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UNIVERSITY OF SOUTHAMPTON

MANAGERIAL DECISION-TAKING IN A SOCIAL
SERVICES SETTING

Location of Day-Care Facilities
for the Mentally Handicapped

G H HENRY SONNENBERG

Submitted for the Degree of
Doctor of Philosophy

April 1983

"Managers do not solve problems; they
manage messes."

R L Ackoff. "The Future of
Operational Research is Past".
J.Opl.Res.Soc. 30(2), 1979, 93-104.

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1. This research enquired into the siting of day training centres for the mentally handicapped in Hampshire; the provision of such facilities is a responsibility of the local authority social services committee. The work was undertaken over the period June 1979 to June 1982. The author held at different times over this period an SSRC studentship and a Southampton University research studentship, as well as a post-graduate exhibition from The Institute of Chartered Secretaries and Administrators. Funds for the project were made available also to the University, by the Hampshire County Council/Hampshire Area Health Authority Joint Care Planning Team. The author is appreciative of this financial support.
2. For the duration of the project, the author was provided with working facilities in the social services department research section in Winchester; a quiet room was also available there for private study, though this was usually engaged in at the University. The research section staff were helpful and considerate and involved the author in their social functions. The author is grateful to have had their friendship. The head of the section, Mr D Ward, is singled out for particular mention: he was especially patient and understanding. Thanks also go to the assistant director (resources), Mr M Gardner, who handled administrative arrangements.
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UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF SOCIAL SCIENCES

ACCOUNTING AND MANAGEMENT ECONOMICS

Doctor of Philosophy

MANAGERIAL DECISION-TAKING IN A SOCIAL
SERVICES SETTING:
LOCATION OF DAY-CARE FACILITIES
FOR THE MENTALLY HANDICAPPED

by G H Henry Sonnenberg

The research is an application of techniques of managerial decision-taking in a local authority social services department. The approach is an eclectic one, drawing together techniques in determining the location of day centre facilities for mentally handicapped trainees, where the centres are to cater for many clients spread over a large geographical area. The work was undertaken in Hampshire, though the results are applicable elsewhere. It involved the participation of the managers themselves.

Trainees travel to centres in vehicles hired at the local authority's expense. A simple distance metric which could be applied where there would be a lack of information on actual routes was developed and tested by reference to transport cost data.

The study pointed to alternative transport policies yielding economies. Contracting for more taxis and fewer high variable cost coaches and keeping journeys short would reduce costs without increasing travel times. There would be larger savings with more trainees on coaches if some journeys could be longer. The choice for management involved a trade-off between transport costs and time-savings: it could not be assumed, as is usual in, for example, cost-benefit studies, that shorter journeys would be preferred. Managers were asked to express preferences. Values of time-savings, which varied with journey lengths, were then obtained using a linear programming formulation. The preferences suggested planning for trainees to attend nearest centres.

A conceptually straightforward iterative computer procedure is described for determining future centre locations. This uses the distance metric and explicitly takes into account both transport costs and travel times. It can be used in a variety of 'what-if' situations.

The study was of immediate practical application to the problem in hand. A principal conclusion is generality of the methodology.

INTRODUCTION

1. Local authority social services departments provide day-care facilities for mentally handicapped adults, in what are known as training centres. This study considers factors relevant in deciding where such centres should be located within the jurisdiction of a county authority having responsibilities over a large geographical area. The research was conducted specifically in Hampshire, with the co-operation of the social services department there; the findings are applicable generally. Throughout this thesis the term "Hampshire" refers to the county council social services department unless the context suggests otherwise.
2. This work differs from conventional theses. The research was conducted with the participation of the decision-makers, in the social services department, whose actions were being examined. As the project proceeded, their perception of the problems facing them changed, with the emergence of the importance of efficient transport arrangements. So did attitudes; in particular, mental health advisers at headquarters and, in some degree, social workers in the field came to appreciate more than in the past that it implied no lack of compassion for clients to have explicitly to trade-off alternative uses for scarce resources one for another. Accordingly, the scheme of the research had also to evolve, and change course.
3. This adjustment to the needs of end-users, the decision-makers, was not untoward. Ackoff (1) has criticised operational research/management science practitioners for their "obsession with techniques, combined with unawareness of or indifference to ... the changing needs of management brought about ... by radical changes... in the environment in which it is practised... practitioners decreasingly took problematic situations as they came, but increasingly sought, selected and distorted them so that favoured techniques could be applied". He subsequently (2) argued the need for participation which "provides... an opportunity for

learning how the parts of the system interact and how these interactions affect the performance of the whole. Such learning enables those engaged in the process to make decisions... that have better effects".

4. Participation, in the context of this project, was also to help ensure that findings would actually be used, notwithstanding that the influences on implementation are unclear (Polding and Lockett (3)). It was seen here as important that end-users should be committed to the research and Hampshire were therefore asked to help finance it. The author received (not simultaneously) an SSRC studentship and a Southampton University research studentship as well as a post-graduate exhibition from The Institute of Chartered Secretaries and Administrators. Hampshire's Social Services Committee approved the provision of funds for the project, to be made over to the University's Department of Accounting and Management Economics out of monies made available for research by the Hampshire County Council/Hampshire Area Health Authority Joint Care Planning Team (4). The establishment of this financial link was appropriate: "There is no point in devoting resources to research ... directed towards a specific end-use which the prospective end-user does not want; equally it is a misallocation of resources unless the end-user attaches sufficient importance to the research... to be willing... to pay" (Rothschild(5)).

5. Hampshire's commitment to the project was also demonstrated by their willingness to provide the author with working accommodation in the social services department research section with freedom to consult county officials (not only in social services, but also in other departments such as treasurer's, planning, surveyor's and education.) To put this in perspective, the research section was primarily engaged in survey research, "lacking... a model or structure within which to locate the results" (Boldy and Clayden (6)).

6. On commencement of the research, the section put a circular round departments informing them of the project. A series of seminars was held to acquaint officials with the purpose of the research and to invite their support. These were successful in generating discussion and stimulating subsequent interest and further enquiries.
7. Even so, "ensuring user involvement is a difficult task" (Adelman (7)). It is arguable if Ackoff (2) is right when he says that participation is not difficult to obtain because it is "fun". To maintain interest, especially in the outfield which can feel remote from headquarters, a number of working papers were circulated setting out findings as the research proceeded. These papers were prepared by the author and were issued as part of the social services department's series of research reports which experience had shown were always widely read.
8. The working papers are appended and this, too, represents a departure from convention. The reports enabled the author to demonstrate that the project methodology was "responsive to what the employing group values"; but that the research was "also to try to change perceptions" (Mitchell (8)). The papers led to more seminars and presentations as well as discussions at meetings of social work management teams.
9. A further feature of this project, distinguishing it from some others, is that it is multi-disciplinary, involving operational research, economics, accounting, computer simulations and location theory. It could not have been otherwise for "there is ... no escape from the conclusion that operational research/management science must be problem ... and not technique orientated" (Eilon (9)). Hampshire's social services managers were already aware that a single source of advice or data is rarely sufficient for decision-making. For example, conventional accounting data are unlikely to provide all that is needed to appreciate the behaviour of costs of conveying clients to and from training centres (see Coverdale et al (10) in the context

of hospital costs): "accounting data are homeostatic; that is, they try to preserve the status quo ... whereas decision analysts are often trying to change the status quo" (Rivett (11)).

10. That several disciplines could be involved in a decision-making process was not in managers' minds in doubt. It was their practice to consult widely, both with other departments, such as education and planning, and with other agencies, such as the health authorities and voluntary associations. What they additionally needed, to complement the data usually available, but often seemingly incapable of resolution into a coherent whole, was analytical advice as distinct from special pleading. This was what they hoped for, above all else, from the project in deciding where to locate training centres: "the decision maker must decide how to weigh different objectives ... nonetheless formal analysis can be ... useful in reducing the number of variables that must be considered subjectively." (Abernathy and Hershey (12)).

BACKGROUND

11. In 1979, Hampshire had 10 purpose-built training centres for the mentally handicapped, providing day-care and help in acquiring living skills for 1,350 adults. The facilities were located in the main centres of population, at Aldershot, Alton, Andover, Basingstoke, Bishopstoke (Eastleigh), Fareham, Havant, Portsmouth, Southampton and Totton. About 40 trainees from the county attended a centre at Christchurch; these facilities had been lost to Dorset in 1974 following the re-drawing of local government boundaries.

12. The trainees' places of long-term (overnight) care were either their own homes, where they lived usually with relatives, or residential institutions, namely county-owned and private and voluntary hostels and health authority hospitals and locally-based hospital units (lbhu's). Hampshire were willing to provide transport between the training centres and the places of long-term care and did so in most cases. The trainees were not

charged for transport nor were they charged for places at the centres.

13. The trainees received small weekly payments related to attendance and performance at the centres. These were wholly financed by sales of output from the centres' workshops. The trainees were expected to contribute to the cost of lunches provided, but the charges were not deducted from the weekly earnings. The handling of cash was seen as aiding the learning of social skills.

14. The demand for places exceeded the supply and to keep to the guidelines in the 1971 White Paper "Better Services for the Mentally Handicapped" (13), as updated by the 1980 Blue Review "Mental Handicap: Progress, Problems and Priorities" (14), it was estimated that Hampshire would need to provide a further 550 places in the period to 1996. This took account of the expected increase in the Hampshire adult population, including the anticipated demand from school-leavers. It did not allow for the possibility that about half of the 800 residents in the two large sub-normality hospitals in Hampshire, Coldeast and Tatchbury Mount, would be decanted by the Hampshire area health authority (see Felce *et al* (15)) into lbhu's, yet to be built at locations yet to be decided, and that a proportion of this number would then need day-care from the social services department instead of from the hospitals as hitherto.

15. Hampshire's Senior Management Team (SMT), comprising the Director of Social Services and his principal advisers, had been considering how best to meet the demand for day-care from mentally handicapped adults in the future. Deliberations had centred on where to locate further day-care facilities.

16. The stimulus for some research here came principally from increased financial stringency, following the 1979 General Election and change of Administration. This is not unexceptional (eg Hopkins *et al* (16), Patel (17) and Derbyshire (18)), though other eventualities such as local government re-organisation can

similarly act as a catalyst (Groom et al (19)). It also came from a realisation that as most of the large centres of population in the county now had training centres, and now that the number of training centres on the ground (10 in all) could be considered large, the locations of future centres had to be chosen with care as with more centres catchment areas would begin to overlap. It could no longer be assumed that the next location for a centre would be the largest town for which there was as yet no provision.

17. Not that this had ever been a sole criterion. The very fact of having located facilities in large centres of population, given that trainees had not in the past been integrated with local communities in their day-time activities (contrary to ideas propounded more recently by the National Development Group (20)), suggested that transport considerations, too, had probably been influential.

18. Transport arrangements had not, though, been taken into account explicitly in siting new centres, save that estimates of cost (but not associated factors such as journey lengths) had been prepared for the purposes of capital project submissions to the social services committee. These estimates had been based solely on out-turns for other centres.

19. Now, with increased financial stringency, the Senior Management Team sought to exercise greater financial control over the transport sub-head of the training centre budget. There were four reasons for this. First, the transport bill accounted for a large and growing proportion of training centre recurrent expenditure. The author had pointed out that even modest savings in the bill would be worthwhile in terms of their impact on expenditure under other budget sub-heads. SMT's acceptance of the possibility of utilising transport savings for other purposes to the advantage of trainees, and being prepared to argue the case in the county's policy and resources committee, was an important step forward in their thinking.

20. Secondly, it had been possible to fill places at two recently-opened centres only by transporting in trainees from further afield than had been intended. A more systematic approach to the estimation of transport costs at the project appraisal stage would be beneficial. This would highlight not only further scope for containing costs, but would also draw attention to what managers were aiming to achieve for trainees in terms of journey lengths.

21. Thirdly, transport costs are influenced by locations of centres in relation to client populations. An appreciation of the behaviour of transport costs would focus attention on the need to consider the siting of local authority training centres on the one hand and the siting of health authority lbhu's on the other as related rather than self-contained exercises. It was not the intention that a model should be developed covering all decision-making in the mental handicap field, both residential as well as day-care within the purview of both the local authority as well as the health authorities and private and voluntary agencies, though it was recognised (Clayden (21)) that by drawing "boundaries closely around the area of immediate concern ... the total ... system may be performing below its potential because of a lack of understanding of the way the constituent parts of the system interact" (see also Boldy (22), Coverdale and Negrine (23), Dokmeci (24), Gibbs (25) and Simpson (26)). Such a "balance of care" model would have been too ambitious for an initial enquiry. The research project rested on the more modest view that a structured approach to the location of training centres would at least enable social services to be authoritative in their discussions with health authority partners. For example, a district health authority was proposing building a training centre itself near Winchester (27); Hampshire wanted to know if this was an appropriate location, and needed first an analytical framework within which it could prepare a credible strategy.

