) Accounts and Papers, (3); 1953-54; Navy, Defence, House of Commons: XXII.

2. Ibid.

the 27th July 1954 and questioned Sir John Lang, the Permanent Secretary at the Admiralty, about it. Their main concern was to establish why an order had been placed for the aircraft before a prototype had flown. In response to a specific question on the defects which led to the cancellation of the order, Sir John said they resulted from 'trying to develop the aeroplane beyond the stage that it could fly .... We had three factors in the mock-up that flew. There was a lack of what was called stall warning ... you got excessive rudder bar forces which led to the aircraft diving out of trim, and you got a tightening in turn at altitude .... At the time at which we placed the production order, we, in the sense of the Admiralty and other people concerned, thought that these disabilities could be eliminated by further adjustments in the aircraft, but eventually we were not successful and we had to abandon it.'[1] He was then asked whether the addition of the third crew member had been the decisive change that had made the aircraft operationally unacceptable. He denied this, laying the blame not only on 'the one man, but the equipment he was going to operate and the fact that it meant a larger fuselage and the engine coming a bit further forward.'[2] The subsequent Report of the Public Accounts Committee merely contained an abbreviated history of the Firefly VII programme, and no criticism was voiced of either the Admiralty's or the MoS's handling of the contract.[3]

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1. Third Report from the Committee of Public Accounts, P. 453, Paras. 5675 and 5676; 1953-54, (101-1): Reports; Committees, (1); 1953-54; Accounts, Public to Army and Air Force Act: IV.
2. Ibid. Para. 5680.
3. Ibid. P. lxv., Para. 117.

The House of Lords discussed defence again in December 1954 through the medium of an 'Amendment to the Address in Reply to Her Majesty's Speech' moved by Lord Chatsfield. This was critical of the declining cruiser strength of the Royal Navy, and the resulting limitation in the country's trade protection forces. In the course of the ensuing debate the lack of an ongoing carrier building programme was raised. Lord Teynham maintained that 'the convoy must have its light fleet carriers, either with it or in the offing, to give protection when it is attacked from the air many hundreds of miles beyond the range of shore based fighters ... no new light fleet carriers have been laid down. Are we to have no modern light fleet carriers on a steady rebuilding programme?'[1] In a similar spirit, Lord Winster insisted that 'we want the heavy carrier for the offensive, the light carrier for merchant convoy and the ferry carrier for supply. If that is agreed, why are there no carriers on the stocks today?'[2] The new emphasis on the offensive role of aircraft carriers was underlined by the speech of Lord Fraser of North Cape: 'The question of aircraft carriers is a debatable point, and always has been; but in my view one has to look upon the aircraft carrier as an advance base near the point of danger .... It is capable of attacking in places which are un-get-at-able by other means.'[3]

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1. 190 H.L. Debs., 2nd December 1954. Col. 151.
2. Ibid. Col. 165.
3. Ibid. Col. 170.

The relationship between conventional and nuclear forces in the British defence posture became increasingly controversial between 1954 and 1955, and both the 1955 Defence White Paper and Statement on the Navy Estimates reflected this development. The former attempted to articulate at some length the complementary roles of strategic nuclear forces and the Navy. It argued that the 'deterrent must rest primarily on the strategic air power of the West, armed with its nuclear weapons. The knowledge that aggression will be met by overwhelming nuclear retaliation is the surest guarantee that it will not take place.'[1] 'But we cannot rely only on strategic airpower .... We must also demonstrate that we have the will to survive and the power to ensure victory .... On our side, we must have a Navy capable of dispersal and concentration at will which, ... can seek out and destroy the enemy's naval forces and preserve effective command of sea communications.'[2] 'The Navy is still required to contain and destroy enemy forces at sea so as to allow free movement of supplies and troops and to give both our land and air forces support in their operations.'[3] 'The traditional task of the Navy in peace-time is, as it always has been, to sustain our foreign and colonial policy ... in limited conflicts of the Korean type it can provide quickly, by reason of its mobility, powerful assistance to the land battle.'[4]

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1. <u>Statement on Defence, 1955</u>, p. 6, para. 19. 1954-55. Cmd.9391. Accounts and Papers, (3); 1954-55; Navy, Defence, House of Commons: X.
2. <u>Ibid</u>. p.7, para. 21.
3. <u>Ibid</u>. p.8, para. 26.
4. <u>Ibid</u>. p.10, para. 40.

This exposition was closely related to a lengthy document produced by the Admiralty to explain 'The Role of the Royal Navy in the Age of Thermo-nuclear weapons,' which formed the first part of their Statement on the 1955-56 Navy Estimates.[1] This started by pointing out that 'in local wars ... the sea and air power of the Royal Navy can be brought to bear quickly and effectively in almost any part of the world.'[2] It then proceeded to ask rhetorically 'what of its role in a future war fought with the newest weapons of mass destruction?'[3] The answer given was that 'If such a war were to come the role for navies remains clear. Their functions would be

a) To search out and destroy enemy ships wherever they are and by all means within their power to prevent the enemy from using the seas for his own purposes.

b) To protect the communications necessary to support our warlike operations and to safeguard the supply lines of the Allied Countries.

c) To provide direct air support for operations ashore and afloat in those areas where it cannot readily be given by shore-based aircraft.'[4]

The statement then went on to claim that 'the Fleet carrier is the most powerful vessel the Navy has in service: she is

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1. Explanatory Statement on the Navy Estimates, 1955-56. Cmd. 9396. Accounts and Papers, (3); 1954-55; Navy, Defence, House of Commons: X.
2. Ibid. Para. 3.
3. Ibid. Para. 4.
4. Ibid.

armed with squadrons of aircraft which can defend our ships against surface, air and submarine attack, destroy the enemy submarines and aircraft at sea or at their bases, attack shore targets and in certain areas support army operations ashore.'[1]

Considerable space was devoted to the Fleet Air Arm, emphasis being placed on the Navy's ability to 'deploy air power very quickly to any part of the world in either global or local wars. It is of particular value, first in areas which are not well provided with airfields suitable for modern shore-based aircraft, and secondly for operations beyond the range of such aircraft.'[2] It was reported that 'the year 1954 saw the introduction into the Fleet Air Arm of the angled deck and the deck-landing mirror-aid. These developments, together with the steam catapult which will shortly come into service add greatly to the power and efficiency of aircraft carriers.'[3]

In addition 'in the sphere of anti-submarine warfare, the turbo-prop Gannet has come into service and squadrons have already been formed. This aircraft and its equipment show great promise. Furthermore, intensive trials and experiments with the use of helicopters for anti-submarine work have proved their value in this role, and a helicopter specially designed for anti-submarine work has been ordered.'[4]

In parallel with these documents, a White Paper

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1. Ibid. Para. 9.
2. Ibid. Para. 42.
3. Ibid. Para. 43.
4. Ibid. Para. 45.

on the Supply of Military Aircraft was also published explaining why delays had occurred in the whole military aircraft programme. This dealt at some length with the philosophy of military aircraft procurement in the post-war period, but only one paragraph was devoted to naval anti-submarine aircraft. This merely stated that 'the Gannet was originally devised in 1946 as a two-seater anti-submarine aircraft. In 1948, it was redesigned to carry a third crew member, and the production contract was placed in January, 1951. Development and production have proceeded smoothly apart from some difficulty with the engine under certain conditions, which has now been overcome. The Gannet is a formidable submarine hunter and will be delivered to the Navy in substantial numbers in 1955.'[1]

The issue of the supply of military aircraft was debated at length in the Debate on Defence in the House of Commons in March, 1955. In the course of the debate, the Minister of Supply felt able to report that 'The Fleet Air Arm is almost entirely equipped with turbine engined aircraft .... The Gannet is also in squadron service with the Royal Navy and is operating satisfactorily.'[2]

In the debate on the Navy Estimates, the offensive role of the aircraft carrier, especially in limited wars, was again emphasised. The First Lord argued that 'in defence of the aircraft

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1. The Supply of Military Aircraft, p. 8, para. 35. 1954-55. Cmd. 9388. Accounts and Papers, (3); 1954-55; Navy, Defence, House of Commons: X.

2. 537 H.C. Debs., 1st March, 1955. Col. 2092.

carrier, it proved its value for all to witness during the Korean War. There may be more wars like the Korean War.

The expert advice given to the American Navy and to our own fully supports the carrier battle group in a war of nuclear weapons as a self-protecting largely self-contained mobile air-field.'[1] For the Opposition, Mr. Callaghan went further by arguing that 'heavy aircraft carriers have a wider purpose nowadays than merely to fly off fighters for self-defence or for defending a convoy. They have a strike role, and the Navy ought to concentrate a great deal of its attention upon an advanced type of strike aircraft to fly from the Ark Royal, the Eagle and the Victorious. I say the Victorious because she has been practically rebuilt since 1950 .... I take my share of responsibility for that, because I signed the Minute for the work to go ahead, but I am glad to say that I stopped the conversion of any more, and the conversion of the five has not gone ahead.'[2] The Parliamentary and Financial Secretary to the Admiralty took a rather more neutral line in winding up the debate, arguing that 'the primary role of the aircraft carrier ... is to provide our own forces with protection and, in company with our other forces and coastal command, to deny the enemy the seas.'[3]

The offensive capabilities of the Navy's carrier force were further accentuated in the 1956 Statement on Defence, and

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1. 537 H.C. Debs. 3rd March 1955. Col. 2252.
2. Ibid. Col. 2264.
3. Ibid. Col. 2273.

the Statement on the Navy Estimates that accompanied it. The Statement on Defence was primarily concerned with putting forward an integrated philosophy for dealing with both the problems of nuclear war and of limited conventional war. It argued that 'in the deterrent must be included ... the ability to hold the line by land, sea and air until the nuclear counter-offensive has broken the back of the enemy assault.'[1] It went on to state that 'the Navy will maintain an effective fleet capable of supporting this country's influence and interests as a world wide power and a member of the Commonwealth and NATO. The further development of new weapons and techniques should enable it to strike whatever may threaten us by sea in the future whether in limited or global war.'[2] 'In limited war we plan to make immediately available in any part of the world a force of aircraft carriers equipped with modern aircraft.'[3]

This Defence Statement was based on a 'review of the future development of the Services. This review has been carried forward for as long a period as possible ... proposals for this year have had regard to probable developments over the next seven years.'[4] In the light of this review 'allowance has been made for small reductions in the total orders for certain aircraft. The main types affected are Valiants, Hunters, Seamews

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1. Statement on Defence, 1956. p. 4, para. 4. 1955-56. Cmd.9691. Accounts and Papers, (4); 1955-56; Navy, Defence, House of Commons: XXXIII.
2. Ibid. P. 7, Para. 15.
3. Ibid. P. 9, Para. 22.
4. Ibid. P. 6, Para. 13.

and Shackletons.'[1] In addition, it was reported that the Admiralty 'plan to keep in the reserve fleet only those ships capable of putting to sea at short notice and fighting effectively in a modern sea war. Of the other ships in reserve, those that are obsolete or have reached the end of their useful life will be disposed of.'[2]

The Statement on the Navy Estimates pointed to the fact that 'the activities of the Royal Navy during the past year ... have shown how quickly and effectively the sea and air power of the Royal Navy can be brought to bear in almost any part of the world.'[3] It argued that 'in a global war, our sea lanes would be open to attack by a massive underwater fleet and a powerful surface fleet which would be at sea with their fleet train. The main purpose of the Navy would be to retain control of the seas by destroying the enemy ships, submarines and aircraft.'[4]

In the course of the Debate on the Navy Estimates, considerable attention was paid to the Seamew cancellations and the anti-submarine helicopter programme. In his opening speech in the debate, Mr. Ward, the Parliamentary and Financial Secretary to the Admiralty was able to reveal that 'the only piston engined aircraft still in the front line are the American Skyraiders for early warning. These will be replaced later by a special version

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1. <u>Ibid</u>. P. 20, Para. 83.
2. <u>Ibid</u>. P. 9, Para. 25.
3. <u>Explanatory Statement on the Navy Estimates, 1956-57</u>. P. 4, Para. 7. 1955-56. Cmd. 9697. Accounts and Papers, (4); 1955-56; Navy, Defence, House of Commons: XXXIII.
4. <u>Ibid</u>. P. 4, Para. 9.

of the Gannet.'[1] He then went on 'to deal with the use of the helicopter for underwater warfare. It is proving very efficient at operating an asdic set from the air free from ship noises .... (There are) great possibilities of this method of anti-submarine defence ... we are now planning to use the single rotor S58 (helicopter).'[2] In his opening speech for the Opposition, Mr. Callaghan demanded to know 'what has happened to the Seamew which has dropped out of the picture? In 1954 we were told that the Seamew was being ordered to operate from trade carriers. Where is it today? What is the policy of the Admiralty? .... Has it been abandoned as I believe? If so, I want to ask the Admiralty why it was ever ordered, and are we continuing to order it.'[3]

A very extensive reply to these queries was provided by Mr. Geoffrey Stevens, a backbench MP. He explained that 'the Seamews were produced by Short Brothers in answer to a specification requiring a modest performance, primarily for anti-submarine duties, but in particular an aircraft which was to be exceedingly cheap and easy to construct.'[4] 'It was to be an aeroplane which would be capable of operation not only from a carrier but also from small and restricted airstrips.

As I understand the situation, the Short Seamew has undoubtedly fulfilled the requirements of the original specification

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1. 549 H.C. Debs., 28th February 1956; Col. 2320.
2. Ibid. Col. 2321.
3. Ibid. Col. 2338.
4. Ibid. Col. 2429.

but in the last month or two reports and rumours have reached me that, now that a few more Seamews are available, Navy Pilots who have flown them are not entirely happy with their performance. They have found that the Seamew has a cruising speed which is far below modern operational requirements and that its terminal diving speed is not much more than 300 knots, which is also below what is required.

I do not know whether these rumours are true. If they are, a rather curious situation arises. I have never heard a report or a rumour that the aircraft does not fulfil the original requirements. Yet when it comes into service it is found to be unsatisfactory. Surely, that opinion should have been expressed when the original requirements and specifications were first published. Is it possible that money has been wasted on an aeroplane which has never been and could never be of great value.?'[1] In response to these extensive criticisms, Mr. Ward pointed out that 'we are having some Seamews in the RNVR. The new strategic concept brought about by the hydrogen age has rather altered our thinking, in terms of the original use for which we ordered the Seamew, but it is certainly a perfectly good aircraft.'[2]

The publication of the 1957 Statement on the Navy Estimates signalled the termination of the Seamew programme, for it reported that 'the recently announced decision ... to disband the Air Branch of the RNVR has naturally caused great disappointment...

