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CHINESE UNIVERSITY DEVELOPMENT PROJECT

Report to the Panel and Commission of visit made by M.L. Somers, Institute of Oceanographic Sciences, Wormley, Godalming, Surrey, UK in November 1984 to The Radio Engineering and Automation Institute, South China Institute of Technology, Guangzhou, China.

NATURAL ENVIRONMENT RESEARCH COUNCIL
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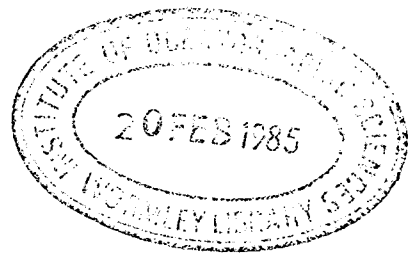


CHINESE UNIVERSITY DEVELOPMENT PROJECT

SOUTH CHINA INSTITUTE OF TECHNOLOGY, GUANGZHOU

# Report to the Panel and Commission of a Visit to the Radio Engineering and Automation Department in November 1984

by M.L. Somers

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January 1985

1. INTRODUCTION The origins of my good fortune in being invited to work for a month at the South China Institute of Technology lie originally in a common interest at S.C.I.T. and I.O.S. in sidescan sonar. Contact was made when my colleague at I.O.S., Dr J.S.M. Rusby, made a tour of Chinese laboratories in 1982 during which he visited Professor Xu Bing-Zheng at S.C.I.T. The opportunity was provided by the Chinese University Development Project with its plan to support specialist visits from the West to selected departments of key Chinese Universities. The request from S.C.I.T. was channelled through the International Advisory Panel to Dr Rusby who suggested my name to Professor Zienkiewicz, a member of the I.A.P. I saw Professor Zienkiewicz in January 1984 and was contacted by the Panel the following month, after which I wrote to Professor Xu.

My original intention was to make the trip in October but at Professor Xu's suggestion I delayed it until November. The request to delay by a month was made because the Radio Engineering Department was expecting a similar visit by an expert in Information Theory. In the event he postponed his visit by a year, but I was not aware of this and in any case November suited me much better.

I.O.S. has been active in sidescan sonar since its invention and the first description to appear in the open literature in 1958 was by I.O.S. authors, though the Institute was then N.I.O. (the National Institute of Oceanography). Since then the Institute has retained its interest in both the techniques and interpretation of sidescan sonar. The original equipment was developed for use on the Continental Shelves in water depths less than 200 metres. However, the main Institute interest lay in deep water and it was natural that we should seek to develop the technique on the larger scale required for full ocean depths. My connection started in 1966 when I joined Dr Rusby on the development of GLORIA Mk I for use in the deep oceans. I have been with the project ever since and assumed leadership of it in 1975 when we started to develop GLORIA Mk II. Since then I have supervised an active programme of development and deployment. Strangely enough I.O.S. has remained the only laboratory in the World, to the best of my knowledge, to maintain an active interest in deep ocean long range sidescan sonar.

Meanwhile, at the South China Institute of Technology interest in sidescan sonar started in 1971 when the Department of Harbours approached the Institute for help in surveying for wrecks and other underwater obstacles. In response to this request, Lin Zhen-Biao and the nucleus of

his present team produced the sidescan sonar SGP-1. The Department of Fisheries also expressed interest more with the idea of charting seabed hazards to nets than finding schools of fish. In technical terms I have more to say later on SGP-1, but in view of the shortage of materials and the difficult conditions under which they worked, SGP-1 was an astonishing success, culminating with a double triumph in 1976. First a dredger belonging to the Guangzhou Hydrographic Department lost her buckets and after a fruitless search lasting months called on the SGP-1 team, which found them within two weeks. Second SGP-1 was used to survey the route of the China to Japan telephone cable.

The group's plans which included an improved successor, SGP-2, suffered a severe setback in 1978. Although China was no longer a closed country and the Cultural Revolution was over, its economic effects were biting hard and S.C.I.T. suffered in the economic depression as much as anywhere else. The result was a complete suspension of work on sidescan sonar, which is only now being lifted. SGP-2 is not yet complete and is suffering a number of fairly severe technical problems, which I will take up in the body of the report.

Because of the very specialised nature of our common subject and the particular emphasis in the request resulting in my appointment, the bulk of my time was spent in contact with a small group of people and this restricted my opportunity to widen my contacts in the University, a situation which is reflected in my report.

In the following sections of my report I start with a narrative of my visit which is followed by an appraisal of the structure of the South China Institute of Technology and the role of the Sonar Laboratory. After that I deal with the laboratory itself and its plans and strategy, followed by the recommendations made in my report to the Department. I next deal with my lecturing and the materials I took to China, and I finish with some remarks on the possibility and desirability of follow-up visits and exchanges between S.C.I.T. and western laboratories with interests in sonar.

2. NARRATIVE My initial letter of appointment by the I.A.P. arrived in February 1984 and I soon entered into correspondence with my host department with a view to establishing the main subject areas of interest to them where I might be able to help, and more particularly detailed lists of topics. I am bound to say that this correspondence was disappointingly slow, partly

because I had a heavy sea-going commitment throughout the summer, but also because the replies I received from China were sporadic and a little vague. This caused me a few difficulties with my preparations which I enlarge upon in a later section.

I was given to understand by Professor Xu that I would be asked to lecture three or four times each week, and having submitted a list of topics and receiving no comment from S.C.I.T., I set about preparing my lectures. I later realised that my instructions from the Panel suggested that I limit my lecturing to two or three times a week to allow more time for discussions with my Chinese colleagues. In retrospect I would from the point of view of my exchanges with my host department endorse that view but I should mention that throughout the month my lectures were attended by three workers from the Underwater Acoustics Institute at Hangzhou and it was undoubtedly to their advantage to have the fuller set of lectures. In the event I gave a total of 15 lectures of which 14 were prepared before my visit and the text mailed to China in advance, and one was a more or less impromptu contribution to a departmental seminar during the 32nd Anniversary celebrations of S.C.I.T. I deal in more detail with my lectures in a later section.