22. Fourthly, Hampshire's policy and resources committee, responding to the need for economies, had asked all

departments, including social services, to put forward "options for reductions" to be set against "bids for funds" for the financial year immediately ahead (1980-81). It became clear that in the foreseeable future no further traditional training centres would be built other than one already agreed for New Milton in the New Forest to replace the Christchurch centre. Furthermore, it was proposed, as an emergency measure, to charge trainees for transport (in the event, the charges were not introduced because of legal objections under the Road Traffic Acts); clients were to be informed that the politically sensitive charges would be phased-out if transport arrangements could be made more efficient. This fourth point argued in favour of considering locational issues proper as a second priority in the research project, with attention being devoted in the first instance to related transport matters.

23. Against this background, the author considered it appropriate to consider the arrangements for transporting trainees in Hampshire and to make recommendations as to how senior management could (i) reduce transport costs, having regard to the distances trainees would have to travel, and then (ii) take transport costs and journey lengths into account in deciding where to locate additional facilities. It was implicit in this broad approach that transport costs did not have to be minimised.

TRANSPORT SURVEY AND DISTANCE METRIC

24. The review was wide because senior management lacked information and were unsure how they could help specify the aims of the study. It was decided therefore to undertake a survey of existing (September 1979) transport arrangements (Henry Sonnenberg (28)) so as to obtain a basis on which to elicit from SMT explicit recognition of the objectives for trainees they were implicitly pursuing. The survey was also to assist in formulating policy proposals in the context of the transport charges.

25. The survey covered the 1,050 trainees for whom transport was provided or paid for by Hampshire. These trainees either travelled in hired double-decker buses, coaches, mini-buses and taxis or, in about 50 cases, received refunds of bus fares. Other trainees were taken to and from centres by parents, using their own cars or walking.

26. Most of the vehicles contracted for by the county for the trainees were engaged by the education department who also organised transport for the county's school children. The double-decker buses, used for the Portsmouth and Southampton trainees, were hired direct by Social Services under arrangements going back to when the two cities were county boroughs.

27. There was no need to consider seeking information from clients' families (there could be no question of approaching mentally handicapped trainees direct), nor was it necessary to travel alongside trainees so as to obtain observations first-hand (the District Audit Service did attempt this a few months later when verifying for their own purposes some of the author's travel time figures; they did not conclude that their approach was to be commended). Instead, much of the data needed for the survey was obtained from administrative sources. Other studies have also used authorities' own statistical records (eg Hogg (29) referred to fire service research station reports), but in some instances the range of data likely to have been available appears not to have been fully explored (eg Belford and Ratliff(30), in considering the bussing of students to schools in Florida so as to achieve racial balance, confined travel details to origins and destinations; cost factors were ignored).

28. Two sources of administrative data were used for the survey.

First, vehicle loading schedules were examined to obtain for each contract the names of trainees, their pick-up points on journeys to centres and their pick-up times. The times of arrival at the centres were also noted. Information on distances the trainees travelled was not for the most part available.

Secondly, vouchers and schedules supporting social services

transport accounts provided costs of contracts and modes of transport as well as details of refunds of fares. The schedules for refunds gave names of trainees and pick-up points; journey times were ascertained from bus operators' published time-tables.

29. The cost data were for the financial year ended March 1979, these being the latest available figures. The numbers of trainees on the loading schedules and in the accounting documents were similar and additional data obtained from the social services computer-based Management Information System (MIS, (31)) showed there had been few training centre admissions and discharges from the beginning of the financial year 1978-79 to the time of the survey. It was not unreasonable, therefore, to relate the loading schedule data to the cost figures.

30. Costs of contracts entered into on behalf of Social Services by Education were in most cases wholly re-charged to the social services department. In the other cases, adult trainees were accompanied by mentally handicapped children travelling to and from school; in these instances the re-charges were for a proportion only of total contract costs. The loading schedules suggested that neither the modes of transport nor the routes undertaken had been influenced by decisions to convey children. As the children were utilizing spare seating capacity at no additional cost to the county, the proportionate re-charges were, for the purposes of the survey, adjusted upwards to reflect total contract costs. As against this, a service charge made by Education to Social Services, calculated as a percentage addition to contract costs, representing a contribution towards Education's administrative overhead, was ignored; Education's headquarters' costs would not have been reduced had Social Services contracted for all its vehicles direct.

31. Information on distances was not available from these administrative sources. An attempt could have been made to measure distances on maps; this would have been a formidable undertaking. Davies (32) claims that "road distances can be measured easily on a map", but she had nonetheless assumed that the



entire population of a parish or electoral ward all lived at one point. Other writers also have adopted the point (or centre of gravity or centroid) approach (eg Abernathy and Hershey (12), Groom et al (19) and Jennergren and Obel (33)). The point method was adopted for the transport survey in this paper, but whereas some researchers have referred solely to centroid grid references for parishes and electoral wards on the grounds that the latter are "the smallest population groups about which statistics are published" (Davies (32)), it was decided for the purposes of the project to use points within 5x5 kilometre squares following the National Grid.

32. In many cases locations were deemed to lie in the same grid square as the centroid grid reference for the parish calculated by the Office of Population Censuses and Surveys for the 1971 Census (34). In most cases, though, trainees' locations were assigned to actual grid squares with the aid of street maps supplied by the county surveyor's department. For future up-dating, Hampshire have decided to continue with this method and assignment to grid squares is to be facilitated through the addition of postal codes to clients' addresses on MIS so that grid references can be generated using the Post Office's "Postzon File" service (35).

33. There were two reasons for using grid squares. First, Hampshire's planning department were able to provide annual estimates of population for the county by enumeration district (36). Such figures, as Davies (32) suggests, are not published routinely as the errors inherent in estimates for such small areas are large, but they can nevertheless be made available for research purposes and provide a basis for obtaining reasonably accurate population totals, within the confines of the estimating assumptions, when aggregated-up for larger areas. As it is therefore possible to obtain reliable figures for 5x5 kilometre squares, with the aid of centroid grid references for enumeration districts, also supplied by OPCS, and bearing in mind that such squares can be aggregated to form catchment areas of almost any size and shape (a facility which is not available when using larger irregularly shaped parishes and wards), the use of squares was seen as attractive. Robertson (37) also found that "it

is a simple matter to add and subtract these 'building bricks'".

✓In the event, enumeration district figures were not used for the purposes of the project (see paragraph 115), but the possibility is there in future up-dating.7

34. Secondly, it was appreciated that data on a grid square basis could more easily be handled within the capabilities of Hampshire's own main-frame computer software packages. Robertson (37) had reached a similar conclusion: "the computer procedure required that electoral data were assumed on the squares of a gridded map". Brans et al (38) also found it convenient, apparently computationally, to use a (hexagonal) grid so as to achieve a homogeneous distribution of nodes. It should be noted that the use of grid squares for Hampshire was to provide added flexibility: Tobler (39) has observed that "there are now a number of instances in which ... data have been collected at regular spatial intervals, for the obvious reason that numerous analytical investigations are thereby greatly facilitated". It was not, then, a matter of distorting the methodology of the project to comply with computer constraints.

35. The use of a computer was essential. With less than a hundred points spread over the 500 square kilometres of West Glamorgan, Groom et al (19) had had to build a matrix representing over 4,500 inter-nodal connections; for Hampshire, there were nearly 200 5x5 kilometre squares, implying a matrix nearly 5 times as large. Whilst it would be helpful in this context to have a measure of distances that was relatively straightforward to apply, there was no case for such a measure being naive. Certainly it could not be assumed, as for Abernathy and Hershey's (12) hypothetical medical service area, that "the horizontal and vertical axes are parallel to the general directions of major highways" just so as to be able conveniently to go on to say "we define distance between two points... as the rectangular separation (the sum of the vertical and horizontal distances) between the two points. This is considered more valid than the direct distance between the two points, since individuals will travel on highways in the general directions of the two axes". This approach could perhaps be justified if the area were wholly

urban (see below), but there is instead spatial separation between their cities. Their method further lacks conviction when the writers continue by saying that as individuals travelling from one point to another in the same census block would be shown to "travel zero, or a very small distance", it is necessary to make "a correction for this possibility ... by assuming that the average distance from the center of the census block to the border is the lower bound on the distance traveled within a census block".

36. The method to be used in gauging distances had to take into account that in planning for the future there would be changes in the number and geographical distribution of trainees; moreover road patterns and, more importantly, routes could alter. Mole (40) points out that "the most successful Routing packages ... employ a computer map of the ... road network". These are intended to handle current, rather than future, scheduling requirements. It was considered, therefore, that distances should be imputed. (Routing considerations are in any case difficult to model. Belford and Ratliff (30) argued that "requiring that the assignments permit efficient routing of the buses, seems to be a secondary criterion for optimality, rather than a primary one... if routing considerations are explicitly included in the model, the problem becomes computationally intractable". This does not, however, excuse them leaving transport considerations out of account altogether.)

37. The aim was to provide broad measures of actual distances which could be used for planning purposes when large numbers of trainees are involved, spread over a wide area. A variant of the rectilinear (or rectangular or lateral) distance method was devised which took into account also Euclidean (or straight line) distances; this synthesis was proposed because the literature is inconclusive as to the relative merits of these and other measures in general terms. Ginsburgh and Hansen (41) propose data checks for Euclidean distances only, having regard for whether the road network is basically rectangular "as for instance in an urban area" or is lying across inter-city areas (flat on the one hand

or hilly on the other.) As against this, Love and Morris (42), argue that "the standard assumption that urban distances are rectangular is not supported... the Euclidean distance is more convenient to use and appears to estimate urban distances more accurately unless the road network has a strong rectangular bias". In an earlier work (43), Love and Morris suggest that "when estimating distances between points which are relatively close, the curvature of the roadways becomes important and might well be accounted for by a function... representing a cross between the rectangular and the Euclidean metric. Contrarily, when estimating distances between more distant points, the curvature of roadways might be thought of as being 'averaged out' so that a... straight line function better estimates actual road distances".

38. For the purposes of the project, lateral (or rectangular) distances to centres were measured in terms of grid squares, ie grid references were taken to a broad resolution of 5 kilometres. Lateral measures of distances to centres, as observed in the transport survey, were then regressed on averages of associated ranges of straight line distances. These ranges allowed for (i) the coarseness of the grid, and (ii) numbers of stopping (pick-up/set-down) points on journeys; there was also recognition of (iii) variations in relative lengths of vertical (north-south) and horizontal (east-west) movements possible with given lateral lengths. For the detail, see Henry Sonnenberg (44, appended).

39. The straight line lengths provided by the resultant regression equation were then converted into actual distances by "a generally accepted method ... which is to inflate straight-line distances by multiplying them by a constant" (Love and Morris (43)). In Patel's study for rural social service areas in India (17) "it was found that a factor of 1.5 needed to be applied to shortest Euclidean length to convert it to likely actual length for the kind of terrain existent in Dharampur ... The Public Works Department uses this ratio in making its estimates for this region". The constant selected for the training centre project was $\pi/2$, on the grounds that it was intuitively appealing, but a slight modification

was made in scaling so as to transform the coefficient on the lateral distance term appearing in the actual distance relationship to unity. This produced the elegant equation (all in terms of 5 kilometre squares):

$$\text{actual distance} = 2 + \text{lateral distance}$$

40. This relationship was attractive in that it provided a method for gauging actual distances by simple inspection of a grid map. The distance in kilometres could be obtained merely by multiplying by 5. It should be noted that the addition of the constant, 2 squares, in no way replicates the procedure adopted by Abernathy and Hershey (12): they applied a constant only to lateral distances of zero.

41. The equation was found to be consistent with some unverified data on distances obtained for administrative purposes by the education department from vehicle operators shortly after the transport survey was made. It was also reckoned satisfactory when applied to routes around Southampton Water and for Portsea-Hayling Island where the principal physical barriers to movement are encountered (the remainder of Hampshire is relatively flat and accessible). Some support also came from work undertaken by the district audit service who drew on the transport survey findings when making an investigation of their own in 1980 into transport arrangements for trainees attending the Bishopstoke centre (45).

42. It is emphasized that the relationship is intended for use when considering, aggregatively, journeys undertaken by a large number of trainees. This is not to say that the number of trainees on any individual route has to be large. The equation is meant to recognize also that routes may need to meander to pick up passengers on the way and that route lengths should be within the maximum distance (namely, 9 squares laterally) observed for the transport survey.

43. The transport survey first confirmed that the training centre transport bill was high. In 1978-79, it amounted to £320,000, compared with about twice that figure for employee

remuneration (including National Insurance and pension contributions) and total training centre recurrent expenditure of £1 $\frac{1}{4}$ million. The figure for transport was about £50,000 higher than in the social services department transport accounts (paragraph 30).