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1. Ibid. Col. 2430.
2. Ibid. Col. 2468.

The decision was taken in the best interests of the Royal Navy as a whole in order to ensure that ships can still be replaced and equipped with modern weapons within the stricter limitations of Navy Votes.'[1] It further reported that 'considerable numbers of British built Whirlwind helicopters will be delivered during the coming financial year for use in the anti-submarine role. Those aircraft, are expected to be in service in the second half of 1957.'[2] These helicopters were to replace the Gannet in the Fleet Air Arm's anti-submarine squadrons.

The 1957 Defence White Paper continued the trend towards viewing the Navy's prime role as one of conducting offensive operations in limited war, rather than conducting a new 'Battle of the Atlantic'. It conceded that 'the role of naval forces in total war is somewhat uncertain ... there is the possibility that the nuclear battle might not prove immediately decisive; and in that event it would be of great importance to defend Atlantic communications against submarine attack.'[3] It went on to argue, that 'on account of its mobility, the Royal Navy, together with the Royal Marines, provides another effective means of bringing power rapidly to bear in peace-time emergencies or limited hostilities. In modern conditions the role of the aircraft carrier, which is in effect a mobile

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1. Explanatory Statement on the Navy Estimates, 1957-58. P.11, Para. 39. 1955-56. Cmnd.151. Accounts and Papers, (4); 1955-56; Navy, Defence, House of Commons: XXII.

2. Ibid. Para. 38.

3. Defence: Outline of future policy. P. 4, Para. 24. 1956-57. Cmnd. 124. Accounts and Papers, (4); 1956-57; Navy, Defence, House of Commons: XXIII.

air station, becomes increasingly significant.[1]

One final aspect of the naval anti-submarine aircraft development programme was raised by the Estimates Committee during 1956, when one of its sub-committees was conducting an enquiry into the supply of military aircraft. They had been supplied with basic data on all the postwar aircraft projects, and had also examined in detail the organisation for military aircraft development and production.[2] In the course of providing oral evidence for the sub-committee, Mr. L.J. Dunnett, Deputy Secretary at the Ministry of Supply, was questioned on a document listing aircraft projects which had been cancelled due to changing requirements. He was asked to explain the background history of the sole naval aircraft included in this list, and stated that 'the decision to produce an anti-submarine version of the Sturgeon was taken very early in 1949. The Navy had under development at that time what has turned into the Gannet as an anti-submarine aircraft, but in the form in which it then was it was a two-seater aeroplane. With the developing views of the Navy for anti-submarine work they stated they required three men with a good all-round view. There were grave doubts as to whether the Gannet could be modified to take three men with an all-round view instead of the two for which it was designed; and in view of the importance of an anti-submarine aeroplane to the Navy, it was considered to be too

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1. Ibid. P. 6, Para. 37.
2. The Supply of Military Aircraft. Second Report from the Select Committee on Estimates, pp. 68-84. 1956-57. (34) Reports: Committees; 1956-57; Consolidated Bills to Estimates: V.

big a risk to rely solely on the Gannet, with the doubts whether it could be modified to take three people; so the Sturgeon was started as an insurance against the Gannet failing. Work continued for about two years; the thing was then reviewed and the Gannet in its redesigned form as a three seater looked so promising it was decided that the Sturgeon should not go on any longer as an insurance against the Gannet failing.'[1]

These official statements and records of Parliamentary debates provide a useful guide to the way the Navy's thinking about its future rôle, and the place of fixed wing anti-submarine aircraft within it, evolved between 1954 and 1957. The Navy gradually moved from a position where the carrier force was justified in terms of its defensive trade protection capabilities, towards one where the force was seen to have a more positive, offensive set of roles both in peacetime and war. In peacetime, increasing emphasis was placed on its capability to perform rapid, limited, intervention operations: in wartime, emphasis was placed on its ability to sink the potential enemy's fleet and to attack land targets. By 1957, the idea of refighting the 'Battle of the Atlantic' had been abandoned, and with it the reserve carrier capacity, aircrews and fixed wing anti-submarine aircraft necessary to perform such a task. Attention was now focused on defending naval task forces and military convoys, and helicopters, rather than fixed wing aircraft, appeared to

1. Ibid. P. 249, Col. 1738.

be more effective in performing anti-submarine duties in support of them. As a result, Fleet Air Arm Squadrons equipped with Gannet ASMks1/4 aircraft began to be re-equipped with anti-submarine helicopters from 1957 onwards, and by July, 1960, the former had been completely withdrawn from squadron service.[1] It was ironic that after a ten year gestation period, the Gannet should have seen only three years service with the Royal Navy before being replaced in anti-submarine squadrons by helicopters,[2] while the Seamew, which had been built to meet the original aspirations of GR17/45 was cancelled before it even entered service.

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1. Taylor, op.cit., p. 370.
2. For a listing of the Fleet Air Arm Squadrons which operated the Gannet AS Mks1/4 and their dates of formation and disbandment see Appendix III. As can be seen from this, only one squadron operated the type after mid-1958.

CHAPTER 9

ANALYSIS, 1952-1956.

This chapter will conclude the systematic examination of the relationship between the propositions on weapon procurement evolved in Chapter 1 and the evolution of the British naval anti-submarine programme between 1945 and 1956.

Proposition i. Uncertainty is inherent in weapon procurement projects, but the types of uncertainty involved are directly related to the stage that has been reached in the evolution of the project.

A major change had occurred in the GR17/45/Gannet project by 1952: it was no longer an aircraft which might be produced at some point in the future, it was one which was certain to be produced. This revolutionised attitudes towards it, for it had become an asset ripe for exploitation rather than a project struggling for survival. In a peculiar fashion it had acquired a life and a momentum of its own: passing the threshold into production and acquiring a large production contract appeared to have transformed it from a struggling aspirant into an established product which effortlessly generated new variants.

One effect of this change was that what constituted 'the Gannet project' became very difficult to delineate with certainty, and this affected the elements of uncertainty surrounding it. Prior to 1952, the future of the project was inextricably bound up with the changing concepts of anti-submarine warfare and the composition of the carrier fleet. After 1952 these matters still remained relevant, but the trainer, AEW, strike and transport versions of the aircraft were all related to different operational needs and concepts. It was through this process of diversification that the aircraft acquired an existence independent of the needs and concepts which had produced it: an entity which had previously been dependent on its environment had now become independent of it. This meant that the uncertainties inherent in the project were also much more diverse than previously.

The configuration of the Gannet AS Mk 1 had become frozen by 1952, and the target uncertainty generated over the succeeding years was a product of the degree to which changes took place in perceptions of the nature of anti-submarine warfare and its importance in national strategy. The major change in perception was over the need for fixed wing anti-submarine aircraft. Their inherent weakness was their limited capacity for conducting underwater search operations, in which they were totally dependent on a limited supply of sonobuoys. These buoys could not be recovered for re-use, and could not be rapidly repaired or replaced if they malfunctioned in an operational situation. In addition, the speed of the aircraft made plotting and attack of underwater targets a complex operation. The development of anti-submarine helicopters equipped with dunking sonar appeared to represent a much more promising, effective and reliable way of hunting submerged submarines. Its major initial limitations lay in the state of technical development of the helicopters of the period, which made hovering for long periods a hazardous affair and restricted their payload and endurance. The advent of gas-turbine powered helicopters such as the Bristol 191 and Wessex eliminated some of these shortcomings, and made them appear a much more attractive underwater search vehicle than sonobuoy equipped fixed wing aircraft. They also had the inherent advantage that they could operate from many different types of naval vessel if suitable landing pads were provided, whereas fixed wing aircraft could only operate from an aircraft carrier. This meant that a task force could provide itself with an airborn anti-submarine capability without the necessity of having an aircraft carrier present.

This change in relative underwater search capabilities was parallelled by changes in the nature of the submarine threat. The advances in conventional and hydrogen peroxide powered submarine design which had occurred in Germany in the last years of the Second World War were starting to be translated into operational designs in the early 1950's by the world's leading navies.[1] They represented an emerging threat from submarines capable of sustaining very high underwater speeds, often much higher than that of existing surface ship escort vessels. In addition, work was known to be going ahead on nuclear reactors

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1. For a discussion on this point see A. Hezlet, The Submarine and Seapower, Peter Davies/London, 1967, pp. 228-237 and pp. 241-250.

suitable for powering submarines.[1] These would offer great power and underwater speed, and virtually unlimited endurance. So long as the principal underwater threat came from the submarine operating on the surface at night or in bad weather, as in the North Atlantic in 1942/43, or even operating at schnorkel depth, as in the last few months of the European war, the anti-submarine aircraft with its large patrol radius, radar equipment and human observers could perform an invaluable role. As the nature of the future threat changed to that of the swift submerged submarine, its value declined rapidly, especially when it became apparent that aircraft fitted with large AEW radar sets were better equipped to detect submarines on the surface or schnorkeling than specialist anti-submarine aircraft equipped with inferior radar equipment.[2]

The joint impact of these two developments led to a situation in 1954/55 where it was decided that the Royal Navy no longer had an ongoing need for a specialist fixed wing anti-submarine aircraft. This decision was reinforced by the fact that the Gannet configuration had begun to appear technically suboptimal in the circumstances in which the aircraft was to be operated. It was clear by 1952 that no new Escort Carriers were likely to be built, though it was 1956/57 before the idea of preparing for a general war at sea which would allow time for merchant ship conversions to appear was finally abandoned. This meant that

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1. Project work on a British submarine reactor was well under way by 1950. See Gowing op.cit., Vol. 1, pp. 239 and 445.

2. See A. Hezlet, Aircraft and Seapower, Peter Davies/London, 1970, p. 330.

the Gannet and the Seamew would be operated from either Fleet or light Fleet carriers with lengthy flight decks, while the advent of the operational steam catapult in 1954 completely removed the need for naval anti-submarine aircraft to have a short take-off capability. The size of the Gannet's power plant had been largely dictated by the need for sufficient power to provide this short take-off capability, and in normal flight only half the power plant was used to sustain cruising speed. If catapult launches were to be the normal method of take-off, the aircraft possessed a power plant almost twice as large as was necessary. The impact of this can best be assessed by comparing the chief technical characteristics of the Gannet with those of the French Breguet Alize anti-submarine aircraft. This was produced in the mid-1950s after the advent of the steam catapult and after the French Navy had displayed some interest in purchasing the Gannet. It had greater endurance than, and a comparable weapon load to the Gannet, but was powered by a Rolls Royce Dart engine of only 1,975 eshp and had a normal loaded weight of only 18,078 lbs.[1] The continued development of aircraft of the Gannet type could only be technically justified on two grounds: twin-engined safety and the possibility of operations from small aircraft carriers which did not possess steam catapults. By 1955, the latter justification was no longer tenable.

In parallel with these developments, the priority assigned to anti-submarine warfare within the Navy was slowly decreasing.

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1. Jane's All the Worlds Aircraft, 1959-60, Samson Low, 1959 p. 117. Normal endurance is specified as 5 hrs, 10 mins and take-off run, 1,890 ft.

This change was directly related to changes in the Navy's perception of its peace-time and war-time missions, and the relative importance it assigned to them. The debate centred around the possible role of the Navy and particularly its carriers, in total nuclear war; the nature of such a nuclear war; and the degree to which the Navy could justify its existence purely in terms of its peace-time or limited war activities. It seems to have been agreed that the Navy could justify the retention of its light Fleet carriers for both peacetime and wartime trade protection duties in geographically limited areas of the world, and to provide support for limited intervention operations. The Korean War experience appeared to reinforce heavily the strength of the latter argument.

Justifying the retention of large Fleet carriers proved more difficult. They seemed too valuable to risk in limited war situations and their running costs appeared to make them unsuited for peacetime trade protection duties. The Navy seem to have initially argued that in a total war situation, the carriers were needed to stage a repeat version of the Second World War 'Battle of the Atlantic', these carriers serving as easily mobilised bases for fixed wing anti-submarine aircraft.[1] As operational Fleet carriers commissioned from 1949 onwards, this nominal anti-submarine role was maintained. The continuance

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1. For an extended discussion on this issue see J. Simpson and F. Gregory, 'The Evolution of British Naval Equipment, 1945-70,' Section III, 'Britain's Post-War Aircraft Carrier and Naval Aircraft Policy' pp. 4-10; Paper presented to the Conference on British Defence Policy, 1945-70, Wessex Hotel, Winchester, 30th April, 1974.

of work on the new Fleet carriers and the agitation to modernise the existing ones could be seen as preparations for a more ambitious future role. The full nature of this was only to emerge with the NA39 requirement for a naval bomber capable of carrying nuclear weapons. Public statements on naval policy from 1954 onwards tended to emphasise the positive offensive role of the Navy's heavy carriers in nuclear war and play down their anti-submarine role.[1] The latter, together with trade protection, had now become the major justification for the light Fleet carriers, for it seems to have been realised that the three carriers of this type completed during the early 1950s would be incapable of operating large numbers of second generation jet aircraft. Plans were drawn up to use them for trade protection duties, equipped with less advanced aircraft such as the Skyhawk, Seamew and both anti-submarine and anti-ship missile equipped Gannets. The intention was that RNVR personnel should be trained to man these aircraft, but the abolition of the flying branch of the RNVR in early 1957 effectively terminated this idea, besides producing the cancellation of the Seamew order.[2]

The priority assigned by the Navy to the convoy escort and anti-submarine roles was thus a function of both changing national perceptions of the Soviet maritime threat and the

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1. A more detailed discussion of the factors which produced this change is contained in Crowe, <u>op.cit.</u>, pp. 126-136.

2. The impetus for this change is alleged by Crowe to have been the full realisation of the impact of the hydrogen bomb upon warfare. This was believed to make the idea of mobilising conventional forces to fight a thermonuclear war irrelevant. <u>Ibid.</u>, pp. 147-153.

dominant framework or paradigm of the type of warfare likely to be encountered in future that was in existence at a particular point in time. By the middle of the decade changes in these two elements had led to the role of the Navy's carrier fleet evolving from a nominal concentration on trade protection and convoy defence duties to emphasis being placed upon much more offensive anti-shipping strike and ground support functions. This in turn led to both a decline in importance of the trade protection role, and a demand for airborne equipment that could safeguard fast moving task forces and troop convoys from attack by speedy hydrogen peroxide or nuclear powered submarines. Sonar equipped helicopters had the potential to offer that protection, and moreover did not necessarily need an aircraft carrier to operate from: fixed wing anti-submarine aircraft did not have such potential, and their reliance upon aircraft-carriers meant they lacked flexibility of deployment.