The material I took to China, purchased with the Equipment grant, consisted mainly of the ten or so textbooks (or their modern equivalent) which I would not in my own office be without.

In the case of both the lectures and the books I would, again with the benefit of hindsight, make some changes. Of course my appointment was the result of a very specific request and hence more specialised than that of most visiting experts, also I was the first such visitor to S.C.I.T. so it is perfectly reasonable that there was some difficulty in the early communication. Fortunately the damage is not severe as my discussions were most productive and I am in the process of sending supplementary material to cover most of the specific topics of common interest. This aspect is one on which I will expand later in this report.

Meanwhile with the valuable help of the Panel I was making my travel arrangements including tickets, visas, inoculations, etc., and I left the U.K. on Friday 2nd November. I took the obvious way from the U.K., flying to Hong Kong and travelling from there to Guangzhou, by train as it happens, though both air travel and a hydrofoil are available. I was met at Guangzhou station by Professor Xu Bing-Zheng, two members of the Sonar

Laboratory staff who were to be my closest colleagues, Messrs Lin Zhen-Biao and Yin Jun-Xun, and two members of the Foreign Affairs Department.

I was at first lodged in the Guangdong Guest House in central Guangzhou and travelled the 10 km to S.C.I.T. by Institute car each day. It was explained to me that due to the International Trade Fair, hotel accommodation was scarce and I would as soon as possible be moved to a better hotel, though as far as I was concerned the Guangdong Guest House was perfectly all right. However, it became obvious almost at once that it was a severe disadvantage to be in the city centre. In the first place, having to pay for the car would mean that I could not live within my per diem allowance, in fact my expenses would exceed the total amount of money I had taken to China. Secondly, it would be very much more difficult to spend the afternoons at S.C.I.T., which I felt then and know now I needed to do. Finally, the sheer amount of time spent travelling would have been a great waste. I voiced my fears at the end of the first day and fortunately I was offered a room in a University house on the campus. Though the facilities were basic by Western standards, it was perfectly comfortable and being less than 10 minutes walk from the Department was extremely convenient. The house was cared for by a woman, employed by the University, who also brought my meals and did my laundry. This accommodation was so much more convenient and desirable than a city hotel, that the fact that it was less than half the price was merely a bonus, and I was very comfortable and happy there for the rest of the month.

I first visited the Institute on Monday 5th November when I was introduced by Professor Xu to various teachers and researchers and was given background information about the organisation of the Institute, shown a film about S.C.I.T. and taken on a tour of the Radio Engineering and Computer Departments. In the evening I was guest at a welcome banquet with five of my Chinese colleagues.

Basically my lecture commitments were on Mondays, Tuesdays, Thursdays and Fridays, with laboratory discussions with my Chinese colleagues in the afternoons and all day on Wednesdays. In fact the programme drawn up by my hosts did not specify any commitments on the afternoons of my lecture days, but as soon as I moved onto the campus, I started spending the afternoons working, except one or two spent sightseeing in Guangzhou.

At the end of the second week I returned to Hong Kong to collect my wife who was to join me for the second half of the visit. As it happened, this caused me the only problem with travelling of the whole month, because unknown to me, on leaving the country, my re-entry visa was cancelled. By luck I went at once to the China Travel Service to buy the return tickets, so the error was discovered just in time to make arrangements for a new visa before they closed for Saturday afternoon, and in the event I lost only one morning's work.

With a fairly heavy programme of lecturing, discussions with my colleagues in the afternoons and writing up the day's work and preparing the next day's lectures in the evenings the time sped by and almost before we realised it the visit drew to its close. Before the last discussion session I drafted my report to my host department and discussed it in some detail with my colleagues, as a result of which I was able to correct some errors of fact and emphasis before the final draft. During the final weekend my wife and I moved into a hotel in central Guangzhou and we were able to repay a little of the hospitality we had received by giving a banquet for senior members of the Laboratory.

We finished our round of farewells and left Guangzhou by rail on the morning of Tuesday 4th December.

3. THE SOUTH CHINA INSTITUTE OF TECHNOLOGY The Institute stands in extensive grounds some 10 km NE of the city of Guangzhou. It was founded in 1952 by an amalgamation of all the engineering departments of the Guangzhou Universities (4 in all), and now stands on the site of the Sun Yat-Sen University. It is one of China's 23 Polytechnic Universities and is designated as a 'key' institution.

The student body consists of 8000 undergraduate and 500 graduate members, divided as far as I could tell from a casual observation equally between male and female. In fact, any questions I asked about equal opportunities for women were met with incomprehension which I took to indicate a satisfactory state of affairs. The staff number 60 full professors, 260 associate professors and 1200 lecturers and researchers, according to the figure I was quoted. I was surprised at the number of professors, but not working in a university myself, I have no yardstick.

There are 19 Teaching Departments and 3 Research Institutes with only graduate students. The Research Institutes are

(1) The Institute of Radio Engineering and Automation,

(2) The Institute of Material Science,

(3) The Institute of Chemical Machinery.

Within the Institute of Radio Engineering and Automation there are 4 Groups:-

(a) Underwater Sound,

(b) Data Communication,

(c) Image Processing,

(d) Automatic Control.

My assignment was to the Underwater Sound Group. The four groups have a total of 40 graduate students; 2 of them are Ph.D. students and the remainder M.Sc. In China the M.Sc. takes 2 years and the Ph.D., which is never taken without an M.Sc., a further 2-2½ years. The undergraduate curriculum is 4 years in length and the students work 2 semesters of 20 weeks each, with one 8 week summer vacation and a shorter one at the Chinese New Year. The Underwater Sound Laboratory had one Ph.D. student and no M.Sc. students, being primarily an 'applications' laboratory.