44. The survey also observed that, secondly, about a fifth of the trainees were not attending their nearest training centre. Had nearest centres been preferred, those at Basingstoke and Bishopstoke would have been over-subscribed; there would in contrast have been no difficulty obtaining places in the newer centres at Alton and Andover. About 30 trainees travelled from Basingstoke to Alton.

45. Thirdly, half the trainees were travelling for more than an hour a day on return trips to centres and over a quarter travelled for more than an hour and a half. In a few cases, return journeys lasted more than 3 hours. Fourthly, only 5 of the 66 hired vehicles covered by the survey arrived at centres before the 9 o'clock opening in the mornings and left again after they closed at 4 o'clock in the afternoons. Only a quarter of the trainees attended the centres for the full 7 hours a day. This was not associated with the need for children on the vehicles to be set-down and collected within shorter school hours.

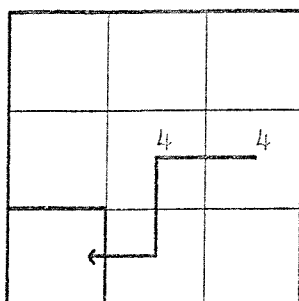
46. Fifthly, it transpired that on several of the routes to centres it would have been cheaper to have used taxis instead of mini-buses and coaches. It was not just that, say, 12 trainees all starting out at the same point on a route could be conveyed more economically in 4 taxis than in a 14-seat mini-bus; there was also the point that still greater savings could be obtained using taxis when trainees were staged along a route at several points instead of being at only one (Diagram 1).

RESEARCH OBJECTIVES

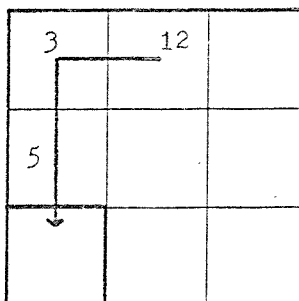
47. Social services senior management were not surprised by these findings; there had been anecdotal evidence for some time. They were now of the view, with the survey findings to hand, that

DIAGRAM 1: Costs of Conveying Trainees to Centres

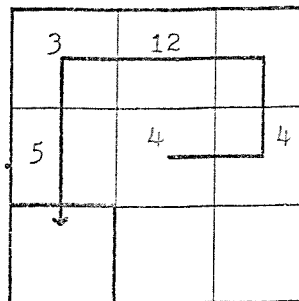
The routes show numbers of trainees being taken to the centre in the bottom left-hand grid square:



Route A



Route B



Routes A and B
combined

The illustrative passenger seating capacities and annual hiring costs of vehicles are :

Mode	Seating capacity	Single journey lateral route length(grid squares)					
		1	2	3	4	5	6
Annual cost (£)							
Taxi	3	900	1050	1200	1350	1500	1650
Mini-bus	14	4300	4600	4900	5200	5500	5800
Coach	29	6500	7000	7500	8000	8500	9000

On route A, minimizing the number of vehicles would involve hiring a mini-bus for a lateral route length of 3 squares at an annual cost of £4,900. If all 8 trainees travelled 3 squares, then costs could be minimized using 3 taxis (£3,600). With 4 of the trainees travelling 2 squares, it is necessary to hire 2 taxis only over the full journey length and 1 over the shorter length; the annual cost is then £3450.

On route B, minimizing the number of vehicles involves using a coach at an annual cost of £7500. In this case, if costs are to be minimized, it is necessary to use a mini-bus over the full route length, notwithstanding that this is more expensive than hiring 4 taxis for the 12 trainees who are 3 squares from the centre.

DIAGRAM 1 (cont'd):

It is then necessary to hire a taxi over a 2 square length, picking up 1 of the 3 trainees 2 squares from the centre and 2 of the remaining 5, and a taxi over a 1 square length for the remaining 3 trainees. The annual cost is then £6,850.

On routes A and B combined, it is necessary to hire a coach to minimize costs, involving an outlay of £9000.

If routes A and B are combined, there is an annual cost saving of £1,300. As against this, 4 trainees would then travel 6 squares laterally in a single journey instead of 2 and 4 others would travel 5 squares instead of 3. Assuming a linear relationship between journey lengths and travel times, and letting x_1, x_2, x_3, \dots be the reductions in travel time associated with reductions in lateral journey lengths of from 6 to 5 squares, of from 5 to 4 squares, of from 4 to 3 squares, ..., SMT can then be asked to specify the direction of the inequality for a constraint :

left hand side	direction of inequality	right hand side
$4(x_1 + x_2 + x_3 + x_4) + 4(x_2 + x_3)$?	1300

to be used in a linear programming formulation where the objective function takes the form : $x_1 + x_2 + x_3 + \dots$ and where $x_1 > x_2, x_2 > x_3, x_3 > x_4, \dots$ with all the x's being positive.

Education had not been adequately briefed by Social Services and that improvements could be effected by appointing a social services officer with whom Education could liaise on transport logistics. This was a suggestion also of the district audit service.

48. It was now agreed with the author that the purpose of the research should, in the first instance, be to provide an indication of possible savings in the transport bill that would result, in the context of sending existing trainees to existing centres, from a social services liaison officer (i) changing the modes of transport used, and (ii) modifying the routes. This information would assist in justifying the need for the new post. The research could then, secondly, pursue the idea that the officer would need to weigh transport costs on the one hand against trainees' travelling times on the other. Senior management had already accepted that transport costs need not be minimized if trainees had, as a result, to travel long distances. Thirdly, it would then be appropriate to consider how transport costs would be affected by changing (i) the centres attended by trainees, and (ii) the capacities and locations of centres. This was seen as a longer-term planning issue involving a need to make assumptions about changes in the size of the client population and in its geographical distribution.

CHANGING THE MODES OF TRANSPORT

49. Because arrangements for transporting trainees to the centres in Portsmouth and Southampton using double-decker buses contracted for direct by Social Services were considered satisfactory by SMT, attention was directed at the other centres where Education provided coaches, mini-buses and taxis. The transport survey data had been transferred to magnetic disc for analysis using the Statistical (computer) Package for the Social Sciences (SPSS (46)). Regressions, modified in the light of figures from Education on revisions to contract rates following minor route modifications, suggested the marginal costs to the county of travel by coach, mini-bus and taxi were 24p, 16p and 12p a mile (at 1978-79 prices).

50. There was reason to believe that coach and mini-bus costs were less sensitive to distance than the regression equations implied. This was partly because many of the coach and mini-bus operators were linked through membership of trade associations which themselves negotiated with the county on behalf of contractors. Journeys were therefore costed for the purposes of the project using averages of observations for each of the three modes by distance. (This judgement was finely balanced: it might have been preferable to have accepted the regressions.) The cost of transporting the 750 trainees at these average rates using the existing modes of transport was £270,000 in a full year.

51. In order to estimate the cost of conveying these trainees along the same routes substituting cheaper modes of transport, taking into account that trainees were staged along routes at several points, it was necessary to develop an algorithm. A trial and error approach would have been too time-consuming. Application of the algorithm (a form of branch and bound technique) suggested that by increasing the number of taxis from 20 to over 100 and reducing numbers of coaches and mini-buses from about 40 in all to about 20, the transport bill could be reduced by about £45,000 to £225,000 a year.

52. Even allowing for a 20% error, this saving would have been sufficient at 1978-79 prices to provide the salaries of 8 training centre instructor supervisors. The saving was more than was required to justify the creation of the social services transport liaison post.

MODIFYING THE ROUTES

53. Two sets of revised lateral (not actual) route patterns were considered. The first, involving 55 routes, was designed to minimise the distance each of the 750 trainees would have had to travel to reach the centre currently attended. The second reduced the number of routes to 30 and some trainees would therefore have been unable to travel shortest distances. The route patterns were in neither case optimal in the sense of minimising transport costs. It was unimportant that vehicles

might not actually follow these routes (Belford and Ratliff (30)).

54. With the 55 "shortest distance" routes, the algorithm suggested that about 130 taxis would have been required. The number of coaches and mini-buses needed would, in all, have been about a dozen. These vehicles would have cost about £215,000 a year to hire. On average, each trainee would have travelled about $3\frac{1}{2}$ miles a day less than on existing routes.

55. The 30 "reduced" routes would have required about 60 taxis; the number of coaches and taxis would then have totalled about 20. The annual cost of hiring these vehicles would have been £185,000. As compared with the "shortest distance" case, 120 trainees would each have travelled about $12\frac{1}{2}$ miles a day more.

56. The algorithm was applied to 200 routes in all, including alternatives; the results were analyzed using SPSS. Regressions indicated that the cost of hiring vehicles on a route could be wholly explained in terms of the length of the route on the one hand and the number of trainees along the route on the other. The marginal hire charges would, at 1978-79 prices, have been 20p a mile, with an average of 2-3 vehicles on each route.

COMMUNICATION BETWEEN EDUCATION AND SOCIAL SERVICES

57. These further savings from route revisions, of up to £40,000 a year, were large. They were sufficient to provide the salaries of a further 7 instructor supervisors, making at least 15 in all, assuming a 20% margin of error.

58. The district auditors pointed out that Education were pursuing a policy of minimizing numbers of vehicles hired and at the same time ensuring as far as possible that trainees' journey lengths were not excessive. In doing so, Education were foregoing the opportunity to secure both

(i) the greater flexibility in route scheduling afforded by relatively cheap, short-distance taxis, and (ii) the economies of scale offered by long-distance coaches. Education were not unaware that financial savings foregone were substantial. In the author's view, this deliberate application of their policy cautioned that the appointment of a transport officer in Social Services with whom Education could liaise might not in itself provide a remedy for the deficiencies high-lighted by the transport survey. SMT might additionally have to impose constraints.

59. The lack of communication between Education and Social Services, which both departments had identified as a cause of inefficiency, was attributable, first, to the design of the questionnaire used for trainees applying for admission to centres. Secondly, it resulted from an indifferent response of SMT to a 1977 internal departmental working party recommendation that guidance should be given to Education on trainees' travelling times (47).

60. The admissions form, known as "the MH1", ran to 5 pages of A4; excluding explanatory notes. It was completed by the social worker assigned to the applicant. The information requested by the form referred almost wholly to behavioural attributes of the client, gleaned from information supplied by teachers, mental health advisers and psychologists. The social worker also recommended the centre to be attended; reasons for the choice and second preferences were not expected. There were two questions only on transport, asking simply: "is transport required ?" ("yes" or "no"); and, if so, "is an escort needed ?" ("yes" or "no"). There was no obligation on the social worker to consult transport officers either on the centre selected or on transport costs. The application would be discussed at a case conference attended by social work and mental handicap advisory staff who would make a decision on admittance; transport officers would not be present.

61. When an application was successful and transport was needed, the MH1 provided the basis for the authorization of the expenditure. The mode of transport to be used was influenced by the answer to the question on escorts. These were provided on all hired vehicles with the exception of taxis. In the event, 90% of trainees travelled under supervision; most MH1's said that escorts would be required and the use of taxis was therefore usually precluded. The route length was influenced by the view in Social Services that trainees should not travel "long distances". The 1977 working party had not defined this; nor was guidance provided in the semi-official "code of practice" for training centres issued by the National Development Group (20). Education, therefore, formed their own view, based on arrangements for conveying mentally handicapped school-children. This led to a multiplicity of routes, rather than a few, to each centre.

62. Education did not query the MH1 information or seek views on travel times partly because social workers are often out on field work. It was for this reason that the idea of nominating an officer in Social Services responsible for transport logistics with whom Education would liaise was considered attractive by SMT and the district auditors. The author doubted that the appointment of the liaison officer would be sufficient to rein-in expenditure and persuaded SMT that the lack of communication was a more deep-seated problem.

63. The examination of the MH1 admissions procedure and subsequent discussions with officers involved showed that it was not so much the division of responsibilities for transport between the education department on the one hand and the social services department on the other that needed to be tackled as the tension that existed between officers in the administration group on the one hand, who happened to be in Education, and officers in the specialist mental handicap advisory group on the other, who happened to be in Social Services. The social services transport logistics officer

would be in the administration group and the tension on transport matters and the concomitant lack of financial control would be likely to continue unless formally checked.

64. Education administration officers did not suggest that the social worker's "yes" response to the question on escorts might mean "'yes' if an escort is on offer, but 'no' otherwise" in case they should find that they had strayed outside their area of professional expertise. For the same reason they would not point out that a trainee's travelling time could be reduced if an alternative centre were to be attended or that putting a new entrant on to an existing coach route would be cheaper than hiring a taxi specially, the longer distance then involved notwithstanding.

65. In the same vein, social services advisory officers did not comment on the late arrival and early departure of vehicles at centres; they assumed this was a technical matter for logistics staff. In fact, it seems likely that contractors, sensing that social services training centre managers would take no action, had come to informal agreements among themselves as to when to be at centres so as to avoid congesting limited turn-around facilities and that Education had then acquiesced.