All of these elements added up to a massive increase in the target uncertainty surrounding the Gannet anti-submarine aircraft as production deliveries started, culminating in a decision to equip at least half the future anti-submarine squadrons with helicopters being taken <u>prior</u> to the Gannet's entry into squadron service. This declining perception of need for the aircraft was not too surprising, given the four and a half years that elapsed between the Gannet being selected for production and the first aircraft entering squadron service. It suggests that target uncertainty will always tend to increase once a production decision has been taken, if only because this involves a commitment to a frozen design which is no longer easily adapted to meet changes in military requirements. In this case the problem was much more profound, as a completely different type of weapon system appeared to be most appropriate to the new military need.

Compared to this target uncertainty, the other elements of uncertainty present in the Gannet project from 1952 onwards appear to be rather insignificant. Some technical uncertainty appears to have persisted, particularly over the performance and operating characteristics of the engine. It took a considerable time for it to be recognised that the unreliability of the engine was the major cause of development delays, while vibration problems had still not been permanently cured by 1957 when the Gannet anti-submarine squadrons started to disband. These technical problems merged into uncertainties over internal programme management. Both the development and production programmes suffered from co-ordination problems as a result of the MoS contracting directly for many Gannet components, but making little effort to centrally manage the project. In addition, the MoS seemed very insensitive to the problems suffered by Fairey with engine auxiliary equipment, and appeared to make little effort to resolve them.

It seems likely that the Seamew suffered from a very similar process of increasing target uncertainty between 1952 and 1957. The substance of this was identical to that suffered by the Gannet, except that its limited weight and restricted crew made it a much less potent anti-submarine aircraft than the Gannet, and gave it less scope for adaption to new roles.

The Gannet could do everything it could do rather more effectively and it was in production in large numbers. Once it became established that anti-submarine aircraft would be mainly operated from Fleet carriers fully capable of coping with the Gannet's take-off weight it was very unclear what role the Seamew could perform that the Gannet could not do just as well.

In contrast to the dominance of target uncertainty in the Gannet and Seamew projects once a production decision had been taken, technical uncertainty proved to be the crucial element with the Firefly VII. There was no doubt the aircraft was needed, and that it was the only interim design available to enable the new sonobuoy equipment to be placed in service as rapidly as possible. The issue was whether it was technically feasible to produce a satisfactory aircraft, capable of carrying the specified equipment and weapon loads, without embarking on a major redesign. It was still unclear in early 1952 whether it was feasible, but this rapidly became resolved when the naval test pilots at Boscombe Down stated unequivocably that they regarded the aircraft as unfit for operational service. In practice, it should have been self-evident following the report on the HMS Vengeance night-flying trials with Firefly V aircraft that the Firefly VII would have similar shortcomings when operated at night, and that the production of an acceptable design was a near impossibility. To this extent the uncertainties were sustained by deficiencies in internal project management. The Firefly VII project thus differs radically from the other two anti-submarine aircraft projects in that it suffered from technical and internal process uncertainty once the production decision had been taken, rather than target uncertainty.

The impetus provided by the existence of orders for the Gannet led to the generation of ideas for new variants. The trainer version was a simple conversion, and served a need only so long as Gannet aircraft were in operational service. The AEW 3 suffered from little target uncertainty as the capabilities of its radar were known, and were believed essential for providing support for carrier task forces, but it too suffered major technical uncertainties, as its protracted and tortuous development programme indicated. The basic technical uncertainties were whether the existing airframe could be effectively redesigned to accommodate the new radar set, and whether the new engine could be developed without difficulty. Neither of these operations proved easy. Technical uncertainty thus proved to be a major component of all the production development programmes considered by this study.

<u>Proposition ii. External factors dominate a weapon project at certain key points, specifically decisions on inception, production and cancellation. At other times the process operates autonomously.</u>

This period offers rather contradictory evidence about the proposition. While the changes in perceptions of the Russian threat, in the dominant strategic paradigm and in weapon technology all combined to ensure that no Mk II Gannets other than the AEW 3 would be produced, they occurred too late to have any significant effect upon the Gannet AS Mk 1 production run. It was these external factors which limited that aircraft's major operational life to a little over three years, despite the development effort that had preceded it, and led to its complete withdrawal after just over five years service. The effect upon the Seamew appears to have been much greater, for it seems likely that it was these external factors, rather than technical problems, which led to the decision to cancel the production programme in 1957 after several aircraft had been completed and delivered to the Navy.[1] Finally, the decision to place a production order for the Gannet AEW 3 resulted from the need to obtain supplies of its AN/APS 20 radar from the United States, and the conditions imposed on such supplies by its government. These issues were the dominant element which precipitated the production decision.

In contrast to these examples of external factors preventing inception, limiting operational service, producing cancellation and expediting a production decision, the Firefly VII programme was terminated as a result of decisions and activities within the project. Flying trials were an integral part of a military aircraft project, and it was on the basis of these that the decision to cancel was taken. It may have been reinforced by the belief in some quarters that the aircraft was obsolete, and that its entry into operational service would hamper the early introduction of the Gannet, but the dominant element

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1. It appears that the Seamew did suffer from structural and handling problems, but the importance of these to the final cancellation decision is unclear. For further details on these problems see Barnes, op.cit., p. 453-4.

appears to have been its rejection for operational use by the Naval test pilots. This action also served as the external factor which dominated the decision to take up the United States Government's offer of Avenger aircraft, and place them into operational service as an interim anti-submarine aircraft. Thus apart from the Firefly VII example, this proposition appears to be reinforced by the events of the period.

Proposition iii. Governments act purposefully and as unified entities both to maintain their defence R & D base, and to avoid having to make conscious choices between conflicting alternatives.

The government did not act to maintain the R & D base related to naval anti-submarine aircraft during this period because the programme was dominated by production activities, and this brought in its train extensive development work. In addition, the plentiful supply of R & D finance contained in the rearmament budget enabled projects to move forward on the basis that they would go into production as rapidly as possible, rather than as a means of keeping the design departments of aircraft firms in being.

It is difficult to identify any decisions on the Firefly VII and Gannet projects which were motivated by a desire to maintain Fairey's research and development facilities, though there were a number which were clearly affected by production considerations. A desire to smooth out production and maintain Fairey's production labour force at a stable level appeared to underlay the desire to retain a minimum number of Firefly VII's on order in 1952, and to reduce the Gannet production rate and close one production line in 1954. Fairey seem to have been fully occupied with design and development work on the Firefly VII and Gannet through to 1956, and there was little need to actively seek fresh R & D work in order to sustain their design teams and development staff.

In the case of the Short Seamew, there may be firmer grounds for arguing that the development and production of this aircraft, and the development of the anti-submarine Sturgeon which preceded it, were motivated by a desire to keep Short's naval design and development team in being. Although the Seamew was developed to meet an existing naval requirement, its rationale became increasingly weak when it became relegated to the role of an aircraft to be used by reservists from reserve trade protection carriers in the event of future major conventional maritime warfare. Despite this case, the period contains no convincing evidence to indicate that there was any conscious attempt by any group to maintain the R & D base.

Governmental decision-making behaviour in relation to situations involving choice or conflict has been previously identified as being closely related to the existence or absence of consensus among the various decision-making groups concerned with a particular issue. Several decisions related to the naval anti-submarine aircraft programme were made between 1952 and 1956. The most important of these were the decision not to proceed with the Firefly VII as an operational aircraft: the decisions to reduce the number of Firefly VIIs on order and increase the number of Gannets; the decision to order and subsequently cancel the Seamew; the decisions to develop and produce anti-submarine helicopters and concentrate on them for future airborne anti-submarine operations; the decisions to develop the Gannet AEW 3 and to place a production order for it before the prototype had flown; and the decision not to proceed with the other Series II Gannets.

The decision not to proceed with an operational version of the Firefly VII was taken because of the existence of a major defect which had first been identified at the end of 1950. It took more than a year for this defect to become accepted as sufficiently important to warrant cancellation of the bulk of the order, and conversion of the remaining aircraft to a training role. A major cause of this was the conflict between the acceptance of the standard of pilot's view by the civilian AD/RDN and its rejection by the Navy's test pilots. There were indications that the civilian technical staff at Boscombe Down also regarded the aircraft as acceptable for operational service. The lack of positive action in this case was once again a product of the schism between elements of the governmental apparatus.

The decision to increase the Gannet order following the decision to cancel the Firefly AS Mk VII appeared to be taken rapidly and positively, though once again it was a product of conflicting pressures and interests within the governmental structure. The MoS were anxious to retain as much of the

Firefly VII order as possible and to maximise the Gannet order; the Admiralty wished to minimise its Firefly VII order, though it recognised the industrial logic behind linking the two orders together, while the Treasury was against making any financial commitments beyond the end of the next financial year. Out of these elements emerged a compromise decision, its speed dictated by the agreed necessity to give Fairey positive instructions on what it should do.

The Gannet AEW 3 production decision appears to have met with little sustained opposition from groups within the governmental structure, despite the open-ended commitment that it implied. This may well have been a product of the pressures for a rapid decision imposed indirectly by the United States government, and it is thus difficult to see it as an example of a purposive policy. Two further examples of decision processes which were very protracted due to the different interests and groups involved were the Seamew cancellation and the switch from anti-submarine aircraft to helicopters. It must already have been clear by 1953 that the Seamew lacked a very positive place in the evolving structure of naval equipment, yet the decision to cancel it only occurred by stages, as both the RAF and the Navy were stimulated to consider its future by events such as the disbandment of the reserve air squadrons. Similarly, the decision to switch from anti-submarine aircraft to helicopters appears to have been taken in principle in mid-1954, when suitable helicopters were ordered, yet it was a further two years before work associated with the anti-submarine version of the

Series II Gannet was terminated. Both of these events indicate that where a positive stimulus was lacking, or where bringing the issue to a decision might have risked internal governmental conflict, the tendency was to pursue no single policy line. This period appears to indicate that there was a positive tendency not to seek a rapid resolution of possibly contentious issues unless external circumstances were pressing. The search for unity, or at least the avoidance of conflict, thus produced a lack of policy and purpose.

Proposition iv. The weapon acquisition process is conducted solely through closed politics, and public debate and discussion exercises no influence over it.

The period 1952-1956 was notable for the way much greater public discussion and debate took place over defence in general, and the naval anti-submarine aircraft programme in particular, than at any other period since 1945. A large number of aspects of the Navy's aircraft and aircraft carrier programmes were subjected to detailed scrutiny by House of Commons Committees. The Comptroller and Auditor General brought both the ASV 15 and Firefly VII cancellations to the attention of the Public Accounts Committee, but the members of this committee appeared loath to criticise the activities of the Ministries involved. The Comptroller did make certain civil servants aware that nugatory expenditure on a project might lead to public scrutiny of their past activities and decision, but the only evidence of it having any direct impact upon their behaviour was the demand from Sir John Lang that the MoS should provide the Admiralty with a written guarantee that the Gannet would be an acceptable operational aircraft.

The Estimates Committee discussed the supply of naval aircraft early in 1952 following a visit to HMS Eagle. In the course of this visit a number of naval officers appear to have voiced criticism of the Admiralty's naval aircraft production programme and advocated the termination of work on the Firefly VII in order to accelerate production of the Gannet. The Committee's major concern during the ensuing hearings was to try to establish how the naval aircraft procurement process operated and where it could be improved. No sustained attempt was made to examine the appropriateness of the existing programme. In 1956, when the Committee received evidence on the problems surrounding the supply of military aircraft, it accepted unquestioningly the incorrect explanation that was offered for expenditure on the anti-submarine version of the Sturgeon.

Neither of these Parliamentary Committees was able to question the witnesses they examined very effectively because they lacked alternative sources of information and informed assistance. They had no direct access to relevant documentary material: they did not call in outside experts; and they made no attempt to question industrialists about specific projects. In consequence, their questioning of witnesses tended to be extensive rather than intensive, and their recommendations and criticisms rather timid.

Naval anti-submarine aircraft and carrier policy were openly discussed in the course of three further types of parliamentary activity. The first was Parliamentary Questions. These fell into two main categories: the occasions upon which a member asked a question in order to allow the government to publicise selected items of information, and the occasions upon which members had obtained information from private sources, and either wished to have it officially confirmed or to use it to criticise or embarrass the government. Two points emerge from these Parliamentary Questions. First, informed parliamentary discussion of naval equipment policy reached a peak immediately after the Labour Party's defeat in the October 1951 election, and then slowly declined as the Labour ex-ministers' knowledge of contemporary naval policy issues became obsolete. Secondly, the majority of the Parliamentary Questions were asked by two backbench MPs. They had taken a detailed interest in naval equipment matters, and seemed to have access to sources of information both within the Navy and in the aircraft industry.

A second type of parliamentary activity was the production of the annual White Papers on Defence and the Navy Estimates, which formed the basis for debates on these issues in both Houses of Parliament. These documents contained little positive information on the Navy's anti-submarine aircraft programme, but they did contain details of changes in government priorities within the defence area, such as the change from a defensive, general war to an offensive, limited and nuclear war role for the Navy's Fleet carrier force.

The debates in both Houses of Parliament on these documents were often highly informative. There were a number of reasons for this. One was that they provided a forum within which it was possible to publically discuss the internal disagreements that existed between the services over defence policy. This applied particularly to debates in the House of Lords, which contained a number of recently retired senior officers of all three services. A second element was that both Opposition speakers and backbench MPs could use the Commons' debates to publicise information they had obtained through unofficial channels, and try to force a government speaker either to refute or tacitly confirm it in the course of his winding up speech. This technique was instrumental in allowing information on the Seamew cancellation to be divulged, though the Firefly VII cancellation passed without comment. It also allowed a limited public scrutiny of the Gannet project to be carried out between 1952 and 1955.

It seems valid to draw three conclusions from these Parliamentary activities. One is that although they publicised the naval anti-submarine programme to a much greater extent than had occurred before 1951, there is no direct evidence to suggest that they acted as inputs into its decision-making process, or in any way influenced or affected governmental decisions. The second is that although House of Commons Committees made attempts to investigate the most glaring examples of nugatory expenditure, they had little option but to accept the MoS or Admiralty's version of events, as they had no access either to official documentation or independent sources of information. It is noteworthy that on occasions these versions of events were grossly inaccurate and misleading. Whether this was a product of the quality of the briefing given to Committee witnesses or a conscious attempt to cover up administrative and managerial deficiencies within the Ministries concerned, is unclear. Finally, only a very few items of equipment from among the total being produced under commercial contract were subject to scrutiny. Those items being developed by government establishments appeared to escape investigation altogether, probably because expenditure on them could be 'buried' within their non-functional budgets and accounts.