Generally research projects are proposed by departments through the S.C.I.T. management to the Ministry of Education or one of its Bureaux, and the selected ones are supported by either the Ministry, the Provincial government or a local factory for which it might solve a problem. Sometimes it happens that a customer will approach a department with a specific problem, a case in point being the enquiry which started the S.C.I.T. work on sidescan sonar.

The Radio Engineering and Automation Institute occupies a large building (Building No. 3) of 6 floors at the centre of the campus. The lecture room is on the top floor and the Sonar Laboratory is on the second floor.

Since the Sonar Laboratory was so much the centre of my activities I include a list of the staff and their responsibilities.

| | |
|---|---|
| LIN Zhen-Biao | Head of Group. Specialist in civil sonar and bio acoustic systems. |
| YIN Jun-Xun | Assistant Head. Interests are sonar display methods, sonar slant range correction methods and linear FM signals. |
| CHAI Han-Tian | Signal design, reverberation studies. |
| LIANG Yao-Rong | Ph.D. student, signal design, linear FM systems. |
| DIAN Yue-Wu | Tape recording systems, digital recording. |
| ZHANG Yuan-Bing | Receivers, transmitters, linear system design. |
| LUO Guan-Xiang | Transmitters and linear FM systems. |
| XIE Wen-Yun | Transducers. |

In addition there are three technical assistants. The titular head of the laboratory is Professor XU Bing-Zheng who is also chairman of the whole Radio Engineering and Automation Institute. It appeared to me that Professor Xu gave LIN Zhen-Biao a very free hand in running the underwater sound laboratory. Other groups such as the Image Processing Laboratory are headed by a professor, sometimes backed up by an assistant professor.

I now give my impressions of the leading members of this team, because as will be seen in due course, they have ambitious plans for the laboratory which will need considerable investment if they are to be realised, and it is appropriate to assess whether the staff have or can acquire the skills needed to do so.

Professor Xu is an acknowledged intellectual in his mid fifties. I get the impression that he has a special interest in the Sonar Laboratory, but he plays little part in its day-to-day running.

LIN Zhen-Biao I found very impressive indeed. Much of the credit for

the success of the sidescan sonar, SGP-1, is his. He has made significant contributions to the theory of wide band FM signals and also had a hand in many of the engineering details of SGP-1. He recently spent two years in France at a laboratory in Lyons specialising in signal processing. He has a cheerful, friendly and generous disposition, and shows no resentment for the reverses and difficulties he has encountered in life. Having been at school when Russian was the first foreign language and more recently had to concentrate hard on French, his English is understandably shaky, but armed with a dictionary and his fierce concentration, he rapidly masters English text. During the Cultural Revolution he was unceremoniously shipped off to the forest to serve two years as a wood-cutter. I find it hard to rate him as an organiser and leader of his team; certainly they all respect his abilities but that is not quite the same thing. If I have any doubts they arise from his academic outlook and obvious preference for intellectual pursuits.

YIN Jun-Xun is an altogether less complicated character. He is a born first lieutenant and could make an excellent job of organising and setting up the facilities they need to realise their ambition of becoming a force in the field of sidescan sonar. YIN is one of those rare and fortunate people who are protected from the adversities of life by finding genuine amusement in their own misfortunes. During the Cultural Revolution he spent no less than seven years as a worker in a chemical factory - ill paid drudgery without even the benefit of being healthy outdoor activity. It is a measure of his quality that after that break he returned to university as a teacher and took an M.Sc. His qualities will be an essential ingredient in any success with which the group may in future be blessed.

CHAI Han-Tian is a theoretician. He is quiet, shy and self-effacing but, as far as I could ascertain, very talented and he is certainly well respected by his colleagues. I do not see him as an organiser or inspirational leader, but in other ways he is a key member of the group.

LIANG Yao-Rong is the Ph.D. student, extremely bright and his knowledge of acoustics is as good as anybody else's in the group which is to say very good indeed. He is extremely quick on the uptake and misses nothing. He was in on all my discussion sessions and also, as far as I could see, is a valued member of all the laboratory caucus meetings, to borrow a political term. His friendly, helpful and generous nature persuades one to forgive a hint of pedantry in his manner. I was surprised to learn that he is 29,

partly because he is a little immature for that age and partly because I find it hard to account for all his years. I assume that it is usual at S.C.I.T. to do a few years teaching before embarking on a higher degree. I do not think he was touched by the Cultural Revolution, though he would have entered University well before it ended.

These four are without question the leaders of the laboratory, although DIAN and ZHANG were usually included in my laboratory discussions.

4. THE SONAR LABORATORY AND ITS PLANS The University and the Sonar Laboratory are agreed on the explicit ambition to become the leading sidescan sonar group in China, and to be, and be seen to be, comparable with most Western laboratories with interest in this field. Now it so happens that sidescan sonar is divided roughly into three regimes of operation according to frequency and hence maximum range. There is a high frequency short range high precision regime useful in close range work such as inspection of harbour works, close range bottom searches, etc. Second there is the shallow water, mid-frequency medium range survey region covering the bulk of applications. Finally, there is long range deep water work. SGP-1 belongs in the first category. The second group is rather well covered by commercial interests both in the USA and Europe. The final region has so far been the almost exclusive province of IOS. LIN has accurately analysed this situation and determined not to dissipate his efforts in the mid range region (ranges of 400 m to 1.5 km) because Chinese technology is at present so far behind the best Western laboratories and the resources they can devote to catching up are quite inadequate. He has very sensibly determined that their best course is to concentrate initially on the area where they have experience with SGP-1, and can reasonably expect to hold their own at least in China. Then on the basis of this work and, he hopes, a link with my team at IOS he wishes in a few years to start work on a long range sonar for use in the deep offshore waters of the South China Sea. If all goes according to plan this will coincide or even anticipate the extension of offshore activity in this area to the continental margin and beyond.