VALUING TRAINEES TRAVELLING TIME

66. SMT did not envisage that a liaison officer should have any difficulty bringing recalcitrant contractors into line. They recognized, though, that to be effective in dealings with mental handicap advisory staff, the officer would need high level backing in two ways. First, they agreed that the MH1 form would have to be re-designed. It would be incumbent on the social worker to consult the transport officers when filling in the form and to provide additional information on transport that could be taken into account by the case conference.

67. Secondly, SMT accepted that they themselves had an obligation to make the strategic judgement on how transport costs on the one hand should be weighed against trainees' travelling times on

the other. At the tactical, day to day, operational level, the liaison officer would then be able to control otherwise open-ended expenditure by accepting those case conference decisions falling within the strategic guidelines and rejecting all others. This was not to imply that the recommendations of advisory staff were to be subordinated to logistical considerations, but rather that advisers' views were to be reflected in the judgement to be made by SMT; it would be open to the advisers to influence that judgement.

68. These changes in procedures, strengthening the position of the social services transport officer (who is now in post), have recently been introduced. It may be noted here that they did not receive an immediately favourable response from social workers at outstations. Whilst they accepted in seminars and at team meetings that savings in transport expenditure could mean increased resources for other purposes within the mental handicap programme, they continued to take the line that compassion for clients, in what is essentially a caring service, dictated a need for larger expenditure under all sub-heads. The author does not claim personally to have won the support of social workers in the need for the new systems. The new procedures were agreed because of the lead given by senior advisers at headquarters and in the three large divisional social services offices who were well informed as to the purposes of the project and who supported its aims.

69. This experience with field workers possibly differs from that of Burton et al (48) who obtained the apparently willing support of an inter-disciplinary team including social workers and nurses in formulating a mathematical health care model in North Carolina: "the major point is to illustrate how a conceptual framework, expressed as a mathematical model, served to integrate and guide the efforts of this inter-disciplinary team". It is not clear, though, that the model is actually being used: "the entire resource allocation system ... cannot be completed until sufficient empirical evidence has been collected to estimate the transition probabilities of the technology matrix".

70. It is possible that in Hampshire social workers were approached at the wrong time: headquarters were recommending the abolition of the divisional offices, and subordinate area office staff, who included the field workers, were fearful that this would reduce the quality of the service they provided to clients. (The importance of timing for implementation, specifically in the context of computer simulation projects, is underscored by Tunnicliffe Wilson (49).) On balance, though, it should perhaps be recognised that "the quantification of subjective judgements is not an easy or a pleasant task for people such as social workers... who are not used to thinking about... their work in quantitative terms" (Derbyshire (18)).

71. Derbyshire extends his comment to "social work managers"; in Hampshire, though, senior management, having accepted the need to trade-off transport costs against travel times, were prepared to participate further, in an exercise designed to measure the strength of their preferences. It became clear that managers had only hazy ideas as to what they were trying to achieve for trainees. They pointed, for example, to the 1971 White Paper (13): "each handicapped person needs stimulation, social training and education and purposeful occupation and employment in order to develop to his maximum capacity". The author suggested to SMT that this "general principle" did not preclude the notion that travel could serve a useful training function. For example, the National Development Group (20) argue that trainees should be encouraged to undertake at least some travel where this would help in achieving greater independence: "the essence of the [training] centre should be that it is 'in' the community, giving... [trainees] the experience of travel from home to centre". But senior management did not accept that the Group had commuter travel in mind. They were instead of the view that trainees should spend part of their time, under supervision from the centres, shopping or visiting the local swimming pool, etc so as to develop the ability to cope with living in the community and the competence to handle money (including spending wisely the money they earned in the training centres). In this

context, they felt it would not come amiss for trainees to be further encouraged to use the local bus to the town centre so as to gain the necessary confidence to ask for destinations and tender bus fares. They did not agree, and were sure the Group were not suggesting, that commuter travel was in some sense therapeutic. They emphasised this by making it clear that hired vehicles should be at centres on time so that a full day's training could be obtained.

72. The author asked if lengthy travel times had benefits in the sense that families would receive greater relief from the strain of having the trainees at home. SMT agreed that the burden of caring for mentally handicapped dependents full-time was substantial and often not adequately recognized (see Nissel and Bonnerjea (50)), but they did not see that this could be taken to imply that longer, rather than shorter, journey lengths were desirable. Relief for the family was intended to be provided in large measure through increased independence for the trainee. It was important that the trainee should be able to lead as "normal" a life as possible when at home. Indeed, it was important also to discourage reliance by the trainee on the centre.

73. Given, then, that the trainee was to be viewed as any other adult and given that for the future, with more efficient transport arrangements, trainees would attend centres for the full 7 hours a day, SMT appeared to be taking the line that savings in travel times had a value, to the trainees themselves, as distinct from their families (who could for this purpose be ignored), in terms of leisure time foregone. Senior management confirmed this and agreed that it was for them, on behalf of the trainees, to come to a view on what the savings would be worth. They appreciated that in order to reduce distances travelled, for example through route modifications, transport costs would increase; they would need to know if an increase could be justified.

74. However, "there is no theoretical basis for using any single proxy to represent the value of commuter time savings, values have been commonly based on empirical evidence. The most

common approach to attempts to measure commuting (and other non-work) time-savings values has been to find out what travellers were willing to pay for faster travel in situations of choice" (Sharp (51)). Oort (52) agrees that "the most promising approach is one that relies on the observation of actual choices between alternative means of travel, the speedier alternative being also the more costly".

75. This "revealed preference" method was used by Beesley (53) who concentrated on a small sample of passengers choosing between methods of travel to central London where one method is slower and cheaper and another is quicker and more expensive. He made the simplifying assumption that "people are indifferent to the proportions of travelling time, walking time and waiting time associated with each public transport choice, and that they are indifferent to the proportions of time spent on each ... mode of public transport". For the purposes of the training centre project, walking and waiting times were ignored on the grounds that the information was not available. This was thought not to matter for, as between one transport option for an individual and another, the times were unlikely to differ markedly. Beesley's assumption on modes was retained, though for the project it was translated from public to hired vehicles.

76. A difficulty with Beesley's approach is that "there are bound to be differences between individuals in their valuation of time, and also differences for the same individual on different occasions" (Tipping (54)). Such inter-personal and inter-temporal factors can, however, be assumed away if SMT are, as here, collectively acting on behalf of all trainees, and on a consistent basis. De Serpa (55) notes the inconsistent choices made by a number of Beesley's respondents and suggests that non-economic factors may have been important. (Tipping (54) provides the example here of the inconvenience of arriving at work too early following a possible change to a shorter journey.) The need for SMT to make consistent choices is mentioned below.

77. Beesley's approach is also criticised by Lee and Dalvi (56) who argued that those preferring time to money value time differently from those preferring money to time. Again, though,

this can here be assumed away. Lee and Dalvi later (57) implicitly criticised Beesley further on the grounds that his calculations of private car costs were critical for the outcome. For the training centre project, costs are based on observations for contracted vehicles and the argument that the figures admit wide variations has less force; nonetheless, it points to the need to keep the regression data under review.

78. It had initially been intended to compare the values placed by SMT on time savings with trainees' earnings at the centres. Sharp (51) says that "there are... undoubtedly many circumstances in which travel is regarded as... an 'inferior activity' and when an increase in income will result in the partial substitution of some preferred activity (such as spending longer at home before starting a commuter journey) at the cost of buying a quicker but dearer form of transport. Most empirical work on time-savings values shows that there is a strong positive association with income levels". Oort (52) mentions that "actual tests... suggest that reductions of travelling time are evaluated at somewhere about one third of the individual's rate of pay".

79. Data on trainees' wages were being obtained for another purpose (see below) and it would have been a straightforward matter to have obtained an average payment. There was a complication, though, in that trainees' wages are constrained to low figures partly so as to avoid abatement of Social Security benefits (58). It is rare, therefore, for a trainee to earn more than £4 a week. Even so, a method could have been devised for grossing the amounts up. For example, trainees earning £4 a week were in many cases engaged in gardening at county homes for the elderly and this could perhaps have been equated with the lowest wage paid to council groundstaff and used as a benchmark for converting other trainee wages.

80. In the event, it was decided not to pursue this, bearing in mind that SMT and not the trainees themselves were making the valuation of time savings. It was important that SMT should make a strategic judgement in an area as yet uncharted.

To have introduced the wages point would not only have been unwise on theoretical grounds, but would almost certainly have prejudiced the outcome of managers' deliberations in that it would have been seized on as a point of reference. There was also the point that trainees' wages were becoming a source of contention (see below) and it was important that the credibility of the project should not suffer on this score.

81. There was a further point as well: it would have been unfortunate if management's views had been coloured by giving them the impression that they should be seeking a single time savings value. It was pertinent to ask SMT if they thought the unit value of time savings was constant. Sharp (51) observes that "time saved from commuting ... does not need to be used for any particular productive purpose in order to have value. Travellers might put the same unit value on time savings of a few minutes made on the journey home from work as they would on much larger time savings". He goes on to say "it might be expected that small time savings would have more value on shorter journeys... empirical evidence on the relationship between the value of time savings and their length does not provide any very clear picture". Becker (59) suggests that "relatively more people use faster mediums, for longer distances, presumably because of the greater importance of the saving in time".

82. Senior management, for their part, were all of one mind that the longer a trainee's journey, the more it was worth diverting training centre resources towards shortening it through increased expenditure on transport. It was reckoned to be worth giving up more to reduce a trainee's travelling time by 15 minutes when the journey already lasted an hour, say, than when it lasted only, say, three-quarters of an hour. Similarly, a reduction of 15 minutes would be worth more in terms of resources foregone when travelling time was currently three-quarters of an hour than when it was half an hour; and so on. (Because of the way distances were determined for the purposes of the project, it was implicit that trainees would always undertake at least some travel; the question was not considered, therefore, as to the value that would be placed on reducing travelling time to zero.)

83. They were reluctant, however, to say more precisely what values they would place on the successive increments of time or distance. This was partly because they did not wish to appear to colleagues to be profligate by putting forward high values nor to appear lacking in compassion for a disadvantaged section of the community by putting forward modest figures. In the main, it was because they had little idea of even the order of the magnitudes they were dealing with. They realized that the values they would be placing on travelling times were by no means notional; on the contrary, they appreciated that additional transport expenditure would have to be met within the cash limit for the training centre budget as a whole.

84. It was a salutary exercise for management to have to think through in this way what it was they were endeavouring to achieve. It is notable that much of the literature on location (for a bibliography see Francis and Goldstein (60) and Haggett et al (61)) stresses the importance of reducing distances without considering how far this goes towards achieving decision-makers' objectives. Some of the literature is discussed later.

85. To help SMT place values on travelling times, a number of linear programming problems were set up in which successive increments of time were the variables to be summed in an objective function to be both maximized and minimized. SMT were invited to decide on the direction of inequalities in the constraints by answering "yes" or "no" to questions such as: "would you be prepared to pay £1,000 a year more on transport at 1978-79 prices to reduce the travelling time of 5 trainees from 60 minutes in a single journey to 45 minutes and of a further 3 trainees from 45 minutes to 30 minutes and of a further 7 trainees from 30 minutes to 15 minutes?" The questions were based on differences in transport costs and journey lengths obtained when estimating the savings from modifying routes; this was not essential, but provided SMT with concrete examples which they found helpful. The journey lengths were converted into travel times using regressions based on the data in the transport survey. The times were meant to be

indicative only, taking into account that distances had been imputed; SMT accepted them in this spirit.

86. For each official, the directions of the inequalities were checked for consistency. It was not seen necessary that there should be consistency as between one official and another. Majority verdicts were then used, with a further check for consistency; the resultant inequalities were taken to be a consensus view. The problems were solved to eventually obtain ranges of values for the increments of time using a Department of Accounting and Management Economics package on the University's main-frame computer.

87. Becker (59) has said "one should be able to estimate a marginal value of time if only from the relation between... mode and distance". The use of linear programming for this purpose does not appear hitherto to have been considered. Its possible further application in this field would be worth exploring. (The Department of Transport provides for modelling purposes unit values of time which are constant only: "modelling values of time should not be taken to extremes of sophistication"(62).)

88. This is not to say that linear programming has previously been ignored in revealed preference work more generally. Renold and Wilson (63) have applied the technique in deriving weights associated with applicants' needs factors in a housing allocation scheme run by the City of Manchester. They, too, asked officials to make (consistent) choices and similarly derived a consensus. Theirs, however, was a two stage approach. In the first stage "checks are needed to confirm (i) that judgements made by one official of different cases are consistent with each other, and (ii) that judgements made by different officials of the same case are also consistent". This second requirement does not seem to have been essential and may have been imposed so that in the second stage "it was therefore considered simplest to rely on the judgement of one official only - in this case the assistant director (management)". In Hampshire, a single official would not have wanted this responsibility (see below).