Although considerable public attention was focused upon the naval anti-submarine programme during this period, it appeared to have no direct effect upon policy or policy making. This was largely a result of the lack of authoritative information possessed by those parliamentarians in a position to raise issues of maladministration, though there may also have been a feeling that to raise such issues was unpatriotic during a period of acute international political tension. The net effect was that despite appearances, the naval anti-submarine aircraft programme remained effectively within the domain of closed politics.

Proposition v. The weapon procurement process is dominated by civilian direction, and industrial and service views or problems have no influence upon it.

Little evidence is available from this period to suggest that industrial views or actions had any influence upon the weapon procurement process for naval anti-submarine aircraft.

On two occasions a major disagreement arose between Fairey and the government over policy towards this type of aircraft. The first was in early 1952, when the Admiralty decided that they would not use the Firefly VII as an operational aircraft. Fairey had to accept this decision despite their trenchant denunciation of the nominal reasons for it. The second disagreement occurred in February 1957, when it was decided to reduce the Gannet order by 25 aircraft. This brought sustained protests from Fairey who urged the Admiralty to reinstate the order. Again, these protests had little apparent impact upon the Admiralty, who refused to alter their decision. A further minor disagreement was over the Admiralty's decision in October 1954 to ask for a reduction in the rate of Gannet production to 8 aircraft per month. Again, this governmental decision was implemented despite Fairey's protests.

Although the available evidence points to total governmental control over the weapon procurement process, there were a number of areas where an industrial firm was able to exercise considerable influence over a decision. Fairey's insistence that the reduction in Firefly VII orders should be accompanied by an increased order for the Gannet precipitated the discussions between the MoS, Admiralty and Treasury which led directly to the decision to substantially increase the size of the order. In addition, the MoS was almost totally dependent upon Fairey's estimates of the time and expenditure required to bring an aircraft to production status, and these estimates were often very optimistic. In other cases programme slippages were due to faults in equipment being developed under direct governmental contact. The problems with the Firefly VII and Gannet propellers, and the Gannet engine fall into this category. The MoS found it very difficult in practice to monitor and control the development and production of such naval aircraft, and because of this, industrial firms acquired considerable influence over the physical outcome of projects, even though their ability to shape policy was virtually non-existent.

The relationship between the civilians in the MoS and naval officers continued to be dominated by the latter's position as customer. It was naval officers who initiated the cancellation of the Firefly VII, despite a prior decision by an MoS official that the characteristic they found unacceptable was acceptable. It was a naval trials squadron which uncovered the Gannet stalling problem in late 1954, and led the MoS to pressurise Armstrong Siddeley to modify the engine in order to correct it. It was a naval officer who insisted that proof should be obtained that the ASMD3 engine had a superior performance to the ASMD1 before the former was substituted for the latter on the production line. In one area, civilians who were not MoS officials did prove to be dominant. In 1952 when the subject of increasing the Gannet order was discussed, the Admiralty found that they could not implement the order they and the MoS had agreed upon because of Treasury opposition. They could dominate the MoS over a reduced Firefly VII order, but not the Treasury over the Gannet.

This period thus provides slightly contradictory evidence on the relationship between civilians and serving officers. If the civilians were in the MoS, the serving officers possessed dominance over them: if they were in the Treasury, the situation was reversed.

Proposition vi. Governments do not act as unified entities when taking decisions on defence projects because of the conflicting interests and expertise of the bureaucratic organisations involved. This creates a lack of positive direction and control over projects.

In the discussion on proposition iii it was established that two types of decision making occurred during this period. One involved a conflict between two or more bureaucratic organisations: a good example of this was the Firefly VII cancellation decision and the subsequent discussions on the number of Firefly VII's to retain on order. The second was precipitated by outside pressures, which in themselves brought forth a fairly uniform response from the bureaucratic organisations involved: the Gannet AEW 3 production decision was a good example of this, as was the general consensus in early 1952 that the Gannet order should be increased, though there was disagreement over the exact figure. These examples suggest that while the general proposition is true, and while there existed a general tendency to let issues such as the Seamew project and Mark II Gannets drift along until a positive stimulus occurred to bring them to a decision, there exists a further dimension to this proposition which has not yet been explored. This is the idea that when confronted by certain externally imposed situations, bureaucratic organisations will be compelled to generate uniform responses, and thus appear to be acting as unified entities.[1]

Proposition vii. Certain individuals may, through their personal or organisational position, determine whether a defence project is sustained or cancelled.

No evidence has been presented of the role played by individuals in the projects under study during this period, but it does demonstrate the way in which an individual's views or decisions may prove difficult to sustain when faced with pressures from groups within other bureaucratic organisations. Thus AD/RDN's decision to accept the Firefly VII's pilot's view was overturned early in 1952 by the attitudes and pressure of the naval test pilots at Boscombe Down.

Proposition viii. Time is the most flexible variable in the weapon procurement process, followed by cost and quality.

This hypothesis is supported by the events of this period. The Firefly VII cancellation decision represented a judgment that the aircraft did not conform to the required quality standards. Similarly, the development history of the Gannet AEW 3 reveals a desire to meet the specifications, irrespective of time and cost targets. The only exception to this was that the endurance requirement had to be reduced at one point in

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1. This idea is similar to one explored in detail by Arnold Wolfers in the context of International Relations, see his Discord and Collaboration, Johns Hopkins Press, 1962 pp. 13 and 14.

order to prevent the aircraft exceeding its specified maximum weight. Attitudes towards cost were dominated by a tendency to develop aircraft on the basis of a rough estimate and then cost and pay for them afterwards. It was only when decisions had to be taken in the early 1960s on the production of additional AEW 3 aircraft that cost started to dominate the production programme, and numbers to be purchased were derived from the money available. Pressure to move both the AS Mk 1 and AEW 3 Gannets and the Firefly VII into production and operational service as soon as possible led to a positive response from Fairey, but the firm's inability to meet the specified time schedules indicates that time was the most flexible of the three variables mentioned in the hypothesis. This proposition is thus supported by the evidence from this period.

Proposition ix. A weapon project comprises the following sequential phases:

e. Production development.

f. Production orders.

g. Military service.

It was pointed out in Chapter 7 that production orders for both the Firefly VII and Gannet AS Mk 1 were placed before production development had commenced and a similar sequence of events occurred with the Gannet AEW 3. In the case of the Firefly VII this had important repercussions, for when it was realised that development work on the production standard aircraft was unlikely to significantly improve their handling qualities, the existence of the large production order compelled the Admiralty to seek an alternative use for it. The history of the Firefly VII thus suggests two possible alternatives to a simple progression from production development to military service. One is production development being unsuccessful and being followed by a decision to cancel production orders. The second is that production development will result in an aircraft judged unsuitable for operational purposes, but suitable for conversion to alternative uses.

The Firefly VII and the Gannet AS Mk 1 were also examples of aircraft projects where the initial production order was increased before any positive results had been obtained from the production development programme. This was inherent in a situation where production planning was a lengthy process lasting between two and three years, and the first production standard aircraft were to be produced on the main production line.

A distinction can also be made in the Gannet development programme between Fairey's production development work, and the work of the operational trials squadron at Ford, which was intended to assess the aircraft's performance under operational conditions. Limitations in the engine control system uncovered during these trials could not have been easily discovered in the course of test flying, and had to be corrected by further production development work. Moreover, the entry of the Gannet into operational service did not terminate development work, for two further engine problems were encountered in operational service. One was the need for a more powerful engine to allow single engined flight under tropical conditions. This was obtained through the ASMD3 engine development programme. The second was the problem of cockpit vibrations. A partial solution was eventually found to this, though the aircraft was going out of operational service by then. Development work during operational service was thus an important component of this weapon project.

A further element in the development history of the Gannet was the attempt to exploit the basic aircraft in a number of different roles. This had first manifested itself during 1950 in the attempts by Blackburn to offer AEW and Coastal Command versions of their GR17/45 aircraft to the MoS, and by project studies of AEW and long range cannon-armed versions of the Fairey GR17/45 prototype. This was followed in 1951 by the Gannet T2, and by 1954 both Target Towing and Series II versions of the aircraft had been proposed, the latter consisted of three variants for anti-submarine, anti-shipping strike and AEW duties, all powered by a larger engine than that fitted to the initial variant. Only the AEW version was eventually produced. This process culminated in the early 1960s in a requirement for a modified AS Mk 1 capable of acting as a small deck-landing transport aircraft. Such a process of horizontal development is probably inevitable, given the savings it appears to offer over designing an aircraft to undertake relatively low priority tasks.

The Gannet AS Mk 1 project also demonstrates that a military aircraft may have a very short service life if it is no longer regarded as relevant to the military problems of the day. It was becoming clear by the mid-1950s that both a large fleet of trade protection carriers and a Fleet carrier force could not be sustained on the Navy's existing and projected budget. The Admiralty decided to concentrate its resources on the Fleet carrier force and abandon the attempt to maintain a specialised trade protection force. In parallel, the threat from submarines able to stay submerged for lengthy periods of time was perceived to have replaced the threat from the submarine which stayed on the surface for much of the time in order to exploit its greater surface speed. The Gannet AS Mk 1 was relevant to operations against the latter craft, but had very limited capabilities when confronted with the former, whereas helicopters equipped with dunking or dipping sonar could deal with both threats. In addition, the latter's limited size and vertical take-off and landing ability would enable them to be dispersed among a large number of naval vessels. In consequence, the Gannet had a remarkably short operational life, and by 1958 was already being replaced by helicopters in the Navy's anti-submarine aircraft squadrons.

This case study thus suggests that the final phase of weapons procurement is a rather more complex process than is suggested by the existing proposition. Six possible stages have been identified. They are:

(a) Production order.

(b) Production development.

(c) Either i Cancellation due to failure to meet requirements.

ii Conversion to other roles.

iii Successful completion of production prototype trials.

(d) Operational trials.

(e) Operational service.

(f) Retirement from operational service on the grounds of

i. length of service, technical obsolescence or increased costs.

ii. changes in strategic or tactical requirements.

In addition, at any point in this process work can start on the development of new variants of the basic design. These may take the form of either improved versions of the initial design, or versions intended to be used in new roles.

Conclusions

The naval anti-submarine aircraft programme was dominated by three major factors as the post-Korean rearmament programme unfolded. The first was the technical failure of the Firefly VII programme, and the numerous development problems experienced by the Gannet, which centred around the power-plant and were responsible for the original MoS target dates for entry into service slipping by over a year. The second factor was the gradual evolution of naval carrier policy, in response to both the internal and external political climate. The initial need to justify the Fleet carrier in terms of its potential convoy escort and anti-submarine role produced a situation of perceived interdependence between the continued existence of the carriers and the continued development and production of the Gannet. By 1954 a much broader based argument for the retention of Fleet carriers was emerging. This gave equal prominence to the potential airborne, surface ship and submarine threat posed by the USSR to British shipping. A more positive role was then proposed for the large Fleet carriers as offensive platforms in both local and nuclear war, with the smaller carriers being initially allocated to trade protection duties, but then converted into assault helicopter carriers. These extensive functions of the carrier fleet appeared initially to offer increased scope for the Gannet and led to the design of both AEW and anti-ship guided weapon versions of it, but a third technical development soon negated most of these possibilities. This was the change in the nature of submarine technology and operations from a mixture of surface and submerged activity to dominance by the latter mode. These environmental changes meant that anti-submarine aircraft had to be primarily capable of performing underwater search activities and that a wide ranging radar and visual search capability was of secondary importance. Heliborne sonar equipment was much more effective than air-dropped sonobuoys in this new primary role and had the additional advantage of not requiring a large flight deck and catapults to operate the parent aircraft. The convergence of these three elements during 1955/56 led to the Gannet being rapidly replaced as the Navy's prime airborne anti-submarine aircraft by anti-submarine helicopters.

CHAPTER 10

SUMMARY AND CONCLUSIONS.

Introduction.

The procedure used in this study has been to confront the conventional wisdom on weapon procurement with a detailed case study of a specific British military equipment programme. In order to do this economically, a rather mechanistic system of analysis was adapted, centred around nine propositions synthesised from the weapon procurement literature. The initial part of this chapter will seek to summarise the results of this analysis, and the latter part to examine certain of their wider implications.

Proposition i. Uncertainty is inherent in weapon procurement projects, but the types of uncertainty involved are directly related to the stage that has been reached in the evolution of the project.

The outstanding characteristic of the naval anti-submarine aircraft programme between 1945 and 1956 proved to be the lack of consensus on what type of aircraft was needed to perform the anti-submarine task. Target uncertainty appears to have been present throughout these eleven years in different forms, with the exception of the period immediately preceding and following the decision to order the Fairey GR17/45 into production, when attention was fixed on the respective flying qualities of the prototype aircraft, rather than the wider issue of whether they were the right type of aircraft to perform the anti-submarine role. Two major sources of this target uncertainty can be identified. One was the lack of any clear idea of the type of aircraft carrier the anti-submarine aircraft would eventually be required to operate from, which in turn threw doubt upon the relevance of certain of the detailed specifications of the aircraft, such as its maximum height, engine power, take-off run, take-off and landing weights, equipment and weapon loads and endurance. Differing assumptions on the characteristics of the parent aircraft carrier led to markedly different conceptions of the optimal anti-submarine aircraft.

A second source of target uncertainty was the lack of consensus on the concept of operations of a naval anti-submarine aircraft. The wartime legacy had been one of aircraft using radar to detect and attack surfaced U-boats, often at night or in bad visibility. The termination of hostilities revealed that Germany had developed new types of U-boat capable of high underwater speed both with and without the use of a schnorkel, and it had to be assumed that other countries would soon build on this experience. Consequently, there occurred a slow evolution in ideas of the desirable balance between the surface and underwater detection capabilities of anti-submarine aircraft. The initial differences of concept were between those who believed the aircraft should be primarily a weapon carrier, and those who thought it should be a fully equipped, self-contained anti-submarine system. The logic of the first position was that the submarine would be detected by a surface ship escort's radar or sonar equipment, and the aircraft would be guided to a position for attack. It could then identify the correct position to drop its weapons either visually or by the use of sonobuoys,[1] and would thus require neither a radar set nor its operator. The logic of the second position rested heavily upon wartime experience, where most attacks on submarines by naval aircraft had been the product of radar detection some distance from convoys. Aircraft were believed to have performed a very valuable preventative role by forcing submarines to submerge, which served to neutralise them because of the limited speed and underwater detection capabilities possessed by the wartime U-boats. It became clear in 1948, when the revised requirement for the GR17/45 was issued, together with the new requirements for the anti-submarine Sturgeon and the three-seat Firefly V, that the second school of thought had become dominant. It was only to remain so for some three to four years, for from 1953 onwards perceptions of the submarine threat focused primarily upon submerged attacks, against which the emphasis on radar and visual detection, which had manifested itself in 1948, was irrelevant. The airborne anti-submarine aircraft best able to combat this new threat was the sonar equipped helicopter, though it would take

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1. It is interesting to note that a very similar concept to this was developed from the late 1950's onwards using helicopters for weapon delivery. Most British frigates are now equipped with a Wasp helicopter to perform this task under guidance from their parent vessel's sonar equipment.

a number of years before helicopter technology could be developed to the point at which its inherent capabilities in this role could be fully utilised. In the interim, it became accepted that the Gannet type of anti-submarine aircraft was not the best type of surface search and reconnaissance aircraft available, this role being taken over by AN/APS20 radar equipped aircraft, initially the Skyraider and later the Gannet AEW 3.