At present the situation with the equipment is that the original instrument SGP-1 can be refurbished and put into operation fairly quickly, preferably with some improvements to the construction of the electro-acoustic transducer. Its successor, SGP-2 is facing a number of severe technical problems requiring essentially a higher level of technology in the laboratory for solution. SGP-2 also faces problems with the field

trials and deployment. Solution of all these is likely to prove expensive. No work has yet been done on the development of the long range sonar.

The aim is to return to the field with SGP-1 starting in 1985, and by accepting contracts for surveys, to earn enough revenue to complete the more powerful and versatile SGP-2. In fact, LIN realises that it will require an injection of funds from outside to complete SGP-2 in reasonable time to the standards required for commercial field work. The source of these funds could be the provincial government or possibly the CUDP; in either case the section on my recommendations will make it fairly clear how the funds can usefully be spent. LIN hopes that in 5 to 7 years time the revenue generated by SGP-2 will enable him to initiate work on a long range sonar for the deep waters at and beyond the continental margin of the South China Sea. Depending on the resources which can be generated for this it would be 5 or more years before it could be deployed.

At present the laboratory is ill-equipped to meet this challenge, a fact readily acknowledged by the staff and management. I am not in any doubt about the intellectual capacity or potential skills of the present staff or their ability to recruit and retain people of a similar calibre. The weaknesses lie in the environment and organisation, and I have dealt in some detail with these in my report to my host department, and summarise this information here.

First I will deal with the laboratory environment. The structure of the building itself is sound but I find it difficult to go much further on the positive side. The general impression is of poor facilities in primitive surroundings, inadequate and out of date equipment and a general ambience that makes equipment construction and practical lab work of any sort an unrewarding,uphill struggle. Fittings like window frames, doors, etc. are of poor quality and are warped and cracked. The decoration, never good, has been systematically neglected. The electrical wiring is old fashioned and inadequate and the supply itself comes nowhere near the standards required of utilities in the USA and Europe, so much so that every laboratory has to have some form of voltage stabiliser. Moreover, Guangzhou is an industrial city in a sub tropical humid climate, and has very few of the emission controls applied in the West. The resulting air pollution causes severe problems with such things as electronic printed wiring boards. Dust is also a major problem for some reason, the corridors and stair-wells having a liberal supply, much of which finds its way into the laboratories.

It is difficult to see what can be done about this in any effective way without major overhaul of the building and the provision of an air-conditioned and filtered atmosphere. The University has a Honeywell mainframe computer supplied with CUDP aid, and it is noteworthy that the Honeywell engineers dispensed with half measures in the installation and effectively built a complete compartment to machine room standards within the allocated space. This involved false walls as well as the more usual ceiling and floor. The instrumentation such as oscilloscopes, oscillators, etc., although old and inadequate in quantity is serviceable, and they are at least passably well off in that respect. There are one or two obvious gaps which they can usually make good by borrowing. For example, there is a logic analyser in one of the other groups which they borrow when necessary, but for the work they aim to do they could easily justify full time ownership of one. The real gap is in the substructure which we almost take for granted in the West. For instance, soldering is no longer a low technology skill, but involves precision temperature controlled irons and well researched mixes of flux and alloy for different applications, yet in the sonar laboratory they are still using heavy old fashioned irons with solid 10 AWG solder and separate rosin flux. Similarly there are no facilities for the production of prototype printed wiring boards, there is no tooling or hardware for wire-wrap boards (a very useful and versatile technique for digital circuitry) and the staff do not have access to a properly equipped workshop. But the most expensive of the facilities missing, and more or less essential for a laboratory engaged in underwater acoustics, is any form of instrumented test tank.

I have dealt at some length with the shortcomings of the laboratory environment, and I have addressed the same subject with some emphasis in my report to my hosts, and in my recommendations, as well as detailing the various facilities, I have stressed the importance of sending a senior member on an extended study tour of Western establishments, including fairly prominently IOS.

As far as the organisation is concerned, the laboratory and indeed the University is suffering from the nationwide shortage of the 'middle layer' personnel such as administrators, accountants, personnel managers, etc. removed by the Cultural Revolution. The people in the office do their level best, but unless my ignorance of the language has badly deceived me, there is no really effective control structure. This results in such unsatisfactory practices as the following. If my Chinese colleagues need for example an advanced integrated circuit, which is either not made at all

or not made reliably in China, they have to go to the budget office and draw sufficient cash to go out and buy it on the black market where the price mark-up is several hundred percent. Since one of the major planks of the CUDP programme is to improve the management, budgeting and record keeping organisations in the target universities, I will not enlarge on this aspect further, but I think it worthwhile drawing attention to it.

5. SPECIFIC TECHNICAL PROBLEMS DISCUSSED DURING MY VISIT These fall largely into three specific areas:

(a) realisation in accurate reliable hardware of signal correlators for BT products in the medium to large range,

(b) signal recording and display and

(c) the design and engineering of reliable transducers for generation and reception of underwater sound.

The items are listed in the order of importance attached to them by my hosts, but in their situation I would probably reverse this, and in any case (a) would be last.

(a) Signal correlators are systems which enable sonar and radar designers to overcome the peak power limitations of their transmitters without loss of signal to noise ratio or range resolution. They are graded according to a parameter known as BT product, where the reference, a short uncoded pulse, has a BT product of one. At S.C.I.T. LIN has chosen to incorporate into SGP-2 a correlator with BT = 100. For reasons which, but for my previous experience of it, I would not be able to fault, he has chosen to use charge-coupled device (CCD) technology. Although CCDs were invented many years ago it is only recently that the technology has been mastered, and it is not widely popular among even the major USA semiconductor houses. This being the case, and considering the lag in Chinese semiconductor technology and the conditions prevailing in the underwater sound laboratory I was not surprised to discover that my colleagues had run into severe problems, and it is not immediately clear how they are to be resolved. Briefly the correlator system prototype is not delivering the design specification and I could not with the time and facilities available determine whether the failure lay in the CCD chip or the support circuitry or (which I think quite likely) both, also with the primitive facilities available to them I cannot see how they can devise and build a test-bed which will resolve the question unambiguously. My recommendation was to abandon the CCD approach and we discussed at length two other means of realising correlators which they can put into effect

without having to resort to the black market to obtain specialised foreign components. Both result in a significant but in my view quite acceptable reduction in BT product. In my experience of sidescan sonar the use of BT products of 100 or more is unwarranted at frequencies much in excess of 50 kHz (the SGP frequencies are 160-190 kHz). The smart approach is to reduce system noise, by paying very careful attention to transducer and front end design, and to pay particular attention to the towfish to eliminate flow noise and mechanically transmitted noise. I have made these points in my report to S.C.I.T., and I am sure that the group can work out a satisfactory solution.