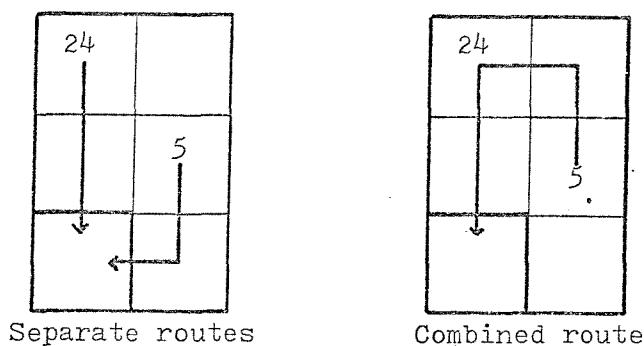
89. Hopkins et al (16) also used linear programming, when considering the preferences of administrators at Stanford University. They found "(not surprisingly, to us) major differences... among individuals working for the same university administration". Their approach differed in that they optimized for each individual, rather than on a consensus, with the resolution of differences then being "for discussion". It is doubtful whether this would have been satisfactory in Hampshire's case. There, the author's method won the support of SMT for three reasons: first, none of the Team was asked to value increments of time explicitly; the LP solutions provided ranges of implicit values with which members could not be associated individually. Secondly, the computer, essential in view of the numbers of variables and constraints, "intermediated" between the Team and the results and incurred the odium for any unrealistic implicit values that emerged in particular rounds. The Team appreciated, however, that they would have to be committed to the valuations which they would finally come to decide. Thirdly, the method appealed to the Team's interest in quantitative management techniques. They felt they were being "scientific"; at the same time they realized their valuations were subjective. (There is a sense, then, where Ackoff (2) is right: participation can be "fun".) This contrasts with the experience of Hopkins et al (16) who discovered with some individuals possible "lack of motivation, misunderstanding, fatigue".

90. In using the valuations of successive increments of time, it may sometimes be found that decisions are required in circumstances where the balance of advantage is not clear-cut (Diagram 2). In these cases there may need to be an appeal to a higher authority, perhaps to a member of SMT such as the assistant director (resources).

IMPLICATION FOR SHORT-TERM POLICY

91. The importance attached by SMT to reducing trainees' travelling time was high. In the short-term it was practicable only to continue sending existing trainees to existing centres, to avoid breaking up friendship networks (this was a view held strongly by case workers). They therefore decided to seek

DIAGRAM 2: Choosing Between Alternative Routes for New Entrants to a Centre



Using the schedule in Diagram 1, to convey just the 24 trainees to the training centre in the bottom left-hand grid square it would be necessary to hire a coach at an annual cost of £7,000. A case conference might recommend that 5 new entrants, located as shown, should all travel by the shortest route; 2 taxis would then be required costing a total of £2,100. If the coach were re-routed so as to pick-up all 29 trainees, the annual cost would be £8,000; the new entrants would then be travelling 4 squares to the centre instead of 2. On cost grounds, a combined route would be preferred. If SMT had valued changes in journey lengths as follows:

from 4 to 3 squares - £150 per trainee a year \pm 20%

from 3 to 2 squares - £100 " " " " \pm 20% ,

then they would be prepared to incur additional transport expenditure for the 5 trainees in the range £1000 to £1500. The increase using taxis, £1100, falls within this range and could therefore be a borderline case, assuming SMT intended that the 20% figure should provide a safety margin.

the cost savings of £45-55,000 a year that would result from a wider use of taxis rather than the larger amount, £85,000, which would follow using more coaches.

92. This had a number of policy implications (which would have included a recommendation to policy and resources committee to withdraw charges on trainees for transport, had the charges been introduced as originally planned). First, there would have to be a re-appraisal of the requirement for escorts. It was considered that most trainees could travel unsupervised. Secondly, there was a need to ensure that taxis could be hired on the scale envisaged. In the event that this would not be possible, consideration was to be given to the idea that trainees' families should be eligible for car mileage allowances for conveying dependants to centres themselves. This would be no more expensive than hiring taxis and would be helpful also where trainees did need supervision.

93. Thirdly, there would be the opportunity to negotiate from a stronger position when dealing with the coach and mini-bus operator associations over future price increases. The likely outcome of this could not be predicted.

94. Fourthly, additional turn-around facilities would be required at some centres to cope with the extra vehicles. The finance for this would be obtained through joint funding arrangements (4) with the Hampshire Area Health Authority who had made available to Social Services an additional £150,000 for each of the three financial years to 1983-84 for capital projects for the mentally handicapped.

LONGER-TERM POLICY

95. This further capital allocation of £150,000 a year was not available for projects which would generate additional revenue expenditure. With savings on transport of over £40,000 a year, it was confirmed that there would be the opportunity to recruit

more staff within overall cash limits. Accordingly, a working party was set up to propose projects, in addition to extensions to training centre turn-around facilities and other purely capital works such as the creation of more training centre office space, which, with associated expenditure on new staff, would be particularly attractive. The author was a member.

96. The working party recommended, and SMT accepted, that a number of 3-4 bedroomed houses should be purchased, which would be under the control of training centre managers, in which trainees could be helped during the day to integrate more with the local community. The houses would have instructor supervisors additional to existing training centre complements. This innovatory departure from the conventional pattern of day-care had been advocated by social services mental health advisers for some time. With the annual savings in transport expenditure it is now to become a reality. This may have an impact on future attitudes of social workers to the project (paragraph 68).

97. The idea of satellite houses brought to the fore the question of future sizes of training centre complexes. Department of Health and Social Security (DHSS) guidelines had been suggesting that places should be provided for 50, 80, 120 or 150 trainees at any one location (64). Social services senior management were of the view that in planning for the longer-term there should be greater flexibility in numbers. The author was therefore advised that in proceeding to the final phase of the project, in considering changing the centres attended by existing trainees and in recommending approaches for determining locations for centres in the future, numbers of trainees to be concentrated on any one complex of day-care facilities need not be constrained.

TRAINING CENTRE COSTS AND WAGES AND ATTENDANCE SURVEY

98. It was decided to treat each 5x5 kilometre grid square as a possible concentration of day-care facilities, the precise nature of the complex (eg one or more conventional centres or a single centre with satellite houses) being for determination in the

future. The regression equations for transport costs were in terms of payments to contractors per route, and this implied that as the number of centres (grid square locations) increased, given the number of trainees, so might the total transport bill, for although overall distances travelled would decline the number of routes would rise. The valuations on travel time savings would help in deciding whether the increased transport expenditure and hence the increased number of sites was justified.

99. For a given number of trainees, there was also the point, however, that an increase in the number of centres, rather than extensions to existing centres, might involve differences in training centre recurrent and capital costs. Larger complexes, for example, might encounter diseconomies of scale (see Boldy on hospital costs (10)) and these would need to be set against perceived advantages for trainees. As it turned out, the judgement of social services mental health advisory staff was that smaller, rather than larger, facilities were to be preferred from the point of view of the "quality of care". The author felt there was a need for advisers to spell out more precisely what they meant by "quality of care" as there might otherwise be the risk that possible economies of scale would be overlooked.

100. It was therefore decided, first, that the behaviour of training centre costs should be examined and, secondly, that an attempt should be made to develop an index showing how the quality of day care varied with training centre size. Advisory staff doubted the merits of this exercise and were reluctant to become involved (see Derbyshire (18)). The author therefore acted alone.

101. Capital costs were ignored on the grounds (i) that historical data were difficult to obtain, and (ii) that future costs would be speculative, varying with the nature of projects (extensions or green field developments and conventional or satellite arrangements) and their geographical location, given wide variations throughout the county in land prices. The uncertain

nature of future projects also militated against estimating recurrent expenditure, but here there was an availability of historical data, supplied by the county treasurer's department, which was worth considering.

102. The information was for 1978-79, the latest financial year for which there were finalised figures; these were at detailed, ledger-head, level. The data had to be modified; for example, many of the items of cost were arbitrary apportionments and in one case a centre had been used for part of the year as an occupational therapy unit, with consequential distortions in expenditures. There were further difficulties with the figures: there were only 10 centres and most were similar in size, so that variability by number of trainees could not confidently be gauged for all items of outlay; yet they differed appreciably in other respects, for example in terms of age and hence in cleaning and heating (electricity or oil) arrangements.

103. In the event, salaried staff costs only were considered, excluding staff associated with (small) special care units, at (two) centres, for profoundly handicapped trainees. A regression suggested marginal costs were constant, even allowing for higher level staff at larger centres. This was not surprising as costs reflected a staffing formula related to numbers of trainees. Given that salaried staff costs are a major component of recurrent expenditure (accounting for 35% of the total, excluding employer National Insurance and pension contributions), it was agreed that estimates would be of interest to senior management in considering options for the future. This information would, though, be no more than indicative, partly because it assumed future staffing ratios would be the same as at present and partly because there was a presumption, with a constant term in the equation, that a larger number of smaller centres for a given number of trainees would be more costly than fewer larger centres; this would require further investigation.

104. The approach adopted for the index of quality of care involved enquiry into the weekly payments (wages) of trainees

and their attendance records over the first quarter of 1979 (Henry Sonnenberg (65)). This period was one for which both (i) the weekly wages sheets in the county treasurer's department, and (ii) the attendance registers at centres were no longer in use and therefore available for analysis. It was also undisturbed by annual and public holidays.

105. Extracted information on wages and attendance for each of 1200 trainees for whom there was a complete 3 month run of figures was linked up via trainees' names with the transport survey data on modes of travel and distances to centres. It was also linked with data on ages of trainees and the nature of their disability (severe or mild) obtained from the Management Information System and the Wessex Mental Handicap Register (see below). An analysis was then made using SPSS.

106. Trainees' wages, adjusted for time lost through absence, were low, being kept to under £4 a week in most cases so as to leave their social security benefits unaffected. They were supposedly paid on the basis of performance at centres, not only in workshops but also in activities designed to develop living skills (see Whelan and Speake (66)). It was not so much trainees' achievement that was relevant for wage determination as their effort; this was assessed by the training centre on a points system. Given this, it was the author's contention that all trainees at a centre should earn the centre's average wage: this would be less than £4 a week as revenue from training centre sales is modest. The greater is the dispersion of wages about the average, it was argued, the more it can be said that trainees are not responding adequately to the training environment. Huddle (67) concluded that "trainable mentally retarded subjects can respond to incentives in essentially the same fashion as normal subjects ... there may be positive behavioral effects on the trainable retarded subjects receiving monetary incentive that may generalise to other areas". He also observed that "trainable retarded subjects require minimal supervision if the task is sufficiently challenging". Whatmore et al (68) hold the view (in a residential setting) that "the class of stimuli

most likely to determine the frequency of specific classes of client behaviour is staff attention".

107. The analysis showed that wages paid for time attended averaged £1.75 a week. Even though this amount was low, the variations around it were substantial: 10% of trainees earned over £3 and up to £4 a week; a further 10% received less than 50p. The dispersion of wages about the average of centre increased with the size of the centre. It could not, though, be inferred from this that there was an inverse relationship between the size of a centre and the quality of care. Further investigation suggested that training centre staff were not awarding wages on as objective basis as had been assumed. Wage rates seemed to depend less on effort than on age and the level of dependency (degree of disability). There was also evidence that as between one trainee and another the rate per day attended was lower the smaller was the number of hours attended, notwithstanding that this was due to transport arrangements. The rate per day attended was also lower the higher was the absence rate. There was nothing to suggest that trainees' wages or attendance rates were influenced by modes of travel or their journey lengths; this was reassuring.

108. As the determination of trainees' wages appeared to be less than rational, the author decided not to pursue the idea of an index of care. This was welcomed by mental health advisers who nonetheless, in common with other senior managers, were surprised by the findings. This and a decline in workshop revenues led to the setting-up of another working party, to review methods of future payment.

WESSEX MENTAL HANDICAP REGISTER: GRID SQUARE ANALYSIS

109. In considering the re-allocation of existing trainees to centres, there was a need to obtain profiles of trainee populations at each centre in terms of trainees' ages, disabilities and places of long-term care (institutional and other) so that new and existing trainee patterns could be compared. In

addition, in planning future locations of day-care facilities, it was necessary to have a firmer idea of the geographical distribution of the mentally handicapped population than could be obtained by applying county-wide prevalence rates to projections of the total population of the county by area.

110. An analysis was therefore made of data held on the Wessex Mental Handicap Register (Kushlick and Cox (69) and Henry Sonnenberg (70)). This covers all mentally handicapped persons who reside in and/or have next of kin in Dorset, Hampshire, the Isle of Wight and Wiltshire and who are known to schools, hospitals and local authority social services departments. It also includes others found through surveys. The register is continually up-dated by the Health Care Evaluation Research Team (HCERT) in Winchester. It was a principal source of data for the 1971 White Paper.