Other forms of uncertainty were present during this eleven year period, yet none was as all pervasive and prevalent as those which questioned whether the GR17/45/Gannet type aircraft was the optimal equipment for the role. It was unclear whether sufficient money would be available to re-equip the Royal Navy with GR17/45 aircraft until the British rearmament budget was drawn up in 1950. Financial limitations appear to have both delayed the start of GR17/45 development in 1945/46, and the building of a three seat Fairey prototype in 1948/49, and may have influenced the decision not to build a fully representative Firefly VII prototype. They also underlay the Navy's equivocation in 1949/50 between a Griffon or Mamba engined GR17/45 production aircraft. After June 1950 these uncertainties and their effects disappeared.

Technical uncertainty persisted throughout the period, though since a development process involves the slow elimination of this type of uncertainty, it was clearly of greater significance at certain points in time than at others. In particular, it was unclear until late 1949 whether the paper calculations of the performance of the GR17/45 prototypes would be realised in practice, and the GR17/45 production decision appears to have been heavily influenced by the uncertainties surrounding the redesigned Blackburn wing. The history of the Firefly VII from mid 1950 through to early 1952 centred upon the uncertainty over whether the aircraft could be modified to gain acceptance by naval test pilots. Technical uncertainty will always be present in any development process and it must be appreciated that all of the production decisions taken during this period signalled the start of a new production development process, rather than the end of development activities. Even after the aircraft had entered service, additional development work was necessary to cure faults uncovered by service use.

One final type of uncertainty inherent in this programme was the ability of designers, development engineers and managers to produce an aircraft capable of meeting the specifications, and the degree to which decisions on it would be a result of individual and group attitudes and conflicts within the bureaucracy. The impact of these elements appeared to be most marked during the prototype development phase, but its effect was to make the substance and criteria of any decision unpredictable.

The conclusion that must emerge from this summary is that target uncertainty was inherent in the whole of this weapon programme, though it faded into the background somewhat while the production decision was being taken. Technical uncertainty was all pervasive, mainly because there was no termination of development work throughout this period. Financial uncertainty was largely removed after 1950 as a consequence of the rearmament decision, though this was totally independent of the stage the anti-submarine aircraft projects had reached. Finally, the production decision removed uncertainties over whether suitable prototypes could be developed by individuals within the competing firms, and over the type of factors which would influence those who decided which projects would be cancelled and which would move into production.

Proposition ii. External factors dominate a weapon project at certain key points, specifically decisions on inception, production and cancellation. At other times the process operates autonomously.

This proposition raises an initial problem of the boundary between a weapon project and its external environment. Two alternative boundary lines seem feasible: that between those directly concerned with a project and both their parent organisations and the outside world, and that between what could be called loosely the military-industrial complex and the outside world. In the former case, disputes within the Admiralty and between the MoS and the Admiralty would form part of the environment of the project: in the latter they would be classified as part of the project itself.

The post-war naval anti-submarine aircraft programme originated in the Directorate of Air Warfare in the Admiralty, largely on the basis that the existing aircraft performing this function were obsolete, and a replacement was needed. The stimulus for the inception of the GR17/45 project thus came from within the Admiralty organisation. The later desire to replace the Skyraider AEW aircraft with a Gannet AEW aircraft originated within the Admiralty on the basis of a similar replacement argument. The inception of the other anti-submarine aircraft projects was heavily influenced by factors external to both the existing programme and the military/industrial organisations involved. The anti-submarine Sturgeon and Firefly VII were both a product of the Navy's search for an interim anti-submarine aircraft, which was itself a response to the deterioration in the international political environment following the 1948 Berlin Blockade. Finally, two projects appear to have been influenced by a mixture of internal and external factors. One was the Seamew, which was on the one hand a product of internal pressures to fill the gap left by the weight escalation of the GR17/45 projects, and on the other could only be started because of the re-armament budget. The second was the Mark II anti-submarine and anti-shipping Gannet, which was partly a replacement project for the Gannet AS Mk I, and partly a response to a perceived threat from the Russian Sverdlov class cruisers. The evidence on inception is thus rather inconclusive.

Production decisions follow a similar pattern. The initial Firefly VII decision seems to have been a purely internal administrative one, in which the Mark VII would replace the Mark VI on the production line as soon as the production design had been finalised. The increased production orders for the aircraft from late 1950 onwards were clearly a product of the decision that Britain would rearm as rapidly as possible, and this in turn was a product of external stimuli. The GR17/45 production decision contained a mixture of internal and external elements. The internal element was that the prototype development programme had reached a stage where it was doubtful if further testing was going to alter appreciably the evaluations of the competing designs. The stage had thus been reached where a production decision was required to continue the normal evolution of the project. The difficulty was that up to mid-1950 the money available for production was very limited and, extrapolating from the Firefly VII budget, might only have been sufficient to purchase 10-20 Mamba powered aircraft per year. This not only led to serious consideration being given to the production of a cheaper, piston engined version, it also raised the possibility that no production order would be placed for the aircraft at all. Once again, the rearmament budget radically altered this situation by providing sufficient money to plan an extensive production programme and purchase a Mamba powered aircraft. This external stimulus proved to be a major factor in the actual production decision.

Two further examples of external factors dominating production decisions are provided by the decision to increase the Gannet production order in 1952 and the production order for the Gannet AEW 3 in 1955. The latterwas a very straightforward example, as the conditions imposed by the United States government upon the transfer of the AN/APS 20 radar sets made it essential to take a production decision much in advance of the point where it would normally have been made. The increase in the Gannet AS Mk I production order was a product of activities by Fairey, the Admiralty, the MoS and the Treasury. If all these elements are regarded as outside the weapon project, then this decision was externally dominated. If they are all regarded as part of the military/industrial complex, it could be regarded as internally dominated. Given the actual circumstances surrounding the decision, it seems appropriate to regard it as a predominantly internal activity, in which issues such as the desire to retain industrial capacity inherent in the idea of a military/industrial complex played a major role, but one which was ultimately dominated by the external intervention of the Treasury.

Four cancellation decisions occurred during this period. Two, the Blackburn GR17/45 and Firefly VII, were intimately related to production decisions discussed above. Both were a product of internal factors, in that in the former case a competitive prototype situation implied that a choice should be made between the two designs, resulting in one being cancelled, while in the latter one the aircraft was judged not to have met its technical requirements. The cancellation of the Seamew and curtailment of the Gannet anti-submarine orders in 1957 appear to have been stimulated by a number of external elements, particularly changes in national strategic and military doctrines, though little direct evidence is available to support this proposition.

The question that remains is whether there were other occasions at which external factors dominated these projects. The answer must be negative. Development processes following inception were autonomous, as were those following production decisions. Production rates were subject to a great deal of planning activity, and some Admiralty intervention to try to ensure continuity of work for Fairey, yet actual production deliveries were determined by elements within the production process, and often bore little relationship to the planned output rates.

This proposition is thus neither validated nor falsified by the events recounted in the study. Both internal and external factors dominated specific decisions, though external intervention was limited to the decisions specified.

Proposition iii. Governments act purposefully and as unified entities both to maintain their defence R & D base, and to avoid having to make conscious choices between conflicting alternatives.

This proposition is linked to the previous one by the argument that national arms procurement is an internally stimulated self-sustaining process, which leads to governments consciously providing work for arms producing companies and government arsenals, even if there exists no pressing military need for the resultant weapons.[1] It implies that governments do act as unified entities, and that those entities have well articulated preferences and policies. The general conclusion that arises

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1. One of the more explicit versions of this thesis is found in Mary Kaldor's European Defence Industries - National and International Implications, IS10 Monograph No. 8, University of Sussex, 1972.

from this study is that the lack of coherence and unity among the bureaucratic organisations concerned with weapon procurement meant that no purposeful policy was possible, and moreover decisions, or their absence, were often heavily influenced by a desire to prevent conflict between those organisations and maintain some form of bureaucratic consensus.

At the end of the Second World War, there did exist a detailed plan for maintaining a British R & D base in the aerospace field. It had been drawn up within the MoS, and consisted of a three year programme of new projects, and their division among those firms whose expertise it had been decided to sustain. It was assumed that in the absence of government orders the rest would either close down or transfer to non-aviation work. A system of competitive tender existed in theory, but in practice a first choice and reserve design firm had been allocated to each project in the aircraft programme by the MoS in advance of the submission of design studies, the criteria used to make these allocations being the design and development performance of aircraft firms during the wartime period. It was hoped that this procedure would allow a minimum number of 'essential' design teams to be sustained during the immediate postwar years and that it would offset the anticipated lack of government production work in the immediate post-war years. These allocations seem to have been based more on absolute judgments of a firm's intrinsic value than any detailed study of the minimum viable size of the British aerospace industry.

This system of prior nomination underlay the majority of aircraft design and development contracts awarded between 1945 and 1948. The judgments inherent in it were those of only a small group of policymakers within the MoS, and other MoS officials and those naval officers concerned with aircraft procurement were often not in agreement with them. The major difficulties experienced in implementing the negative aspects of the policy were that some sections of the aircraft industry obtained substantial export orders in the immediate post-war years and so were able to sustain themselves with minimal governmental assistance; that the financial consequences of providing non-nominated firms with project work was minimal at first; and that those officials and officers who disagreed with the original categorisation made every effort to ensure that work was provided for the firms they thought were valuable. Fairey and Short had both been placed in the category of firms to be sustained, but Blackburn had been excluded from it. The two former firms had consequently been listed as first choice design firms for a number of projects, whereas Blackburn had only been nominated as a reserve design team. Blackburn benefitted from a number of ad hoc attempts to prevent them having to leave the industry, starting with the decision taken in late 1945 to allocate to them alone a design contract for the GR17/45 project, following their failure to obtain a contract for the Universal Freighter project.

The very positive basis of this policy became overlaid with ad hoc adjustments from 1945 onwards as a result of pressures from individuals and groups concerned with aircraft procurement. Fairey entered the GR17/45 design competition and was awarded a prototype contract through a mixture of their own entrepreneurial actions and possible covert naval encouragement. The decisions to allow Blackburn to install Griffon engines in two of their prototype aircraft also seems to have been associated with a conscious desire to give the Blackburn design team every opportunity to sustain themselves. Extensive attempts were also made to provide work for the Fairey design teams, and these included allocating the naval night fighter project to them. The MoS felt by the second half of 1949 that there was no longer sufficient money available to continue sustaining all the existing design teams in a piecemeal fashion, and that a choice would have to be made between those firms which were to be provided with new work, and those which were to be given no further assistance. The Admiralty voiced a clear preference for retaining Fairey and Short in preference to Blackburn, and the latter was given no new design work. This action made certain Ministry officials and serving officers even more determined to give Blackburn every opportunity to obtain a production order for their GR17/45 design and thus allow them to survive. Fairey were the object of similar partisan activities in the early part of 1950, when a Griffon-engined version of the GR17/45 appeared to be favoured by the Navy, and the MoS insisted that Fairey should be allowed to build a version of their design with a similar engine before any production decision was taken.

These concerns ceased to be of importance once the rearmament programme started in the latter part of 1950. The concern then became one of expanding production capacity, and the new production programmes, together with the new project work it was now possible to finance, kept the industry's design teams fully occupied for the next few years. One new consideration that appeared was the regulation of production orders in order to obtain a smooth expansion of production, and the decisions on the Firefly VII and Gannet orders in early 1952 were heavily influenced by this factor. The decision to reduce the production rate of the Gannet in 1954 was dictated by similar industrial considerations, though in this case the objective was to adjust Fairey's production capacity to a level which could be sustained into the indefinite future.

These events suggest that although a policy to maintain a minimum R and D base had been drawn up in 1945, it soon became submerged by *ad hoc* decisions based on the evaluations and views of other groups and individuals involved in military aircraft procurement. By 1949, financial stringencies dictated that the existing spread of aircraft projects could no longer be maintained and a decision was taken to sustain some firms and not others, but this was overtaken by the rearmament programme before it became effective. It is thus difficult to characterise these activities as a purposive policy.

A similar apparent purposefulness, which masked the bureaucratic disagreements which underlay it, can be seen in the way the major decisions on the anti-submarine aircraft programme were generated. These decisions can be divided into three categories: those where a decision to adopt a specific course of action was taken rapidly; those where a decision was postponed in favour of a search for more data; and those where only one course of action was discussed and implemented. The majority of decisions taken during the 1945-46 period fell into the latter category, including the decisions to award GR17/45 design study contracts to both Blackburn and Fairey. The decision to finance the production of prototypes of both Blackburn's and Fairey's designs was taken because of the major differences between the two design concepts, and the perceived difficulty of making a correct decision at that point. A choice was postponed until additional information could be obtained about the flight performance of the two designs, although no deadline was set for such a decision. The partisan attitudes of certain of the participants in the relevant committee discussion meant that any choice in 1946 would probably have generated acute intra-organisational conflict. This early period also saw the unquestioning acceptance of a number of technical specifications for the aircraft, including the undercarriage configuration, the radar and the engines.

A number of very rapid decisions, which facilitated the continuation of the existing GR17/45 prototype programme, occurred during the period 1947-49. These involved a choice between an incremental change in the existing programme and the cancellation or complete reorientation of part of it. The introduction of innovations, such as the fitting of a completely new gas turbine engine to the Blackburn aircraft or the initiation of the M7/49 and Firefly VII production programmes, produced a tendency to delay a decision. This stemmed partly from the need to obtain financial sanction for new expenditure, but was also a product of a lack of internal consensus within the relevant committee or committees on the correct action to take.