(b) The SGP-1 recorder was a very ingenious version of the three-stylus belt system writing on dry electro-sensitive paper. Given the improved quality of modern papers and a re-engineering of parts of the recorder, notably the motor and its control, I think this recorder would be satisfactory for the production of working records. My hosts assured me that it is a constant headache to keep the styli properly aligned and I can well believe it. However, I think a partial re-design rather than a new start is what is required, because the alternatives are themselves fraught with problems. LIN has recently tried a multi-stylus design of great ingenuity, but it proved to be technically beyond their reach and had the major disadvantage of having to use wet paper, a medium which has long been out of favour in this application.

Another problem they face is that of providing a 'zoom' facility, which in some applications could be of benefit, and I could see no prospect of their mechanical recorder being adaptable to this purpose. However, there is a system based on a fibre-optic faced cathode ray tube which would be suitable though expensive, and I am sending details of this. The group also have plans to construct a TV display using a refresh memory and were somewhat anxious to have my reaction to this. My reaction is that this sort of display can be useful but because the data are transient it is best used in conjunction with a computer and tape-recorded data as in the image processing systems which are being applied in the West to sidescan sonar data. We also spent some time discussing digital buffering on a line-by-line basis, which is very useful for effecting slant range correction and anamorphic scale changing. I see this system as being most useful with the fibre-optic recorder due to its great speed. The mechanical recorder is unlikely to be successful in this role as it will need to run at several times real speed.

Tape recording and data logging for short range sidescan sonar can be quite a problem with high data rates and large volumes of data over an extended cruise, so that I see it as an option to be exercised intermittently. Both the analogue and digital approaches involve heavy initial expense, but in the digital case the running costs are lower and the system is easier to maintain at top performance, in fact if it is running at all it should be running at specification. There is no real urgency either to make decisions or to spend money in this direction because not only are other problems more pressing but tape recording, whether analogue or digital, can always be an add-on option in the sense that the data format and rate are dictated by the sonar and not the end use.

(c) In my view the most serious problem faced by the group is the need to become involved in the design and construction of transducers. The SGP-1 transducer was initially successful indicating that the acoustic design was at least adequate, though without test facilities it was impossible to find out whether the design was optimum. Unfortunately the design has an engineering defect resulting in a leakage of water and electrical breakdown. I did not have the time or opportunity to investigate the failure but we had an extensive discussion on the engineering design of that type of transducer and I have undertaken to send more details and material specifications. The SGP-2 transducer was designed and built in the laboratory and although the acoustic design is probably viable, I was horrified at the lack of sound engineering in the execution. The transducer has not been in the water yet, but when it does early failure by leakage of water through the power leads is virtually certain. I am in correspondence with LIN on remedial measures. There is, as it happens, little prospect in the immediate future of it being put to the test as there is no ship available for trials; the new cable ship which was to have served this purpose has been cancelled, and the winch necessary to handle the towfish has been neither designed nor built.

These however are merely the surface problems, the real trouble lies deeper. The acoustic and engineering expertise to design and build acoustic transducers to the necessary standard of reliability can really only be gained by experience and the will to invest in the necessary facilities. At S.C.I.T. they have the theoretical knowledge, but little experience and no facilities. The two major recommendations in my report to the Institute concern this need, and call for the Institute to send a senior laboratory member on an extended study tour and on his return to set up an acoustic test facility adequate to their needs.

6. FURTHER OBSERVATIONS ON THE LABORATORY AND UNIVERSITY There are a few matters which I think could be appropriately mentioned in this report in spite of the fact that they are not strictly included in my duties of lecturing and consulting in underwater acoustics and sidescan sonar. They do have a bearing on the effectiveness of my host laboratory in carrying out its programme.

First there is the question of development facilities for microprocessor systems. Micro-processors are playing an increasingly important role in instrumentation in all fields and underwater acoustics is no exception. Also it is generally conceded, and soon becomes obvious to the practitioner that programming efficiency is closely related to the development facilities available and strongly influenced by the convenience of access to them. The Sonar Laboratory staff have started along this path in that they have implemented a sonar slant range correction algorithm on a Z80 microprocessor. In order to do this they purchased a single board computer introductory kit with a hexadecimal keyboard and display. It also had facilities for user I/O and the ability to write sections of memory into programmable read only memory, but anyone with experience of microprocessors will immediately recognise this as a very rudimentary development system. The code has to be assembled and keyed in by hand and then tested in random access memory. The mistakes can then be corrected and the process repeated until the program is judged to be free of errors, after which it can be transferred to a buffer area of memory and written into the programmable memory. All of these steps are time-consuming and error prone. A special purpose development system is an enormous improvement on this for three reasons: (a) the operating system facilitates and speeds up the maintenance and storage of program files, (b) the assembly process is automatic and thus free of clerical errors and very fast and (c) the finished programs can be downloaded by machine to the target processor. In addition, a good development system has a monitor which allows program errors to be traced and corrected much more easily.