111. HCERT provided facilities for the author to extract from the register the names, ages, disabilities, training centres attended, places of long-term care and locations of the next of kin of the mentally handicapped adults in Hampshire. This exercise was undertaken in the autumn of 1979 at which time the number of persons involved was 4,750. The places of long-term care were then used to assign this adult population to 5 kilometre grid squares in the same way as in the transport survey. This "grid-referencing is a ... tedious exercise" (Robertson (37)) and here, too, therefore, postcodes are being added to facilitate up-dating using the "Postzon File" service. An interesting feature of the analysis was the larger proportion of young persons (eg under 40 years old) in residential institutions (hospitals and hostels) in Hampshire than was observed 10 years earlier by Richards (71) for a mental deficiency hospital in Surrey.

112. Previously when Hampshire had made use of the register, no attempt had been made to analyse the information geographically below social service (district council) area level, this

being the lowest level held on computer, as distinct from card index, records. This was one reason why two recently-built centres had been located beyond easy reach of client populations. "Planning of services does ... have to take place, and adequate planning needs information on the numbers and degrees of handicap in a given area. Probably the most useful sources of such information in recent years have been 'registers'" (Malin, et al (72)).

113. Details of the mentally handicapped population of the county below the age of 16 were not obtained from the register. Here, use was made of information obtained from returns submitted to the education department by head teachers of special schools for the educationally sub-normal. In September 1979, there were over 3,000 mentally handicapped children in Hampshire.

THE LOCATIONAL MODEL

114. This information on the geographical distribution of the mentally handicapped population was complemented by data for the total population of the county supplied by the planning department. Forecasts for the county as a whole were supplied to the year 2001 (73); a breakdown was available for each of the 5 years to 1984 at parish/ward level (36). The long-term projections were based on economic forecasts; the short-term figures reflected housing stock estimates.

115. The estimated population of the county for 1979 was taken as a base. The parish and the ward figures were assigned to 5 kilometre squares by eye by superimposing a grid on a map showing county administrative boundaries. The errors inherent in this method were assumed to be no greater than those in the estimates themselves. An alternative approach would have been to use a population breakdown at the finer enumeration district level and to have assigned these district populations to grid squares using the 1971 Census grid references for districts supplied by OPCS. This was rejected as too time-consuming; the method may be used when up-dating.

116. The decision of SMT that trainees should travel shorter rather than longer distances implied that in the longer-term they should if possible attend their nearest centre. Shortest actual distances were synonymous with minimum lateral distances. Nearest centres of trainees were therefore ascertained by drawing boundaries around grid square locations delineating catchment areas enclosing squares for which lateral distances to centres were shortest. These are analagous to what Davies (32) has called "natural" catchments.

117. This procedure was followed to obtain grid square catchment areas for the 11 centres attended by Hampshire trainees; this included the centre at Christchurch in Dorset. It was then possible, using the Wessex register data, analyzed by grid square, to obtain for each catchment area the mentally handicapped population and its characteristics (the age profile, the numbers who were trainees and/or were in long-term institutional care, etc). The prevalence of mental handicap was also obtained, by referring to the total population for the area; this could be compared with the guideline rates per 100,000 in the 1971 White Paper and the 1980 Blue Review.

118. By making an assumption about the number of routes to each centre, it was then possible to estimate the cost of transporting trainees within each catchment area using regressions of route costs derived from the algorithm. These related transport costs to (i) distances of trainees from centres, and (ii) the numbers of trainees; both were given by the grid square data for each catchment area. (It should be remembered that the distance metric for the project argues for a global approach, as here where there is a large number of trainees attending several centres spread over a wide area.)

119. The regression equations indicated that if instead of conveying 750 trainees to their existing centres they were instead directed to their nearest centres, then, with the emphasis being on short-distance taxis, the annual transport bill could be reduced from £215,000 at 1978-79 prices to probably

under £200,000; it might be of the order of £175,000*. To achieve these savings it would be necessary to change the capacities of centres. The locations of facilities can also change in the long-term, as can their number.

120. Changes in the locations of the existing centres were considered within the nearest square catchment area framework. Having ascertained the grid square distribution of trainees for each area, the squares were weighted by the trainees so as to obtain centroid grid references. It was then assumed that the centres were located in the centroid squares. The catchment areas were re-drawn and transport costs were then re-calculated. This iterative procedure ceases when centroids converge. When a catchment area changes, there can be consequential changes only for those areas with which it has common boundaries (Keeney (74)).

121. This exercise was of interest to SMT in that it provided support for a decision that had already been taken, namely that New Milton should be the location for a new centre to replace the facilities lost to Dorset at Christchurch. The centre is to be opened in 1983 when the agreement that Dorset should cater for Hampshire trainees in the New Forest expires.

122. The iteration produced only a modest further saving in transport costs. The advantage of a centre at New Milton over the Christchurch location was unequivocal, however, when allowance was made for changes in the distances trainees would have to travel. These were assigned the SMT values reflecting the preference for short journeys. It is a strength of this nearest square catchment area "model" (Henry Sonnenberg (75)), distinguishing it from others (see below) that journey lengths as well as transport costs are taken explicitly into account.

123. The model, and the use of centroids for iterating, has its parallel in approaches to the determination of electoral

* The transport bill for the existing 1350 trainees, including those for whom transport was not currently provided, re-allocated to nearest centres, including Christchurch (Dorset), was estimated at £300,000 at 1978-79 prices..

boundaries. These methods assign electoral divisions to larger constituencies so as to achieve equality of population; contiguity is usually obtained heuristically (for the model in this thesis, contiguity is assured, with squares equi-distant from centres being apportioned). The locational model here, like the electoral models, achieves a degree of compactness in the areas it determines through reductions in distances. It does not in fact aim for equality and this has implications for the assignment of squares in terms of speedy resolution. Hess et al (76) use a transportation algorithm where costs to be minimised are in terms of distances of census enumeration divisions from (initially) guessed legislative district centres. Following the assignment of population equally to form districts, their centroids become the district centres in the next round. This iterative procedure continues until there is convergence, though this is not guaranteed. (An integer programming formulation is also provided, but is rejected: "no algorithm currently exists to solve this formulation even for so small an area as Delaware".)

124. Mills (77) also uses a transportation algorithm, in assigning electoral divisions to wards in Bristol. He points out that "since the centre of gravity of each ward is revised at each iteration, then the procedure might never converge if continuous adjustment to ward boundaries were possible; however, since only discrete changes can be made, it seems reasonable to expect that the solution will stabilise". In the model described in this thesis, convergence was always, in the event, obtained (as with both Mills and Hess et al).

125. The implicit enumeration technique of Garfinkel and Nemhauser (78), which inter alia uses geographical compactness rather than the "more reasonable measure of population compactness" urged by Hess, represents an attempt to optimize by satisfying equality, compactness and contiguity constraints simultaneously. Their method is costly, in terms of computer time, and proved unsuccessful when applied to a 55 county state problem (West Virginia): "the number of population units seems to be the most significant factor affecting solution time".

126. In a more recent exercise in Strathclyde, Robertson (37) assigns electors, marshalled by grid squares, to polling stations using an algorithm designed to maximise accessibility; in effect, electors are assigned to nearest polling booths. She does not, however, allow the algorithm to iterate even though "a rearrangement of polling stations would doubtless give greater accessibility". An attempt is then made to achieve population equality through the "judicious movement of certain polling booths ... the successful 'movement' of centres to achieve parity depended on experience". Apparently, "time did not permit a modification of the ... algorithm to optimise parity instead of accessibility". The approach does not seem to be systematic and could be an example of using an inappropriate technique (see Achoff (1)).

127. SMT appreciated that the nearest square catchment area model, though conceptually straightforward, ("Keep ... Large scale problems simple" - Ignizio (79)), would impose a heavy burden on support staff were it to be run manually. Even at the coarse 5 kilometre grid square level, data have to be manipulated for 200 grid squares. They therefore agreed that it should be set up as a computer operation. SMT recognised that this would have the added advantage that the model could draw on the data files of the Management Information System. They also perceived that the model would then be able to handle a wide range of policy issues which past experience suggested were too complex to handle by rule of thumb methods. Some of these issues, including the health authority's intentions as regards lbhu's, had become pressing. It is worth noting here Tunnicliffe Wilson's observation (49): "an urgent problem is likely to have a deadline by which some decision must be made, with or without the help of ... a computer simulation model. The time taken for a simulation project is often very dependent on the time spent collecting and analysing the data ... A realistic assessment of the time required for this is needed to ensure that the project results will be available before the relevant decision has to be taken".

128. Programming assistance, within the purview of the treasurer's rather than the social services department, was not available within the time-scale envisaged; the author had anticipated this and had it in mind to use the Hampshire County Council Tabulation and Analysis Package (TAP). The author attended two short courses provided by the county's computer services department explaining TAP procedures. The package was intended to provide statistical measures, such as standard deviations, as well as cross-tabulations. Unlike SPSS, it also had a logic facility; this, and the capacity of the main-frame computer for handling large arrays of data, enabled it to cope with the large matrices the model requires. One of these, for the distance of each grid square from each of the others, contains 20,000 elements.

129. This use of TAP for manipulating grid data in matrix format was an interim measure. Several hundred lines of logic were required for the model and CPU time was high. Hampshire are now setting it up more efficiently using the recently installed programming language APL (80).

THE MODEL IN ACTION: "WHAT IF?"

130. With the model on the computer, it was necessary also to set up the Wessex register data as an input file. The Education and Planning data on school children and the total population were input as well.

131. In demonstrating the model for SMT it was made clear that, as for example with the total system or balance of care model developed by Coverdale and Negrine (23), it answered "what if?" questions: it did not attempt to optimise. Its "use is likely to lie in the exploration of the resource consequence and other effects of different policy options so that a more well-informed decision can be made" (Boldy (22)).

132. It was decided that output should be in the form of summary information (Table 1 and Diagram 3) showing, first, a selection of policy variables for each catchment area, and,

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*          TRAINING CENTRE LOCATION PROJECT          *  
*          EXISTING THAIKEES                        *  
*          REPLACEMENT OF CHRISTCHURCH FACILITIES    *  
*          TEN LOCATIONS                             *  
*****
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LOCATION	1	2	3	4	5	6	7	8	9	10
EASTING	5	7	8	10	12	13	14	15	15	18
NORTHING	2	12	5	6	4	13	3	4	9	13

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*
*      TRAINING CENTRE LOCATION PROJECT
*      CENTRIGIOS AT END OF THIS ITERATION
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      COMPARED  
* INITIAL RUN AND THIS ITERATION *  
* TRANSPORT COSTS AND TRAINEE CONVENIENCE *  
* TRAINING CENTRE LOCATION PROJECT *  
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TRANSPORT		NOS MORE	VALUE OF	COST AND
A		B	A-B	
COST	DISTANT	TIME SAVED	CONVENIENCE	
300797	180	16500	284297	C
297350	86	50400	246950	D
3443	94	-33900	37348	C-D
CHANGE				
THIS ITERATION				
INITIAL RUN				

[illegible]

NORTH

secondly, transport costs as between one run and another along with values attached to changes in travelling times. Thirdly, catchment areas were illustrated in computer diagrams obtained by using a supporting output table by grid square as input to another package, the Choropleth Mapping System (81). ("The major methods of presenting spatial patterns ... [include] isopleth (line of equal value) ... [and] choropleth (area of uniform value) ... population statistics refer to a defined area, allowing density ratios to be calculated and mapped" - Chisholm (82).)

133. The selected variables for each area included: the total population; the mentally handicapped adult population (with the number in institutional long-term care being shown separately); the number of trainees (again, with those in institutions separated); and the prevalence rate. In addition, an indication was provided of the actual distance travelled per trainee. The journey length was converted into minutes of travelling time using the regressions based on data obtained from the transport survey; this was intended to provide only an impression, given that distance figures are imputed. (Times, as distinct from distances, would be critical when considering the location of emergency facilities such as ambulances and fire engines. Kolesar et al (83) suggest the assumption that travel time equals travel distance divided by average velocity is inadequate: "we found ... that in most parts of New York City travel time increases with the square root of distance for short runs, and linearly only for long runs".) The grid square location of the centre was also shown.

134. There were two items of current cost: first, transport expenditure within each area, assuming the bias towards taxis; and, secondly, training centre salary bills. This item was again to give only an impression; it was based on numbers of trainees and was derived from the regression reflecting existing (1978-79) staffing levels at existing centres.

135. In running the model, it is necessary to specify grid squares in which training centre facilities are assumed to

be located. This is analogous to the need for initial guesses in some political districting studies. The centres need not be on conventional lines: there could be a cluster of facilities in a given square. The nominated squares are starting positions only; in iterating, the model may shift the facilities to other squares.