The tendency to delay any choice which was likely to produce disharmony within the bureaucracy was also present in 1950 and 1951 when discussions were being held on which design to specify for GR17/45 production. The basic cause of delay was the large number of cross-cutting issues subsumed in the decision, and the potential for intra-organisation conflict that they produced. A decision was postponed until the continuing technical trials of the aircraft led to a report being produced which unambiguously favoured one of the prototypes on technical grounds. This clear technical recommendation served to create organisational consensus around the production decision.

Two further examples of rapid decision taking, and two of delayed decisions occurred between 1952 and 1956. The two rapid decisions were to increase the numbers of Gannets on order in 1952, and to order the Gannet AEW aircraft in 1955. A sense of urgency dominated these decisions. In the first case, it was believed necessary to announce the increased Gannet order in parallel with the Firefly VII cancellation decision, and in the second a firm order had been made a condition for acquiring the radar equipment needed for the aircraft. In the other two cases of delayed decisions, that of the Seamew cancellation and the change from fixed wing to helicopter anti-submarine aircraft, the options and their consequences were initially ill-defined and, in consequence, work continued on existing projects until they clearly became incompatible with contemporary military concepts. In the first case this was precipitated by the dissolution of the reserve units who were to use the aircraft; in the second by the decision to order large numbers of anti-submarine helicopters.

Organisational behaviour in relation to the naval anti-submarine aircraft programme thus serves to partially falsify this proposition. Rapid and purposeful decisions were sometimes taken, but only where the circumstances surrounding the decision led to perceptions that only one 'obvious' course of action was worth considering, and no linkage was made to possible future decisions or other issues. This environment imposed a consensus upon the bureaucratic groups involved. Where alternative courses of action were perceived to exist, and were actively advocated by different groups or individuals within the bureaucracy, rapid decision-taking proved impossible. Decisions tended to be delayed until a consensus could be generated, usually on the basis of additional information. In particular, a conclusive technical recommendation, however narrow its base, appeared to serve as a means to terminate opposition to a course of action.

Proposition iv. The weapon acquisition process is conducted solely through closed politics, and public debate and discussion exercises no influence over it.

The history of the naval anti-submarine aircraft programme between 1945 and 1956 indicated that discussion of it took place at three differing levels: at working level between those officials and serving officers very closely connected with it; at Admiralty Board level, and in the Parliamentary and public domain. In 1945 and 1946, discussions on the GR17/45 project appear to have taken place solely at working level. In 1948, the worsening international situation led the Admiralty Board to review their anti-submarine capabilities, and search for an interim anti-submarine aircraft. In parallel, the Board had been seeking the approval of the Chiefs of Staff Committee to retain and modernise its fleet of large armoured aircraft carriers, and one argument being deployed in favour of this was that even in unmodernised form they had a value as rapidly mobilisable bases for anti-submarine aircraft. This made it doubly imperative for the Board to ensure that specialised anti-submarine aircraft were available to operate from them, and that the GR17/45 designs would be able to operate from all the Navy's existing carriers. Although the Navy's aircraft carrier and anti-submarine aircraft programmes became an object of discussion at the highest levels within the Admiralty and Ministry of Defence during 1948, neither was mentioned in any Parliamentary or public forum. The Admiralty Board formally made the production decision on the GR17/45, and the cancellation decision on the Firefly VII, but in practice they were dependent on the advice tendered by those working level officials who were closely concerned with these programmes.

No public debate or discussion on the Navy's anti-submarine aircraft programme occurred before October 1951, when the defeat of the incumbent Labour administration considerably modified this situation. For the first time since 1945, Opposition M.P's had a very detailed knowledge of existing military equipment programmes. This manifested itself from 1952 onwards in a marked increase in parliamentary discussion and debate on the details of the Navy's anti-submarine aircraft programme, although there is no evidence to suggest that this had any direct impact upon decisions taken within the Admiralty and MoS. The only exception to this is possibly the Admiralty's insistence on a written guarantee from the MoS in 1952 that the Gannet would be suitable for operational service, which presumably was intended to absolve them from parliamentary criticism should it prove not to be so. The activities of both the Public Accounts and Estimates Committees of the House of Commons may have placed serving officers and officials in an embarrassing and difficult position on occasions, but they tended to lack the depth of understanding and alternative sources of information and advice that would have made them really effective. In addition, either consciously or mistakenly, information was at times presented to Parliament which was either misleading or factually incorrect and no facilities were available to check its accuracy. It should be recognised that the apparent disinclination of the Public Account Committee to investigate cases of nugatory expenditure vigorously may have been related to the international environment of the time, and a bipartisan feeling that publicising the country's failure to equip itself with certain types of military equipment was not in the national interest.

Some specific decisions were raised in Parliamentary Debates and Questions, but the substance of these interchanges tended to be uninformed, and their impact negligible. As a result all the effective discussions on the programme took place within the Ministries concerned, thus confirming the proposition. It is of interest to note that the majority of the decisions were taken at working level rather than at Board, Chiefs of Staff or Ministerial level, and that those taken at the higher levels tended to reflect the advice and information provided from below.

Proposition v. The weapon procurement process is dominated by civilian direction, and industrial and service views or problems have no influence upon it.

The general conclusion that can be drawn from the case study is that this proposition is incorrect. The dominant role in the anti-submarine aircraft programme was played by the Navy as the customer for the equipment being procured; the MoS and the commercial firms involved could pursue their own interests and views as vigorously as they wished, but would only be successful if the Navy could be persuaded to act in a manner favourable to them. This is underlined by a closer examination of the activities of both the aircraft firms and the MoS during this eleven year period.

The companies involved in naval aircraft procurement appeared to use radically different approaches in their relationship with the MoS and Admiralty. In the immediate post-war period Blackburn did little more than act on MoS instructions, while Fairey took a much more independent and innovative stance. Their strike aircraft project, with its two engines mounted in tandem driving a single propeller, had only received government support after extensive lobbying and consultation both within the Admiralty and the MoS. Their entry into the GR17/45 design competition was also a result of an independent initiative. Fairey saw their relationship with the MoS as one of mutual influence, in which it was perfectly legitimate for them to try to persuade the Ministry and the Admiralty to accept their ideas. In this early period, such an attitude met with considerable success.

Fairey found it increasingly difficult to have their views on the GR17/45 accepted by the MoS or Admiralty after 1946. Although they were eventually successful in gaining permission to fit a Griffon piston engine to one of their GR17/45 prototypes, their views on the need to produce separate search and strike variants of the design, and their demand that the whole requirement be re-examined, appear to have been ignored. These ideas were embodied in the subsequent specification for a light anti-submarine aircraft, but there is no evidence to suggest that this was a direct result of the firm's advocacy of the idea.

No direct evidence of attempts by industry to influence governmental action has been uncovered for the period 1950-51, although it is unclear how far the preference of the MoS for a Double Mamba powered GR17/45, and their demand that Fairey be given the opportunity to produce a piston engined version of their design, were related to possible lobbying of Admiralty and MoS officials by Fairey directors. Fairey's attempts to impose a weight limit on the initial production version of the GR17/45 design met with little immediate response from either the Admiralty or MoS.

The final period from 1951 to 1957 saw Fairey reduced to making ineffective protests about production decisions which had been imposed upon them. These included the decisions to convert the Firefly VII into a training aircraft, and reduce the numbers on order; to reduce Gannet production to 8 aircraft per month; and to cancel the last 25 Gannets on order. In contrast the increase in the Gannet order in 1952 was directly linked to Fairey's argument that a reduction in the Firefly VII order had to be linked to an increase in the Gannet order.

Isolated examples of Fairey's initiatives influencing governmental activities have been uncovered by this case study, but the normal relationship was one of the MoS and Admiralty acting as the dominant customers, and the industrial firm as the subservient supplier. It can be argued that these roles were reversed if an alternative perspective is used, for only the firms were able to supply the customers with their needs, and the latter were thus dependent on them to acquire equipment of the quality and in the time scale they specified. In general however, the behaviour of the firms conformed to the first, more orthodox perspective.

The essence of the relationship between the officials in the MoS and serving officers in the Admiralty was that the latter specified the equipment to be procured, and it was then the task of the MoS to obtain it. In the course of this they might find themselves in conflict with the Navy because of their policies for reshaping the defence industries or because the Navy had decided that one of their requirements was no longer relevant. Major 'grey areas' in this relationship were the direct links, if any, between the Navy and the aircraft companies, as in theory the MoS was the intermediate agency responsible for them. This meant that the Navy should have specified the requirement for the anti-submarine aircraft in 1945, and the MoS proceeded to contract with an aircraft firm to produce it. In practice, the Navy seems to have been unhappy at the possibility that Blackburn would acquire the contract, and it appears that Fairey were encouraged by serving officers, to work on an alternative design. In 1948, both the Navy and MoS worked together on deciding the type of interim aircraft it was practicable to procure, but it was left to the Navy to decide which of the alternatives to proceed with. In 1949/50, when a major schism developed between the Navy and MoS over the engine for the GR17/45 production aircraft, MoS officials had to acknowledge that while they privately might regard any naval decision to use a piston engine as a retrograde step, it was the Admiralty who had to take the final decision. Similarly in 1949, the Admiralty had been advised that if they wished to retain Fairey as a naval design team they had to give instructions to the MoS to modify the prototype development programme in order to provide them with work. When the GR17/45 production decision was eventually taken it was made by the Admiralty and not the MoS. Finally, the decision to reduce the Gannet production rate to 8 per month was again taken by the Admiralty in order to give Fairey some continuity of production. All these examples serve to illustrate that it was Naval officers who ultimately dominated anti-submarine aircraft procurement, rather than the civilian officials of the MoS or civilians in the relevant aircraft firms.

Proposition vi. Governments do not act as unified entities when taking decisions on defence projects because of the conflicting interests and expertise of the bureaucratic organisations involved. This creates a lack of positive direction and control over projects.

The preceding analysis of Proposition iii has rendered this proposition largely redundant, as the two are, as was originally recognised, alternatives. The division of both the MoS and Admiralty into functional directorates virtually guaranteed that in a project spanning as many interests and elements of equipment as a naval anti-submarine aircraft, these directorates and their representatives would have differing interests and perspectives upon issues which needed decision, and a lack of consensus and unity in decision-making would result. This in turn appeared to produce a reluctance to make decisions in the face of opposition and a tendency to delay them in the hope that some technical solution would emerge which could be accepted by all. The result was a lack of positive direction and control. The exception to this general behaviour pattern was where the circumstances surrounding an issue had the effect of imposing a uniform view upon all the directorates concerned. In that case, a decisive decision was usually taken very rapidly.

Proposition vii. Certain individuals may, through their personal or organisational position, determine whether a defence project is sustained or cancelled.

A number of examples of the decisive role played by single individuals have been identified in this study. These include the major impact Mr. G.W. Hall had upon the progress of the Fairey GR17/45 development programme at a point in 1950 where the Admiralty were alleged to be contemplating its cancellation, and the part played by AD/RDN in the prolongation of the Firefly VII project. Further research might well indicate that one person alone was responsible for the decision to hurriedly redesign the Blackburn GR17/45's wing in September 1950; an action which almost certainly guaranteed that it would not be chosen for production. Set against this, however, was the failure of people in apparently advantageous positions to have their views accepted by the decision makers. These included the CNR up to 1948 with his positive views on the integration of aircraft and ships in a combined anti-submarine warfare concept, and Sir Richard Fairey, who recognised, very perceptively, the limitations of the GR17/45 designs. While this proposition was correct in certain instances, it proved to be incorrect in others, despite vigorous efforts by the individuals involved.

Proposition viii. Time is the most flexible variable in the weapon procurement process, followed by cost and quality.

This proposition constitutes an attempt to explore the relationship between the three variables of time, cost and quality which many economists regard as the core of the weapon procurement process. In 1945 and 1946 the GR17/45 programme was in its design and early development stages, and expenditures were minimal. It is unclear whether the year's delay in starting prototype development was a product of financial stringency or the inability of Blackburn to produce a technically acceptable design, but apart from this there is little evidence to suggest that cost was a factor which consciously affected these early decisions. Although there was an expectation that prototype aircraft would fly in 1948, there were no effective procedures for monitoring the progress of their airframes, engines, homing torpedo and radar, and this meant that the MoS did not have the option of maintaining the time schedule by increasing the money and manpower allocated to the project, or alternatively changing the GR17/45 requirement in order to obtain a product of reduced performance within the given time frame. In contrast to the lack of control over costs and time schedules, quality, in the shape of the operational requirement, was both frequently discussed and closely monitored. The absence of reliable information of the eventual costs and time scale of the project resulted in the dominant element in the design and development process becoming the attainment of the performance characteristics specified in the requirement. Quality thus became a very inflexible independent variable, with time and cost becoming variables dependent upon it.

There was little alteration in this relationship between 1947 to 1949, the decisions both to add a third crew member to the specification and to maintain a gas-turbine engine as the power-plant, despite the time costs involved, serving to reinforce it. Time did become a relevant variable during 1948 when demands for the rapid operational deployment of a modern naval anti-submarine aircraft led to the decisions to start conversion work on both the Sturgeon and Firefly, but these pressures appeared to have little direct impact upon the GR17/45 project. In late 1949 and early 1950 there was a marked possibility that the Navy would trade quality for reduced cost by placing into production a piston engined version of one of the GR17/45 designs, but the Korean war rearmament budgets made such a choice appear irrelevant. Cost thus became a more important variable during this period but not a dominant one, with time remaining a residual factor.

The British rearmament programme between 1951 and 1954 was seriously affected by the general lack of trained manpower which could be diverted into the defence industries, and especially the aircraft industry, and this created difficulties in converting money allocated to aircraft projects into effective work on them. The Firefly VII and Gannet programmes were among those affected by this problem, and it proved very difficult to attain the time and production targets set for them. New equipment was incorporated into the specifications of both aircraft, but no attempt was made to trade performance for a reduced development time. In consequence, quality remained an inflexible parameter, with time and cost remaining residual variables. The Firefly VII might have performed a useful operational role with a reduced equipment and weapon load, but such changes were never considered. Finally the Gannet AEW 3 requirement was subject to a similar rigidity in its detailed specifications, and it was only when decisions were being taken on how many aircraft to include in the final AEW 3 production batch in the early 1960s that cost started to play a predominant role in production planning.