Without any of these aids the sonar laboratory team wrote and tested their program for slant range correction, which is no mean achievement, as the program was quite a large one. On the other hand, there is a Z80 development system in the Radio Engineering and Automation Institute, but it is in the Image Processing Laboratory and is very heavily loaded there running image analysis and processing programs. So it is to all intents and purposes not available for its designed purpose. Because one of the topics

discussed in my report to my hosts covered just this subject of the provision of microprocessor development facilities, the situation of this particular development system is both important and interesting. I had a fairly lengthy discussion with the Professor of the Image Processing Laboratory, during which he complained that some of the algorithms on his Z80 machine used as an image processor took a long time to run (some of them up to an hour) which I can well believe. I have already mentioned the Honeywell mainframe computer, and since this could run those same programs in seconds or minutes at the most, I would have expected Professor Ou Yang and his workers to be actively planning for the transfer of their programs to the mainframe. On the contrary the plan is effectively to build an arithmetic processor as a fast add-on for the micro. I will come back to this point to discuss the reasons for this and the lessons to be drawn but first I summarise the conclusions in my report to S.C.I.T. on the provision of microprocessor development facilities.

First it is natural that engineers grow to know and prefer a particular processor, but it would be surprising if every group of S.C.I.T. preferred the same model. Consequently the University has to consider provision of a multi-processor development facility. Second the transfer of programs from one machine to another should be a routine though perhaps not easy process instead of the impossible nightmare or complete re-write it so often is. This means that the source program has to be written in a high level language with the machine dependent parts included at a later stage. This selfsame problem has faced my own employer, the Natural Environment Research Council, which by coincidence also has a Honeywell mainframe with the same operating system. Their solution involved installing the 'C' language which has a three pass compiler in which only the third pass is machine dependent. Thus the third pass can be specified at compile time for the appropriate machine. There are many more details but two points of interest are that the 'C' language is a good compromise between the advantages of a high level language and the overhead in extra code involved in using one, and the program can be checked for logical flow and errors on the mainframe computer, including interrupts. What I have suggested is that something along these lines, though not necessarily exactly the same, should be considered at S.C.I.T., and that if the Natural Environment Research Council solution is of interest I can help to make the right contacts. Of course it could be that such a facility is planned for S.C.I.T. in which case I have probably spoken out of turn, but if so, as far as I know my host group knew nothing about it.

In addition I have suggested to the Sonar Laboratory group that since they have chosen the Z80 and already have a single board computer prototyping system, and as it happens have recently acquired an IBM PC, that they should join the two systems up. To this end I have left them with the address of a software house which has a cross-assembler for the Z80 to run on the IBM PC. Furthermore, it should be routine though not necessarily simple to instal a link between the IBM and the Honeywell, so that if the 'C' system is installed they will be very strongly placed for Z80 work.

Returning now to the question of the Image Processing Laboratory and its plans, when I raised the question with my colleagues it appeared that the answer is financial, because time and resources on the Honeywell are paid for as used and appear as a real reduction in the user's budget. Thus the cost remains prohibitive until the usage builds up, and it appears that it pays workers like Professor Ou Yang to go to enormous lengths to avoid incurring a regular mainframe bill, or even to struggle on in the old way. Of course all such installations have to face this initial barrier, and in the case of my organisation, the Natural Environment Research Council, it was solved by providing the service from central resources and charging virtually zero marginal cost to users. Of course everybody pays in the form of a reduced initial budget, and there is a record of usage which results in a form of post-accounting, but the marginal cost encourages maximum utilisation. Of course I realise that it is not strictly my place to be commenting on these matters in this report, since they formed no part of my assignment, however they will clearly affect my colleagues in the Sonar Laboratory so I consider it within my brief to call the attention of the Panel to the possible problem.

7. A SUMMARY OF THE LECTURES This section contains a description of my lectures in the order of delivery with in some cases amplifying comments. As already mentioned, lecturing took place on Monday, Tuesday, Thursday and Friday mornings, starting at 8.30. I had a blackboard, a slide projector, an overhead projector and a copious supply of tea! I did not lecture on my first day, Monday 5th November, and on Monday 19th November I could not lecture since I had gone to Hong Kong for the weekend to collect my wife and my re-entry visa had been cancelled. I was able to make up the lost ground by giving two lectures on Tuesday 20th November. Generally the lectures lasted with a 10 minute break between 9.30 and 10.00, until 11.00, though some were over by 10.30 and others lasted until 11.30. I found that my rapport with the audience increased over the month, as they got used to me

and I presumably improved my delivery to suit their understanding of English. The four leading members of my host laboratory listed earlier were well aware of much of the material, particularly the theoretical parts. For the rest my audience consisted of junior faculty from other groups plus the visitors from out of town, three people from the Institute of Acoustics at Hangzhou who remained in Guangzhou for the month, and one from the Institute of Marine Technology on the far side of Guangzhou. This gentleman had the most appalling journey starting each day at 5.30 a.m., which made me feel particularly bad about my unannounced absence on Monday 19th November.

The lectures were as follows:

November 6th — Summary of Acoustics - this was really a lecture to establish contact and break the ice rather than impart new knowledge.

November 8th — Sidescan Sonar - a review of the techniques and the trade-offs faced by the designer.

November 9th — Transducers I - the first part of a two part introduction to the analysis and design of underwater transducers. With hindsight I think it would have been of somewhat greater value with less theory and more technical and engineering detail.

November 12th — Slant Range Correction in Sidescan Sonar - a review of the problem and various techniques for its solution.

November 13th — On the Theory of Active Sonar Detection - a review of the basics of signal/noise improvement by means of long transmitted pulses.

November 15th — Synthesis of Linear Delay Networks by O'Meara's Method - a lecture on the basis of designing linear networks for pulse compression and some details of the circuits.

November 16th — GLORIA II - the IOS Long Range Sidescan Sonar - this was the unscripted lecture to the seminar for the 32nd anniversary celebrations at S.C.I.T. There were some additional faces at this lecture.

November 20th — (a.m.) Transducers II - the second half of the two part lecture on underwater transducers, concentrating on the link between the electrical terminals and the acoustic network.