136. It is also necessary to ensure that the input data files are consistent with the time horizon relevant to the decision to be taken. In looking to the short to medium term, say 7 years ahead, there might be a need to include a tranche of the schools' population among those requiring training centre places. This can be done within the computer using selection arithmetic. In looking to the longer-term, there might be a need to increase population figures in line with planning department projections. This can be done using functional arithmetic. (Here, it would be necessary to make some assumption about the future incidence of mental handicap and mortality rates for the handicapped population - see Malin et al (72) and Office of Health Economics (84). In the longer-term runs described here, the mentally handicapped population was assumed to increase at a slower rate than the population as a whole, ie that prevalence would decline.) There might be a need to change the geographical distribution of the client population to reflect proposals incorporated into capital programmes for building new institutions of long-term care. This would involve setting-up and accessing an additional file.

137. For the demonstration, a variety of "what if?" questions was considered. One has already been mentioned: what if a new centre were to be built to replace facilities lost to an adjacent authority through the re-drawing of county boundaries? This exercise was repeated, but with the number of trainees augmented by school-leavers to deal with the question: what if additional places were required to meet the demand from special schools in the next 5 years? In both cases, the model suggested no changes in existing locations, ignoring Christchurch. They helped throw light on where increased capacity would be needed.

138. The most urgent problem facing Hampshire was the need to provide places for residents in the Coldeast and Tatchbury Mount hospitals who, it had been assumed, were to be decanted into lbhu's around the county. Confusion followed the publication of two documents: first, a 1981 DHSS Green Paper (85) suggested that local authorities might be able to acquire ownership of sub-normality hospitals. In this event, the need for decanting might not be so urgent. Secondly, the Winchester and Central Hampshire Health District, having worked on the assumption that Social Services would be unable to provide enough training centre places, had in 1980 obtained approval in principle to build a training centre themselves in 1987-88, in Winchester (27). This could be inconsistent with Social Services' own proposals for meeting demand in this, the central and northern, part of the county.

139. Against this background, the model was run first to compare (i) providing for residents at Coldeast and Tatchbury Mount on the assumption that even in the long-term, to 1996, they were to remain in hospitals with (ii) providing for them on the assumption that they were to be decanted. The questions asked here then were: what if, in the long-term, the health authority were to transfer ownership of the large sub-normality hospitals to Hampshire? and what if the health authority were instead to close the large hospitals and disperse residents around the county? In answering the second question it was assumed locations of lbhu's would be determined by reference to both the location of the next of kin and the geographical distribution of the population of the county as a whole. ("The Department of Health and Social Security ... is particularly concerned with policies which involve a shift in the balance between hospital and residential care on the one hand and care by community based services on the other" - Gibbs (25). It is for this reason that they are developing a total system or balance of care model. Coverdale and Negrine (23) say "the model is used to answer 'what if' questions; for example, 'what will happen to the pattern of service if the discharge of the mentally ill to the community is accelerated'", but they have found that "the calibration of parameters has proved to be difficult".)

140. The model suggested that without decanting, training centre facilities concentrated on Fareham would need to be half as large again as otherwise (Table 2). There was little to choose between the two policies in terms of transport costs which, for 2,300 trainees, would be of the order of £390,000 at 1978-79 prices. Here, it was decided to ask the further question: what if travelling times were to be reduced by siting facilities at an increased number of locations, ie 16 rather than 10 or 11? This was answered in the context of the option to decant: the transport bill increased to £470,000; but when allowance was made for the reductions in journey lengths the larger number of locations was preferable.

141. This is of some interest as the increase in transport costs was possibly distorted by assuming more routes were required than would in practice be necessary. Larson and Stevenson (86) argue "that mean travel distance is relatively insensitive to perturbations in the number of facilities as well as their locations" (see below). Mean distances were insensitive in this instance, as between 10 or 11 centres and 16, but the values placed on reducing lengthy journeys turned out to be critical. This need to trade-off increased transport costs against shorter journey lengths is similar to the problem encountered by Roberts and Gwynne (87) when considering the locations of kitchens for "meals on wheels" services in Worcestershire: "the best use of resources depends on finding the minimum distance to be traveled from each kitchen to its delivery area. If the distance is too long, time will be wasted traveling and there will be less time to serve meals. This will... mean that more vans and drivers are needed. The choice between building an extra kitchen or making vans travel longer distances can be very difficult, especially when there are several possible sites for the new kitchen ... the problem is... too great to approach by manual methods".

142. Turning to the health district proposal for a training centre of its own, the model was run secondly to handle the question: what if a new centre were to be opened soon at Winchester, would

TABLE 2: Numbers Attending Training Centres in 1996
with Facilities Concentrated on 10 Locations

Location	Number of Trainees		Present capacity of centres
	Assuming progress in decanting into lbhu's	Assuming no progress	
Aldershot	173	181	100
Alton	149	127	132
Andover	99	94	126
Basingstoke	218	220	100
Bishopstoke	331	280	128
Fareham	226	368	114
Havant	171	144	119
New Milton	115	104	120 ⁽¹⁾
Portsmouth	369	291	200
Southampton ⁽²⁾	429	471	291
	<hr/> 2280	<hr/> 2280	<hr/> 1430

1. under construction; about 40 trainees attend Christchurch
(Dorset) centre pro tem.

2. including Totton.

this pre-empt longer-term decisions? It was assumed here that progress would be made in decanting from the hospitals in the longer term and that there might eventually be merit in opening a centre at Odiham, near Basingstoke, and closing the centre at Andover. This did not represent an active proposal.

143. The model indicated that if a centre were to be built at Winchester then it might still make sense to keep the Andover centre open. On the other hand, if the centre at Andover were eventually to be closed then it might make more sense, instead of opening a centre at Winchester, to open one at Barton Stacey, between Winchester and Andover. In the context of the further question: what if there were to be a choice as to the order in which new facilities should be built? It seems it would be of little consequence in terms of transport costs and travelling times whether Winchester or Odiham were to be opened first providing the Andover centre were to be kept in use. (On a subsequent run it was found that it made little difference whether to open a further centre near Aldershot as against one near Basingstoke - see Larson and Stevenson (86).)

144. In handling all the above questions, it had to be understood that the outcomes were dependent on the nominated grid square starting positions. With electoral boundary models, locations have initially to be guessed. This was demonstrated by re-running the "16 locations" case assuming at the outset that facilities were regularly spaced on a grid covering not only Hampshire but also parts of adjacent counties. Four of the starting positions were grid squares in Dorset, West Sussex and Wiltshire.

145. This run, as was to be expected in the light of the Christchurch/New Milton exercise, re-located the four out-county facilities within the Hampshire border. It produced an alternative set of 16 locations which in terms of transport costs and travelling times were neither more nor less advantageous than the earlier outcome. In choosing between the alternatives, other factors such as the availability of sites and the possible need

to avoid concentrating large numbers of trainees in areas where the local community is small would be influential.

146. The run suggested that the model would converge more rapidly if starting positions were in centres of population rather than rural areas. In the event that a starting location has a catchment area with no trainees, the model ignores the centre and processing continues on the basis of one less facility than intended by the user. Such an outcome in the context, say, of a proposal to open a new centre might suggest that management's view as to where it should be sited is misconceived.

147. The model is dealing here, then, with such further questions as: (i) what if there were to be a choice of sites? (ii) what if a site lying outside the county was to be considered? and (iii) what if the catchment area of a centre were to include no trainees? These last two questions are important from the point of view more of understanding the way the model works than of formulating policy.

148. Although SMT had said that sizes of facilities need not be constrained for long-run purposes, they took the line that in the short-term they might wish to ask: what if some trainees were to be diverted from nearest to second-nearest centres? Accordingly, some additional logic was introduced. The Christchurch/New Milton exercise was then re-run on the assumption that the Basingstoke and Bishopstoke centres would initially be able to cope with no more than 120 trainees each. The distances some trainees would have to travel as a result were therefore increased.

149. At a presentation to the National Development Team for the Mentally Handicapped* in May 1982, the author was asked if the model could handle the question: what if there were a proposal

*The Team was set up in 1975 by the Secretary of State for Social Services. It has authority to examine local authority as well as health service provision. A function of the Team is "to provide specialist information about the current state of development of services" (15).

to open a number of lbhu's and local authority hostels for the mentally handicapped, where in the county should they be located and how would this affect the siting of new training centres?

It was explained to the Team that the importance of joint planning of facilities had been a reason for building the model. The model could be run first to help determine the locations of lbhu's and hostels by reference to the geographical distributions of the local communities and the next of kin. (Here, the aim would be to minimise distances between populations and the institutions, assuming transport costs and journey times, as explicit factors, could be ignored.) Secondly, the model could then be run again with the input file on the distribution of the mentally handicapped in institutional care amended in the light of the locations of the lbhu's and hostels so as to obtain locations for training centres.

ASSESSMENT

150. The model does not incorporate capital costs of centres.

This is because it is unlikely that centres will in future be built on conventional lines. There could be a move towards clusters of smaller units, including 3-4 bedroomed houses. The uncertainty surrounding the nature of facilities for the future is also a reason why the salaries figures produced by the model do not assume changes in staffing ratios.

151. Furthermore, the model does not directly take into account that care for the mentally handicapped is provided by a number of agencies and that their running costs are inter-dependent. Within Social Services, there is an inter-relationship between costs of training centres and costs of hostels. Boldy (22) comments: "perhaps the most potentially valuable mathematical programming models are those... which are concerned with exploring the wider aspects of allocating resources both between the different health and social service care sectors and between the various patient/client groups ... such... models are likely to be used in a 'what if' rather than an optimizing manner".

152. It should be recognized that Boldy was considering the balance of care models developed by Coverdale and Negrine (23) and Clayden (21). These are not concerned with the specific question of where facilities should be located, notwithstanding that Coverdale and Negrine appreciate that "a change in the provision of a particular service may not only affect services in its administrative group but also those in .../another/. This is especially likely when a change in the location of care is being considered. For example, the policy of moving from a hospital - based form of care for the mentally ill to one centred on the community has implications not only for psychiatric ward and community residential provision, but also for domiciliary support services". Clayden draws on the experience of models in financial management and provides "information which enables the amount of illness presenting to general practitioners and direct to hospital to be converted to a total demand for the different hospital resources ... the implications for the whole health service of changing methods of treatments can be assessed... thus, substituting out-patient treatment for those people currently admitted to hospital for varicose veins saves some six hospital bed days per admission at the extra cost of out-patient treatment (2 visits per case) and visits by district nurses (6 visits per case) and general practitioners (4 visits per case). The computer program calculates the number of patients who would be affected and thus the total effect on the various work loads. Intangible benefits of such a proposed change (eg the convenience of being at home) are not considered".

153. For the purposes of the locational model in this thesis an attempt was made to analyse the behaviour of costs for Hampshire's hostels for the mentally handicapped as well as corresponding costs for health authority residential care (supplied for 1978-79 by the county treasurer's department and Wessex regional health). However, for reasons already given when considering the behaviour of training centre costs, an analysis of the figures proved unrewarding. Nonetheless, the model can positively aid the joint planning of facilities as some of the "what if?" examples

above have suggested; this has represented an important step forward, enhancing the previous planning capability of the county. It is hoped that "the use of ... [the] what-if simulation model in an interactive manner with planners... [will] contribute to the evolution of a more satisfactory language for the planning dialogue between ... authorities" (Gibbs (25)).

154. It is also recognized that transport costs in the model reflect present rather than future modes of travel and that the estimates of journey time are broad averages intended to be no more than indicative. The more important point about future costs is that the model is not constrained by present routing considerations or by the present configuration of roads: it can operate on projections of client populations by grid square, given the method of determining distances. An advantage of the locational model in this thesis, using a grid, is that catchment areas can readily be determined by inspection of a map; actual distances can be gauged simply by counting squares. This approach is intended for use with large problems. Davies (32) used parishes and wards as population blocks and, as between centroids, attempted to measure distances and travel times more or less precisely. She concedes in her conclusion that "in dealing with larger scale services and larger populations... it may become apparent that the problem can be solved without the laborious perusal of timetables and many detailed calculations".

155. Turning to the point about travel times, it needs to be borne in mind that most locational models concentrate, as here, on distances, with times being provided, if at all, for general guidance. For example, Patel (17), in considering the location of social service centres in Dharampur sought to ensure that nearest villages were within a five mile radius: "at worst the walking time to a centre should be about 1½ hours". Generally, time, as distinct from distance, is the more relevant in studies for the location of emergency facilities, for it cannot be assumed that travel speeds are constant (Kolesar et al (83); see also Roberts and Gwynne (87)). Even so, Toregas et al (88) in their study of

emergency facility location are less than specific: "it is assumed that the minimum distance or minimum response time between any user-node/service-facility pair is known".