Superficially, the evidence available from this case study appears to support the proposition, yet it seems likely that there was little conscious realisation of the inter-relationship between the three variables of cost, quality and time during the eleven year period under review. Modern techniques of cost control were still in their infancy in the aircraft industry, and little or no attempt was made to plan, manage and monitor aircraft projects in a similar way to the contemporary atomic energy project. The standard procedure seems to have been to set a quality target, make a crude guess of cost and development time, and then hand the problem over to industry. By 1953, this procedure had been expanded to include regular progress meetings on specific projects, but the MoS were neither undertaking the detailed monitoring of projects, nor attempting to use predetermined progress milestones to monitor the achievements of the industrial firms involved. Their system, or lack of it, permitted easily monitored quality targets to remain inflexible, while cost and time were uncontrolled rather than more flexible variables. It can thus be argued that the case study may not relate directly to this proposition.

Proposition ix. A weapon acquisition process can be usefully divided into the following sequential phases:

a. Background research and the production of a military specification.

b. Design study and competitive tender.

c. Prototype construction.

d. Prototype trials and selection of contractors.

e. Production development.

f. Production orders.

g. Military service.

The naval anti-submarine aircraft programme from 1945 to 1956 contains a number of phases excluded from the seven point process outlined in the proposition. A revision of these phases in the light of the case study would produce a process consisting of:

i Background research and the parallel production of a military specification.

ii Nomination of one or several firms to produce design studies.

iii Evaluation of design studies, leading to (a) nomination of a firm to develop a single design or (b) nomination of two or more firms to produce competitive prototypes based on similar components (parallel development) or (c) nomination of two or more firms to produce competitive prototypes based on differing components (duplicate development).

iv. Advisory Design Conference(s) and adaption of the military specification in the light of the existing design(s).

v. Prototype development of airframe, engines, radar equipment and weapons. Prototype development time will be determined by the component with the longest development time.

vi. Prototype production programme leads to additional information becoming available about the technical capabilities of the design(s). This could lead to a decision to accept either a reduction in the performance requirement or the termination of work on the existing design(s).

vii. Slippage of prototype time schedules will lead to attempts either to extend the operational life of existing weapons system or to adapt another system to fulfil the requirement.

viii. Revision of the military specification in the light of additional information on the contemporary politico/strategic environment, and changes in tactical concepts.

ix. Determination of the criteria of choice between competitive designs in the case of parallel or duplicate development; prototype trials; and the selection of a design and contractor for production. Alternatively, a search may be instituted for suitable adaptions of existing weapons to enable the military specification to be met at reduced cost.

x. The placing of production orders and the definition of a production standard in the light of the availability of new or existing systems and new military requirements.

xi. Construction of production prototypes and their proving trials.

xii. Either (a) Successful completion of production prototype trials

or (b) Conversion of aircraft to other roles

or (c) Cancellation due to failure to meet requirements.

xiii. Operational Trials.

xiv. Modifications to aircraft already produced and those still on the production line to rectify shortcomings demonstrated by production prototype development work and operational trials.

xv. Introduction into operational service.

xvi. Development and production of variants of the aircraft for trainer and other roles.

xvii. Modification of aircraft to overcome faults uncovered in operational service.

xviii. Retirement from operational service on the grounds of either

(a) Length of service, technical obsolescence and increased recurrent costs or

(b) Changes in strategic or tactical requirements.

Towards a Synthesis

'Understanding' can have two different meanings: one relates to those human feelings engendered by effective inter-personal communication, and conveyed by sentences such as "I think I now understand what you mean"; the second relates to a situation where an individual is indicating that he has assimilated all the information available about a subject or situation, and fitted it into a conscious, internally consistent framework of analysis. This process of understanding implies some prior definition of the boundaries of the phenomenon to be examined, the collection of data related to it, and the placement of this data into an existing analytical structure. If the data does not appear to fit easily into this structure, the latter may need to be modified to accommodate it, or alternatively the data can be rejected as unreliable or irrelevant.[1]

Such methodology has been consciously employed in this study. It has left unresolved two issues: what is the phenomenon to be examined and what are its boundaries; and can a coherent analytical framework be constructed by integrating the modified set of propositions summarised in the preceding section? One assumption underlying the study was that a weapon project had

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1. A. Rapoport, op. cit., p. 52.

easily defined boundaries, and national weapon acquisition processes could be understood by amalgamating the events and activities encountered by a large sample of these projects. The whole was assumed to be no greater than the sum of the parts. The events of 1945-1956 that affected anti-submarine aircraft development and production indicate that a weapon project does not have easily defined boundaries. The study was nominally limited to anti-submarine aircraft, but it seemed illogical to ignore the Gannets T2 and T5 and AEW 3 in the narrative as they were clearly perceived by participants as indivisible from the Gannet project. It also became clear at an early point in the research programme that it was impossible to effectively investigate the anti-submarine aircraft programme without some detailed knowledge of both the Navy's operational aircraft carrier fleet and the plans for its modernisation. Finally, although the Navy consistently sought an aircraft capable of operating from World War II type Escort carriers, their search for an optimal concept of anti-submarine warfare led to at least four major changes in other aspects of their anti-submarine aircraft specification. The requirement thus offered no simple guide to the fixing of boundary markers.

Aircraft carrier policy and the anti-submarine aircraft requirement proved to be directly linked to each other, and this generates a picture of the Navy's entire set of military requirements and equipment projects being indivisibly tied together, with changes in one project impacting upon others, and leaving the total programme in a state of continuous flux and evolution.

This evolution was uneven, as some requirements and the configuration of items of equipment remained static for a long time, whilst in other cases requirements were changing much more rapidly than the time within which it was technically possible to develop new items of equipment to meet them. Whether this was a product of British inefficiency in the management of contemporary military technology or of a more determinist and absolute relationship between the factors which produced the rapid changes in the requirements and the rate at which new military equipment could be developed, is unclear. The evidence from the naval anti-submarine aircraft programme suggests the latter.

Reinforcement for this perspective of weapon project interdependence is provided by the evidence of 'spill-over'[1] from one project to another contained in minutes of MoS/Admiralty working level meetings of the period. The structure of project files gives a superficial appearance of internal coherence over time, but a closer examination of them, and of the agendas of meetings at which these projects were discussed, suggests that two of the major inputs into project decisions were a desire to avoid what were perceived to have been mistakes made during past projects, and the problems of industrial management created by the demise of other projects. This 'spill-over' effect was assisted by the same MoS official being responsible for supervising a number

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1. The concept of spill-over has been extensively developed in the literature on international integration, but is intended here to convey little more than pressures exerted across project boundaries. For its use in the international integration literature see E.B. Haas, The Uniting of Europe, Stevens: London, 1958, pp. 291-297.

of projects, and thus being in a position to directly transfer learned experiences from one project to another. 'Spill-over' also seemed to operate in another related area, for once an aircraft design had been proven, there developed a tendency to exploit it by converting it to other uses. All of these considerations suggest that individual weapon projects may not be the most profitable focus for the study of national weapon acquisition processes. Individual projects are subjected to inputs from these external weapon acquisition processes, yet the latter provide only a partial explanation of the evolution of an individual project. Conversely, a study of many individual projects may provide a useful data base for the investigation of these overarching processes, but a fuller understanding requires that they be studied directly, rather than as an auxiliary objective of a series of project studies.

A further perspective upon this choice of research focus is provided by the issue of motivation. Research into any phenomena is a legitimate academic activity, and a choice between alternative foci thus implies the use of normative rather than academic criteria. The simplest normative criteria is the utilitarian one of the desire to use knowledge obtained to resolve a problem or suggest new approaches to it. The desire to investigate national weapon acquisition processes as aggregates can be related to a belief that such knowledge could lead to a greater understanding of the type of arms control measures needed to limit national weapon development programmes at source. The study of individual weapon projects appears to possess an aura of a search for pure knowledge, though it may also be fuelled by desires to improve project management.

One final issue related to the choice of a research focus is the level of abstraction and artificiality implicit in it. A weapon project appears to be a valid analytical category because it is treated as a concrete entity by people associated with it, and is an everyday object of discussion. The Gannet project conjures up images of a particular aircraft, and a set of events associated with it. Weapon acquisition processes do not possess the same public 'visibility' or self-evident identity. Investigation of these processes involves an emphasis upon comparisons between weapon projects and a search for rather more intangible types of phenomena. It may also imply that substantive decisions on weapon projects should be seen as dependent variables of a more abstract central process of national weapon acquisition.

The investigation of weapon acquisition processes thus poses major methodological problems. They can only be observed in action in individual weapon projects, yet such observations will be dependent on prior concepts of how such processes operate and their structure and composition. These concepts can be derived from two sources: areas of knowledge divorced from weapon procurement, and studies of weapon projects. It seems reasonable to use the processes that exist within individual projects as a guide to research into other projects, and thus to build up a comparative study of weapon acquisition processes. It has to be accepted that an *a priori* case can be constructed against such a strategy, based on the proposition that there is no necessary relationship between the concepts used to understand individual projects and those needed to comprehend overarching weapon acquisition processes. The corrollary of this is that a radically different framework should be constructed for the latter. At this stage, such an argument remains at the level of a belief, and its related approach will not be pursued further, but it would be necessary to base such a deductive strategy upon a factual data base, and this in itself provides justification for the study of individual projects.

The exploration and partial resolution of the basic methodological problems of the relationship between individual weapon projects and weapon acquisition processes clears the path for an investigation of the more substantive aspects of these phenomena. Understanding in this context appears to involve both definition and description, and it seems logical to start this operation by attempting to construct a tangible framework for describing the structure of weapon projects into which wider weapon acquisition processes may be fitted. Such a structure is provided by the modified Proposition ix which was formulated earlier in this chapter. In addition to acting as a descriptive guide for the study of further weapon projects, it also represents an attempt to identify some of the determinist elements present in them, particularly those related to the sequential nature of their phases. It appears physically impossible for certain phases or events to occur before others have been completed, while the completion of one phase may indicate in an unambiguous way that the time has arrived to take certain decisions. These imperatives are inherent in any process of technological development, and are factors that decision-makers may ignore, but the consequence will be an unrealistic and impractical decision. Short cuts, such as modifying existing weapons, may exist within this sequential framework, but normally it acts as an absolute set of conditions which decision-makers cannot alter.

The preceding study identified two major phases which had been ignored in earlier studies. One was the existence of an extensive production development phase once a prototype aircraft had been selected for production. The second was the tendency for new variants to proliferate once a design was in production. This expanded descriptive framework for application to weapon projects provides very little insight into specific project decisions, such as those taken to start a project, to choose which one of a number of alternative systems to place into production, and to cancel a project. It also offers no explanation of the internal dynamics and sources of dynamism inherent in a project's structure, or why it must necessarily move from one phase to another in a predetermined fashion.

The simplest method of integrating a project structure and the sources of its dynamism is through an input/output model. In such a model each phase in the structure is potentially a separate analytical entity, with the movement to the next phase and any detailed decisions being the output, and the elements determining or impacting upon those decisions being the inputs. Many of these inputs are qualitatively different from each other, making assessments of the degree of influence any one input exerts over the output difficult, if not impossible, to calculate. No detailed evaluation of this type was undertaken in the study, and it must await further research. An attempt was made to establish some approximate relationship through Propositions i, ii, iii and vii, but these investigations proved to be rather inconclusive. A number of findings relevant to the construction of such input/output models did emerge from them, and can be used as a crude guide to the types of inputs involved in each phase.

The first type of potential input investigated in the study was termed uncertainty. It was used to encompass two separable phenomena: those items of information which are recognised as being either unavailable or uncertain at any one point in time, and those elements in a situation which later proved to have been relevant, yet were then unknown. Examples of these differences were uncertainties about an aircraft's performance and handling qualities before it had been flown and tested, and changes in the perceived need for a particular type of weapon. When viewed as inputs into a weapon project, these phenomena can be more accurately labelled uncertainty and change.

Technical uncertainty is inherent in any equipment development process, indeed that process can be viewed as a set of activities designed to dispel it, and both provide complete knowledge of the equipment's capabilities, and indicate methods of altering the existing design in order that it may fulfil its requirements. This makes it a constant input into all stages of a weapon project, though such uncertainties should be greater at the start of a project than at the termination of its prototype development and production development phases. Change constitutes a much more random input into a project. The study indicated that the changes with the greatest impact were those related to the concept of an anti-submarine aircraft and its detailed specification. In this case the concept changed every 3-5 years, but in some cases, such as naval AEW aircraft, it has remained constant since 1950.

The sources of such a change in requirements may differ widely, and these sources may be seen as sub-divisions of the change input. The case study indicated that they originated from four different sources which were outside the activities associated with the anti-submarine aircraft procurement programme. The first of these was changes in the technology of both submarines and anti-submarine equipment under construction and in operational use. The second was changes in British perceptions of the nature of the military threat posed by certain potentially hostile states, especially the USSR. The third was changes in service priorities and force structures, which in this case involved the future shape of the aircraft carrier fleet. The final source was the changes in the functions of the fleet produced by the attempts to relate existing doctrines and equipment to the evolving theories of nuclear deterrence. All of the changes emanating from these areas were inherently random and unpredictable, and appear capable of impacting upon a project at any point in its evolution.

These types of change are outside of the control of those concerned with developing and producing an item of defence equipment. All that can be done in response to them is to take adaptive action, by changing the configuration of the equipment either to fit any revised requirement or to fulfil some other military role. A number of other inputs are theoretically controllable by those administering a project. The first involves the expertise of the government establishments or commercial concerns assigned the task of developing a new item of defence equipment. Although this development process takes place within the confines of the physical laws of science and engineering, it will be dominated by the managerial skills of individuals in the organisations involved and the creative ability and knowledge possessed by designers and development engineers. Whilst one team of individuals may fail to produce an appropriate piece of equipment, another may succeed. A second input of this type relates to the strategy chosen for developing the item of equipment, and whether this is capable of safeguarding the project against delays and unanticipated problems. In particular, the use of a parallel development strategy for perceived high risk components may insure against potential problems, but involve some extra monetary costs.