November 20th — (p.m.) The Principle of Stationary Phase - this was the lecture postponed from the previous day when I had not managed to get back into China. The subject matter included

some applications of this rather mathematical topic.

November 22nd Hard-wire Digital Correlators - the details of digital correlators to realise pulse compression sonar - with emphasis on the use of special purpose multiplier chips.

November 23rd Generating Long Coded Pulses - this is another aspect of system design for pulse compression sonars.

November 26th Digital Data Acquisition in Sidescan Sonar - a review of requirements and techniques in the display and recording of sonar data with particular emphasis on experience at my own institute.

November 27th Calibration and Measurements on Transducers - dealing with the requirement and techniques which I have recommended to be put into effect at S.C.I.T.

November 29th Distortion Analysis in Signals and Correlators - dealing with the effects of the inevitable imperfections in real systems, how to quantify them and limit them.

November 30th The Synthetic Aperture Technique - an analysis of synthetic aperture applied to sonar, and in particular the barriers to progress in sonar when it is so successful in radar.

The foregoing are the titles and brief contents of 15 lectures - an average of just less than four per week, representing nearly 40 hours on the rostrum. It is no wonder that I thought I knew my audience better at the end.

8. DISCUSSION SESSIONS In addition to giving 15 lectures I had 16 discussion sessions in the laboratory, counting Wednesdays as two per morning and afternoon. These discussions were not structured and were sometimes very lively with several topics coming up, so it is not possible to attempt an exhaustive account of them here. What follows is a series of observations taken from my notes made in the evenings after the laboratory sessions.

Wednesday November 7th was spent discussing the IOS sidescan sonar systems particularly my own project, the long range sidescan sonar, GLORIA. The laboratory had unearthed a considerable number of IOS references, though some were rather out of date, and fortunately I was able to bring them up to date. Not having an up-to-date technical description of our equipment, I had to rely on memory for much of the quantitative detail. I had a brief look at the SGP-1 equipment including transducers and towfish. The

following afternoon I spent tidying and engrossing some of the notes on the GLORIA system discussed the previous day.

On Friday November 9th, we had an afternoon discussion session on the S.C.I.T. sonars, including a detailed examination of their transducer construction. The acoustic design appeared at first sight to be sound, but it was clear that the construction was lacking in technique and quality control, which would I believe account for its early failure due to leakage. As a result of this, I have undertaken to send some material specifications and construction techniques for this type of transducer, but the only real solution is experience backed up by good facilities. We also spent some time examining the display recorder for SGP-1 and LIN's prototype multi-stylus successor. I have put forward a tentative solution to this problem consisting of an improvement of the existing recorder, including improved paper, coupled with a fibre-optic faced cathode ray tube with photographic recording paper for high quality and 'zoom' records. The latter could be coupled with tape recorded data either digital or analogue.

On Monday November 12th, we discussed slant range correction of sidescan sonar data, and my colleagues gave me some of the details of their method. Unfortunately it relies entirely on the unworkable multi-stylus recorder, though it would of course be equally suitable for the fibre-optic CRT, the essential feature being a zero inertia sweep mechanism. The group have recently obtained a supply of improved electro-sensitive recording paper which is very much better than the old stuff used when SGP-1 was in operation. It starts about 3 grey scales whiter than the old, has a harder white surface and is nearly smudge free comparing quite well with the Western product. Their test results are very encouraging except at the very fast 100 m range where there is evidence of stylus instability, which will be hard to cure. During this session I also gave them a fairly detailed description of the GLORIA II logging and display systems, but again there are many details which I could not reproduce from memory, and will have to mail in note form.

The following day we went much more closely into the slant range correction system using a Z80 microprocessor. It was in this session that I started to form my ideas about a better development system for products incorporating micro-processors, because it was then that I learned that YIN had written, assembled and keyed in by hand a 1K Byte machine language Z80 program using the introductory kit computer board previously mentioned. As

it happens we returned once again to the recorder problem in this session, which indicates how seriously they treat it.

On November 14th, which was a Wednesday and so free of lectures, we spent virtually the whole day looking at the condition of their project to build a BT = 100 signal correlator with CCD devices. I was able to go step by step through the history and present state of the project, and by direct observation see the difficulties they are facing in the way of fluctuations, drift and poor signal/noise ratio. On returning to my notes, I am even more convinced that there is no future in persevering with CCD devices, and I could not easily see how to isolate unambiguously the source of the trouble. We went on to cover other possibilities for the correlator, namely (a) the linear circuit group delay approach, (b) a one bit reference with a fast adder-subtractor chip and (c) the preferred but probably unattainable solution of a fast multiplier/accumulator chip. This discussion was continued the following day with my colleagues' design for a hybrid correlator, using digital storage and a high-speed analogue multiplier and integrator as the processor. The principle is ingenious but it requires careful attention to details of timing and stability.

On Friday November 16th I had no laboratory session and the following Monday 19th November I spent with YIN working on the IBM PC. I do not claim to know much about the PC but I was much quicker finding my way through the English handbook.

On Tuesday 20th there was no lab discussion because I was catching up for the lecture missed the previous day. The next day was a no-lecture day and in the morning we talked more about the GLORIA II system, particularly the details of the digital correlator and the pulse power amplifiers. In the afternoon I met a hydrodynamicist, ZHANG Nean-Fang, who had worked on the stability of towed bodies in water, and the operation of hydrodynamic depressors. He had written a paper which he was anxious to have published in a European journal. I am having a little difficulty in this respect because I am not expert in hydrodynamics and I do not have his manuscript, only a version in his English of the abstract. I am trying to resolve this by correspondence, but in the end I will need the manuscript. This subject came up again during my next lab session on November 23rd, when ZHANG returned and we discussed the title which I had little difficulty in drafting for him. The rest of that session was devoted to discussing the background to my report (to the Institute) which I wished to rough out if

not actually draft in time to discuss its major points with my hosts.