156. Hogg (29) found that "the speed of travel was... affected by the time of day and by the nature of the locality through which the journey was being made, but was not affected by the nature of the fire appliance". She therefore estimated travel times between nodes "by splitting up the routes according to the nature of the locality and by weighting journey times at varying times of the day by the number of appliance journeys made during those periods". The construction in this way of a matrix of travel times is laborious and has the further disadvantage that it may not be suitable when planning for several years ahead. Hogg uses a computer algorithm to allocate n sites to m (subjectively) pre-determined sub-areas ($n < m$) so as to minimize response times, taking into account the probability of occurrence of fires in the areas (for a review of this kind of generalized assignment problem, see Ross and Soland (89)). This is repeated with $n-1$ sites and combinations of $n-2, n-3, \dots, n-n+2$ sites. The combination selected is the smallest number of sites consistent with meeting the official guideline minimum response time. The model had only 19 sub-areas, covering Bristol; in contrast there are 200 5x5 kilometre grid squares, covering Hampshire, for the model described in this thesis. Hogg's approach would not be feasible, applied to such a large area.

157. Groom et al (19), in looking at ambulance services, are similarly concerned to ensure compliance with a guideline, the aim being to see that a minimum percentage of calls is answered within a given time. Again, a matrix of travel times has to be constructed. It was convenient, though, that they "found that the number of emergency calls to each node was closely related to the population at the node"; this must have reduced the burden of data collection. They experimented, using a computer, with different numbers of ambulances at different numbers of stations at different locations: "in the course of the study we carried out

several dozen different evaluations". This approach is inferior to Hogg's and, indeed, to that used for the locational model in this thesis, in that there is no iterative procedure. Torgas et al (88) also minimize the number of facilities within a response guideline; for their linear programming model it is necessary to nominate potential locations in advance: "the choice of which points should be taken as potential facility locations is up to the analyst". These cannot be moved as can the starting locations for the training centre model. They further claim that their approach "may equally well apply ... to the location of ordinary services, such as schools, libraries, etc"; the training centre model can similarly be modified for such purposes. A principal disadvantage of their method is that if the number of potential facility locations is large "the proposed solution method will not be practicable", notwithstanding that there can be "several hundred" nodes.

158. It should be noted that these emergency facility studies do not consider costs. Hogg (29) at least, recognizes this: "each additional station should pay for its upkeep in terms of the resultant savings in life and monetary loss from fire... The optimum number of stations... cannot be accurately assessed without using economic criteria... the financial data are not available". Davies (32) also appreciates this point: "the presence of an additional hospital... would reduce... travelling times. The reduction, however, may not be sufficient to justify the extra expense of developing the existing... cottage hospital into a community hospital"; but this is not pursued.

159. The model in this thesis does consider some costs: it explicitly takes into account the importance of transport costs to decision-makers, and associated time-savings. Dokmeci (24) suggests transport costs are likely to be important for health facility location especially if employees, physicians and visitors as well as clients are considered. Woodward (90) offers the view that transport costs can be important because of "the small geographical area of Britain".

160. That cost considerations are not always explicit in the literature is noteworthy. Garfinkel et al (91) draw attention to the point that "objectives and constraints are not easily quantifiable... In terms of capital outlay, it is usually cheapest to build one centralized public facility. However, the convenience and safety of the public, both difficult to measure, are primary goals. This is the reason that a fixed number of decentralized facilities are built. If we are dealing with 'ordinary' service facilities (post offices, schools, public buildings, and the like), then it is reasonable to try to minimize the total distance the public must travel". It is prima facie reasonable (paragraph 149, for example); nonetheless, the minimization of distances takes a lot for granted as the training centre location model with its emphasis on transport costs and journey times shows.

161. The absence of cost data from the Belford and Ratliff (30) model for racially balancing schools has already been mentioned. Here, rectangular bussing distances were minimized in a linear programming formulation subject to constraints as to numbers of black and white students to attend Florida schools. Bussing costs were not taken into account and consideration of lengthy journeys was introduced only in an extension to the model where "it was decided that no student should be forced to travel more than 10 miles". Yet it is claimed throughout that "bus routings that cause students to travel significantly further than the approximate rectangular distances... seem to be politically undesirable". Presumably, "costs are assumed to be proportional to distance" (Wesolowsky and Love (92)); see also Lashkari and Jaisingh (93) who assume a "constant of proportionality converting the distance between facilities... into a 'cost'".

162. Jennergren and Obel (33), in their study allocating students to schools in Odense, also use a linear programming formulation, but again there is no explicit consideration of how much it is worth paying to reduce travel times. Their model looks to 1992 when, with existing schools, there is sufficient capacity to accommodate the expected total number of students. The

model is run first to minimise student-weighted Euclidean (straight-line) distances between schools and the districts in which the students are expected to be living, subject to school capacity constraints. It is then re-run on an assumption that some existing schools could be expanded and that new schools could be opened in designated areas; the two runs are then compared. The model provides no guidance on how to choose between alternatives, yet its purpose is to answer the question: "does a particular configuration result in unacceptably long distances to school?" Nor is there an iterative procedure which would throw light on whether existing schools could in the future appropriately be re-located. The authors claim that its "simplicity was a decided advantage. It made the underlying assumptions very transparent".

163. The training centre model not only explicitly considered travel time savings, but endeavoured also to take into account variations in the quality of care associated with differences in numbers of trainees for whom provision is made at individual locations. It proved not possible to incorporate the author's proposed index of care, though the idea of using dispersions in trainees' wages was certainly innovatory and remains to be pursued in its own right. It is, though, a difficult area: "the measurement of the ... effectiveness of given services for given groups of the population presents considerable problems" (Boldy (22)); then again: "the problem of ... attempting to measure and deduce reasons for differences in 'performance' between hospitals ... clearly demonstrates the need for better and more consistent data systems" (Simpson (26)).

164. The computational simplicity of the model in this thesis should not be under-rated. Though large, in the sense that it cannot be considered as a practical manual proposition, it does not require sophisticated solution procedures as a computer operation. It is emphasised here that the distance metric developed was not worked-up with an eye to conforming to computer requirements; it stands on its own merits, being easy to understand and to apply when considering a county-wide problem. This

contrasts with the approach of Love and Juel (94) in considering solution techniques for large location-allocation problems where "rectilinear distances were chosen since, during the computations, large numbers of location problems must be solved and efficient methods for solving rectilinear problems are well known". It is accepted, though, that the model has substantial computer storage requirements and this will need to be reviewed as it is developed (see Ignizio (79)).

CONCLUSION

165. The training centre project was conducted as a dialogue between the author and SMT. Both parties adopted a flexible, problem-solving approach. The study led to several policy changes, none of which could have been foreseen at the start. It was tempting at the outset to believe that runaway transport expenditure was attributable to a division of responsibility between Education and Social Services, but an examination of underlying procedures suggested that to go forward on the basis of this intuitive argument would have been unrewarding.

166. As a result of the project:

- i. Social Services have appointed an officer to be responsible for transport logistics and to achieve the short-term savings which the project report* suggests are possible. It is appreciated that the officer will be planning routes at a much finer level than was possible for the survey and that the report will need to be interpreted liberally, taking into account also that the trainee population is not static (though "it is ... rare for management to require new ... transport schedules day by day" (Mole (40))). A move to taxis (without escorts) is envisaged and the payment of mileage allowances to families is also being contemplated.
- ii. SMT have become directly involved in the strategic trade-off between transport costs on the one hand and

* Comprising two working papers: see References (44) and (75).

trainees' journey lengths on the other. They have also called for revisions to the MH1 form. SMT recognise that they have a positive role to play in controlling transport expenditure and that this can be achieved leaving the integrity of social workers and other professional advisers intact.

iii. Anticipated savings in transport costs have enabled plans to acquire 3-4 bedroomed houses to be used as adjuncts to centres to be brought forward, following the recommendations of a working party. A working party has also advised that the method of paying trainees' wages should be revised.

iv. Social Services now have a computer model which they are using in association with the health authorities in the joint planning of facilities for the mentally handicapped to tackle a range of problems which hitherto have been intractable. The co-location of training centres and lbhu's is, in particular, being studied with the aid of the model.

167. The implementation of the project's recommendations has not been costly. The appointments of the transport officer and of additional staff for the 3-4 bedroomed houses are to be financed from savings in the transport bill. Moreover, the model required no programming assistance.

168. The model does not provide final solutions: policy decisions require the exercise of judgement. Boldy and Howell (95) observe, in the context of allocating home help services: "there is not just one 'correct' answer. It still remains the job of senior management to make the decision as to which allocation appears to be the most desirable and feasible to implement, knowing the assumptions on which each is based, and the financial and 'political' constraints within the organisation". The training centre model can, though, help senior management screen relevant data and assess alternative courses of action in difficult areas. The output of the model has also to be interpreted liberally.

169. The model is now well-established. In a recent (April 1982) exercise to consider where in the north of the county a new training centre facility should be opened, the assistant director (operations) commenced by asking the research section to run the model so that a preliminary idea could be obtained of the issues involved. There are three principal reasons, in the author's view, why the research findings have been implemented. First, there was the financial commitment to the project. Hampshire had a real problem and were prepared to put resources into researching the area of concern. It was in their interests to participate, to help ensure that the project was seen through and to obtain "value for money".

170. Secondly, the problem was pressing. There was both a climate of financial stringency and a need to respond decisively to health authority proposals to decant mentally handicapped adults into the community on a large scale. There was the fear of being overwhelmed and losing credibility.

171. The third factor is also important: the author spent much of his time actually working alongside officials, sitting at a desk in the research section over a lengthy period. There was the opportunity to be in frequent contact with senior managers both formally and "out of hours". It is unlikely that management would have participated in the project so actively had the author been an infrequent visitor operating from the University by "remote" methods. In no sense was the author seen as an inter-loper: "it is too easy for outsiders to think up possible solutions which would never be accepted by those who would have to live with them" (Tunnicliffe Wilson (49)).

172. The commitment of senior management to a rational approach to decision-making has, then, been behind the project throughout. The author is grateful to have had their encouragement and support.

173. The project, though, should be seen not only as meeting the immediate needs of Hampshire. It has wider connotations, in terms of (i) the particular methodology, and (ii) the general approach.

174. First, the methodology, using lateral distances measured by reference to grid squares and focussing on management's objectives pursued within a cash limited budget, can be applied both to the provision of training centre facilities by other county authorities and to the provision of other services. The project for Hampshire stimulated enquiries from a number of social services departments elsewhere. The interest generated by circulation of the project working papers outside Hampshire was sufficient to justify in 1980 describing the (then proposed) locational model at a meeting of the Social Services Research Group (SSRG) attended by research officers from social services departments in the south-east of England (44). Hampshire, furthermore, are experimenting with the grid square approach as it might be applied to the location of social service area offices and, separately, homes for the elderly. The National Development Team also have pointed to the possibility of using the model in siting places of overnight care (paragraph 149). That the training centre model can be extended into other public service areas is not surprising. Other studies have concluded similarly: "the same approach can be useful in optimization of other public facility systems such as post offices, libraries and schools" (Dokmeci (24)). A principal feature, however, of the model in this thesis was considered to be its computational feasibility, once the data bases are assembled. This simplicity is attractive (Ignizio (79)), bearing in mind here that "social services research ... [continues] to be primarily a question of survey research" (Boldy and Clayden (6)), with little emphasis on modelling.

175. As regards, secondly, the general approach, the author's dialogue with managers brought recognition of the need for innovation. Managers are faced with "complex systems of changing problems ... progress in handling ... problems derives at least

as much from creative reorganization of the way we pursue knowledge and the knowledge we already have as it does from new discoveries" (Ackoff (1)). The locational model in this thesis was not, on grounds of practicality, developed so as to consider training centre issues as part of a wider system. There was, though, an appreciation of the need for a problem rather than a technique orientated approach. A number of ideas have been pointed-up in the thesis and these also have stimulated discussion:

- i. a proposal for measuring distances in situations where there is lack of knowledge of (future) routes to be travelled.
- ii. a suggestion as to how savings in clients' travel times can be valued by managers reluctant to make preferences known to colleagues.
- iii. an illustration of how the quality of care at day centres can be introduced into a consideration of centres' running costs.
- iv. an indication of changes required in administrative procedures so as to facilitate the exercise of greater control over expenditure.
- v. a demonstration that a large-scale model can be run on a computer without the solution time becoming prohibitive.

That some of the ideas, particularly iii. and iv, have specific application serves to underscore the point that the approach was innovatory, meeting the needs of the project in hand.

176. The responsiveness of the project to the needs of end - users is worth underlining again: "if, instead of sending the observations of able-seamen to able mathematicians on shore, the mathematician would himself go to sea, then this would signal much more for the safety of men's lives on that element" (attributed to Isaac Newton by Rivett (11)).

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The Working Papers at references (28), (44), (65), (70) and (75) are in a separate binding. Copies of the papers may be obtained from either Hampshire County Council Social Services Department Research Section, Winchester or the Department of Accounting and Management Economics, The University, Southampton.