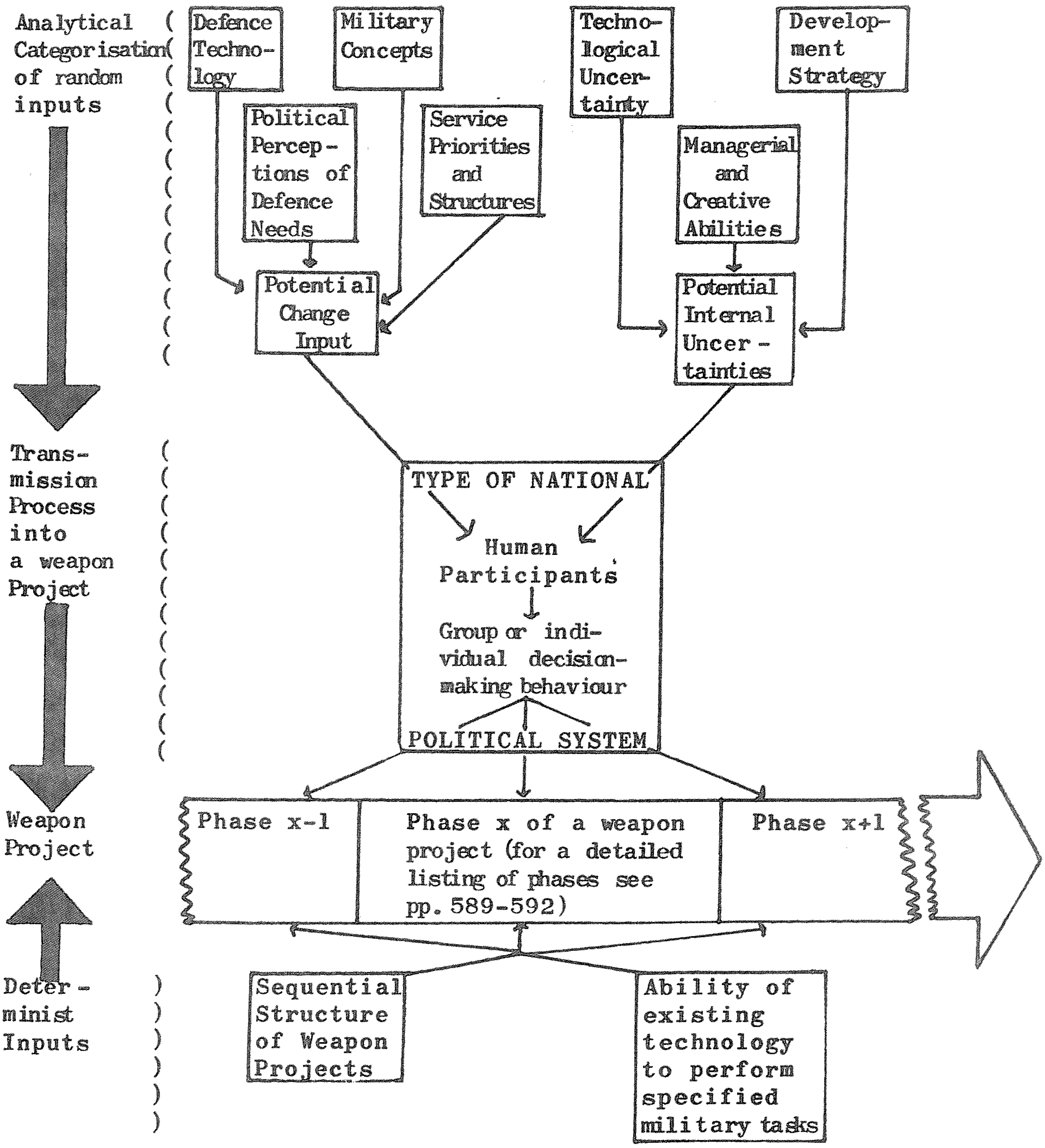
All of these internal and external, controllable and non-controllable, predictable and non-predictable inputs into a project impact upon it indirectly, with the sole exception of certain determinist elements inherent in its sequential phasing. These inputs can only relate to a project through the thoughts and actions of its human participants, who may, or may not, be influenced by them in any project decisions they take or participate in. To establish degrees of influence exercised by individual inputs in this context with any degree of confidence would be very difficult, if not impossible. Thus although an event like a project cancellation is often explained in terms of a single input, such as a change in military requirements, it may be impossible to establish a direct connection between the event, the decision taking group and such a relatively abstract input.

The mediating role played by the human participants in weapon projects adds an additional dimension to any attempt to describe a weapon project. It appears possible to either regard analysis of this role as impossible, due to the unpredictability of human behaviour and influence patterns, or possible, on the basis that individual or group decision-taking procedures conform to certain behavioural laws. Two elements appear to be needed to conduct this latter type of analysis. One is some increased understanding of the influence of organisational role and other situational factors upon an individual's personal decision-making behaviour. The second is a greater understanding of the group dynamics found in meetings where individuals both play a personal role within the committee and also represent their own Ministry, Directorate or other administrative grouping. One of the interesting findings that has emerged in this context from the preceding study was that perceptions of a need to respond to an external stimulus produced within a committee a marked convergence of attitudes upon a single course of action. This raises the question of why such a compelling common reaction occurred, and why possible alternative reactions were either not recognised or ignored. Similarly, individuals taking decisions appear to have often done so in the belief that no choice existed, and there was thus no point in extending discussion to a wider forum.

An additional facet of the central role played by the individual in a project is the nature of the forum within which group decision-making occurs in weapon projects. It is in this area that the type of political system within which a weapon is being developed plays a dominant role. Studies of United States projects have emphasised the high degree of politicisation and public debate that surrounds their inception; the choice of design and contractor; and production decisions. By contrast, this study demonstrates that in the United Kingdom between 1945 and 1956 no politicisation or effective public debate occurred on the naval anti-submarine programme, and all decisions were taken through discussions between Admiralty and MoS representatives, usually at working level, in which the former tended to dominate the latter. Industrial pressures were taken into account in this process, but industry had no direct representation in the decision-making bodies.

Any attempt to synthesise all the elements which appear to be necessary for any description and understanding of weapon projects, and their associated processes, runs the risk of producing a model which appears to be even more complex than the reality it is attempting to simplify, but such a model does have the virtue of being highly visible, with all its facets and assumptions open to challenge. Fig. 2 illustrates the type of schematic process model that may be constructed on the basis of the preceding discussion.

Fig. 2.



The major weakness of this model has already been acknowledged. It makes no attempt to relate the impact of specific inputs to particular phases of a weapon project, and is pitched at a very high level of generality. The case study demonstrated that the uncovering of such linkages is likely to involve very detailed analysis covering many projects, as both internal and external inputs appeared to impinge upon specific projects in a very random manner: indeed Albrecht and his associates may be correct in their assertion that this randomness is an inherent part of weapon acquisition processes.[1] Similarly, it was difficult to make generalisations about the behaviour of individuals and groups placed in a mediatory role between both external and internal inputs and a project. Again, much more detailed and extensive research appears to be required to gain additional insights into this area. Nevertheless, the model can be claimed to have fulfilled the objective of providing an integrated structure which offers a guide to understanding the many elements that comprise an individual weapon project, as well as the weapon acquisition processes associated with it. It should also provide a useful point of departure for any future, more extensive, study of national weapon acquisition processes, though it may be necessary to supplement it with additional research into the activities leading to both the inception of a new requirement, and the conversion of operational or prototype equipment to new roles.

A body of data on a number of aspects of British Defence Policy from 1945 to 1956 has also been presented which may be used by political scientists to investigate issues other than

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1. U. Albrecht et al, op.cit., p. 194.

those contained in this study. This in itself may be a significant development, for it indicates that although weapon procurement in Britain may still remain within the realm of closed politics, its substance is no longer inaccessible to the academic political scientist.

APPENDIX 1

THE GROWTH OF MAXIMUM WEIGHTS AND SPEEDS OF FLEET AIR ARM AIRCRAFT, 1939-1945

Type	Name	Maximum take-off weight (lbs)	Maximum Speed (mph)
Fighter	Skua	8,228	225
	Fulmer	9,800	280
Fighter/ Reconnaissance/ Strike	Wildcat I	5,876	310
	Wildcat IV	6,100	330
	Sea Hurricane	7,800	342
	Seafire FIII	7,200	352
	Corsair IV	12,100	415
	Hellcat II	13,753	371
	Firefly FI	14,020	316
Torpedo/ Bomber/ Reconnaissance	Swordfish I	9,250	139
	Albacore	12,600	161
	Barracuda III	14,100	239
	Avenger TR III	16,400	262
Prototype aircraft	Sea Fury	12,500	460
	Barracuda V	16,000	253
	Firefly IV	16,096	386
	Firebrand TF V	17,500	350
	Sea Hornet NF 21	19,530	430
	Sturgeon I	21,700	352
	Wyvern TF I	21,879	456
	Spearfish	22,083	292
	Sea Mosquito TR 33	22,500	385

Source: Thetford, *op.cit.*

APPENDIX 2

THE RN CARRIER FLEET, 1948-1956.

Dates of Navy Estimates & their Explanatory Statement	Operational Fleet (F=Fleet Carrier LF= Light Fleet Carrier E= Escort Carrier)	Training & Experimental (including non-flying duties	Reserve Fleet	Under-active Construction or Modernisation (M)	Launched but either construction suspended since 1946 or being completed for Commonwealth Navy
Feb.1948. H.C.Paper 60, pp. 228 and 9: Cmd 7337 p.5.	Ocean (LF) Triumph (LF) Theseus (LF) Glory (LF)	Victorious (F) Illustrious (F) Implacable (F) Vengeance (LF) Venerable (LF) Warrior (LF)	Formidable (F) Indomitable (F) Indefatigable (F) Campania (E)	Eagle (F) Ark Royal (F) Centaur (LF) Albion (LF) Bulwark (LF) Hermes (LF)	Powerful (LF) Majestic (LF) Leviathan (LF) Hercules (LF) Terrible (LF) (for RAN) Magnificent (LF) (for RCN)
Feb.1949. H.C.Paper 67, pp. 234 & 235: Cmd 7632 p.6.	Implacable (F) Ocean (LF) Triumph (LF) Theseus (LF) Vengeance (LF) Warrior (LF on loan to RCN)	Victorious (F) Illustrious (F) Warrior (LF) Glory (LF)	Formidable (F) Indomitable (F) Indefatigable (F) Campania (E)	Eagle (F) Ark Royal (F) Centaur (LF) Albion (LF) Bulwark (LF) Hermes (LF)	Powerful (LF) Majestic (LF) Leviathan (LF) Hercules (LF)
March 1950. H.C.Paper 2, pp. 244 & 45: & Cmd 7897 p.5.	Implacable (F) Triumph (LF) Theseus (LF) Vengeance (LF) Glory (LF)	Victorious (F) Illustrious (F) Ocean (LF)	Formidable (F) Indefatigable (F) Indomitable (F) Warrior (LF) Campania (E on loan to Fest.of Brit.)	Eagle (F) Ark Royal (F) Centaur (LF) Albion (LF) Bulwark (LF) Hermes (LF)	Powerful (LF) Leviathen (LF) Hercules (LF) Majestic (LF for RAN)

Feb. 1951. H.C. Paper 101, pp. 244 & 249: Cmd 8160 p.4	Indomitable (F) Theseus (LF) Vengeance (LF) Glory (LF) Ocean (LF)	Indefatigable (F) Illustrious (F) Triumph (LF) Warrior (LF)	Formidable (F) Implacable (F) Campania (E on loan to Festival of Britain)	Eagle (F) Ark Royal (F) Victorious (F)(M) Centaur (LF) Albion (LF) Bulwark (LF) Hermes (LF)	Powerful (LF) Leviathan (LF) Hercules (LF) Majestic (LF for RAN)
Feb. 1952. H.C. Paper 94, pp. 240 & 245: Cmd 8476 p.4	Eagle (F) Indomitable (F) Theseus (LF) Glory (LF) Ocean (LF)	Indefatigable (F) Implacable (F) Illustrious (F) Triumph (LF) Vengeance (LF)	Formidable (F) Campania (E)	Ark Royal (F) Victorious (F)(M) Centaur (LF) Albion (LF) Bulwark (LF) Hermes (LF) Warrior (LF)(M)	Powerful (LF) Leviathan (LF) Hercules (LF) Majestic (LF for RAN)
Feb. 1953. H.C. Paper 83, p. 231: Cmd 8769 p.5	Eagle (F) Indomitable (F) Theseus (LF) Glory (LF) Ocean (LF)	Indefatigable (F) Implacable (F) Illustrious (F) Triumph (LF)	-	Ark Royal (F) Victorious (F)(M) Centaur (LF) Albion (LF) Bulwark (LF) Hermes (IF) Warrior (LF)(M)	Leviathan (LF) Hercules (LF) Majestic (LF for RAN)
Feb. 1954. H.C. Paper 81, pp. 232 & 240-241 : Cmd 9079, p.6	Eagle (F) Warrior (LF)(M) Glory (LF)	Indefatigable (F) Implacable (F) Illustrious (F) Triumph (LF)	Indomitable (F) Theseus (LF) Ocean (LF) Centaur (LF)	Ark Royal (F) Victorious (F)(M) Albion (LF) Bulwark (LF) Hermes (LF)	Leviathan (LF) Hercules (LF) Majestic (LF for RAN)

Feb.1955. H.C.Paper 48,pp. 232 & 240: Cmd 9396 pp.9-10	Eagle (F) Ark Royal (F) Centaur (LF) Albion (LF)	Bulwark (LF) Triumph (LF) Ocean (LF) Theseus (LF)	Indomitable (F) Indefatig-able (F) Implacable Illustrious (F) Glory (LF) Warrior (LF)(M)	Victorious (F)(M) Hermes (LF)	Leviathan (LF) Hercules (LF) Majestic (LF for RAN)
Feb.1956. H.C.Paper 183 : Cmd 9691 pp.7 & 8	Eagle (F) Ark Royal (F) Centaur (LF) Albion (LF)	Bulwark (LF) Theseus (LF) Ocean (LF)	Illustrious (F) Indefatig-able (F) Triumph (LF) Glory (LF) Warrior (LF) Vengeance (LF)	Hermes (LF) Victorious (F)(M)	Leviathan (LF) Hercules (LF)
April, 1957, Cmnd 157 p.7	Ark Royal (F) Eagle (F) Albion (LF) Bulwark (LF)	Ocean (LF) Warrior (LF)	Centaur (LF) Triumph (LF) Glory (LF) Theseus (LF) Magnificent (LF)	Hermes (LF) Victorious (LF)	Leviathan (LF) Hercules (LF) (To India)

APPENDIX 3

THE SERVICE LIFE OF THE GANNET AS Mks 1/4

Squadron	Dates of Operational Service	Source(s) of Information
810	April, 1959 - July, 1960.	Popham/Taylor
812	November, 1955 - December, 1956.	Popham
814	January, 1957 - July, 1958.	Popham
815	February, 1956 - July, 1958.	Thetford/Popham
816 (RAN)	August, 1955 - August, 1967.	Taylor
820	July, 1956 - October, 1957.	Thetford/Popham
824	February, 1955 - October, 1957.	Taylor/Popham
825	July, 1955 - ? 1957.	Taylor/Popham
826	January, 1955 - ?	Taylor
831	November, 1955 - December, 1957.	Taylor/Popham
847	1955 - 1957.	Popham

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