The laboratory sessions from Monday November 26th to Wednesday November 28th were partly devoted to drafting my report, but mainly to going over it with my colleagues and in the process recapitulating on the topics covered in earlier sessions and picking up many overlooked or unfinished points.

The session on Thursday November 29th was devoted to a farewell party in the laboratory for me and my wife, who had earned her place at the table by typing the draft of my report. It was attended by the laboratory staff, the visitors among my lecture audience, Professor Xu and a Professor Chang from one of the other research groups.

The remaining afternoons on Friday and the following Monday were fairly brief and devoted to discussion of the report with the full laboratory staff and a few final technical points.

As a result of discussing my draft I had to undertake modifications serious enough to prevent me leaving the final text behind when we left China on Tuesday 4th December.

9. TEACHING MATERIALS TAKEN TO CHINA As already indicated, the material I took to China consisted of a number of text books on most of the subject areas essential to the design of high performance sidescan and other sonars. With the wisdom of hindsight I would change quite a lot of this material in view of the great competence of my hosts in the theory of the subject. What they really need as will be clear by now is equipment, tools and conditions, and it would have been better appreciated if I had leaned more in this direction. However, it was after all books that I took and they will certainly strengthen the department's design library, for which my colleagues were grateful. The following is a list of the books:-

(a) Signals and Systems by Oppenheim and Willsky, Prentice-Hall.
(b) Theory and Application of Digital Signal Processing by Rabiner and Gold.
(c) Electronic Filter Design Handbook by Williams.
(d) Electronic Designer's Handbook, ed. Fink and Christiansen.
(e) Principles of Acoustic Devices by Ristic.
(f) Op-Amps and Linear IC Technology by Gayakwad.
(g) Using the IBM PC by Lewis.

(h) Z80 Assembly Language Subroutines by Leventhal and Saville.
(i) Microcomputer Interfacing by Artwick.

I had originally intended to take Radar Signals by Cook and Bernfeld and Principles of Underwater Sound by Urick but both are now out of print, and I had to take my own copies on loan. As it turned out my failure to buy them was lucky since they were both in the S.C.I.T. library.

10. THE MAIN RECOMMENDATIONS IN MY REPORT TO S.C.I.T. My report to my host department contained a section detailing the conclusions from my month's work and a list of recommended actions both agreed with my Chinese colleagues as follows:-

(a) To develop SGP-2 in the short term in its high resolution mode.
(b) To upgrade SGP-2 within 3 years to its original specification.
(c) To effect further exchange of material and results on signal correlators, displays and signal recorders.
(d) To set up a facility for the design, construction and testing of acoustic transducers.
(e) To concentrate sidescan sonar development to the high resolution short range and low frequency long range regions respectively.
(f) When conditions are favourable to enter the field of long range sonar construction and operation.

The foregoing are in effect a statement of the strategy of the laboratory. The remainder constitute a shorter range plan to upgrade the laboratory facilities to those necessary to effect the strategy of (a) to (f).

(g) To improve as far as possible the laboratory conditions and services.
(h) To send a senior group staff member on an extended study tour, at least partly to IOS.

And following this, based on the conclusions drawn in the tour report; to

(i) Establish an effective up-to-date workshop.
(j) To improve basic electronic construction facilities in terms of soldering, PCB design and fabrication, wire-wrap techniques, standard chassis construction, etc.
(k) To upgrade the digital electronics capability and the microprocessor development facilities.

(l) To set up a transducer test facility including an acoustic tank of suitable dimensions and construction.

(m) To carry out training programmes in all these techniques as necessary.

(n) To maintain contact with IOS, exchanging information, results, technology and whenever possible personnel.

I have also pointed out that the foregoing programme represents a large investment, and when the group get it all set up and going they will have a duty to share and spread the benefits as a technology leader within the South China Institute of Technology.

Finally, I consider the plan to be ambitious but attainable, and I would not have felt justified in endorsing such a scheme unless I could feel confidence in the knowledge, skill and dedication of the laboratory leadership to see it through to success. Considering the difficulties under which they have hitherto worked, I am confident that with the foregoing programme implemented the Sonar Laboratory will become a key centre for sidescan sonar in China and quite possibly beyond.

11. CONCLUSION To summarise my month's work in China, I would say that I found a group of talented, clever and motivated people working in conditions of depressing shortage and poverty. They are open, friendly and cheerful and I cannot imagine receiving a warmer welcome anywhere. We had many long and detailed discussions and I hope that as a result of these I have been able to recommend an affordable and effective programme of improvement in facilities and working conditions. I have said nothing about the funding of the programme, but I imagine that the Chinese Government would support the study tour and based on the costings coming out of the subsequent report that funds (possibly under the CUDP) would be found for the remainder. All this will take time, but in the meantime the group has to set up a field season in 1985. With good management and a little luck this programme will start to generate some revenue, which will help in its own right and help to establish the credibility of the group. If this is the case I shall take great pride in having been associated in a small way with a success.

It is our wish at I.O.S. to establish scientific links with Chinese laboratories, not only in sonar but in other branches of oceanography, and the groups at S.C.I.T. have expressed keenness to establish a link with I.O.S. Thus I look forward to a growing and fruitful exchange in future, however I have proposed no formal machinery because I am sure that this will

act as a constraint unless it is by chance exactly matched to the future development of both laboratories. For the time being, I will ensure that we have an exchange of annual reports, collected reprints and other literature in addition to the list of material I have undertaken to send to China. Over and above this, I will maintain a correspondence and give what help I can in the way of helping Chinese authors to prepare and place papers in Western journals, and helping to place visiting scholars and students in suitable laboratories. In the latter context I have, I hope, succeeded in placing a young graduate teacher in a British university as research assistant supported by the Chinese Government for $1\frac{1}{2}$-2 years.

Finally, I would like to record how grateful I am for the opportunity to share in this exciting and important programme. It was a most stimulating experience to work for a month with such talented people and I am most grateful for the friendly and hospitable welcome experienced by both my wife and myself.

M.L. Somers, January 1985.