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THE CREATION OF HYDROGRAPHIC SERVICES IN DEVELOPING COUNTRIES

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In most developing countries, progress towards the establishment of hydrographic services has, indeed, been rather slow and this stems naturally from the fact that the limited national economic resources have to be concentrated on the more pressing problems facing these nations. There is also the fact that, unlike the Land Survey departments which in most cases existed under the colonial administration, even a nucleus of a hydrographic service does not appear to have been created in the majority of these states. Consequently, in the various national plans the development of the topographic and geodetic facilities progressed fairly rapidly whereas hydrography, which meant creating a completely new facility, was not given anywhere near the same importance.

Amongst the coastal states of the world there are at least 50 countries that do not, at present, have any national hydrographic services. At the same time there are a large number of developing countries whose existing hydrographic capabilities, being extremely limited in manpower, vessels and equipment, are increasingly feeling the need for expansion in order to cope with the requirements of surveying to meet national needs.

As a result of the growing economic importance of offshore resources and the greatly increased areas of national jurisdiction likely to emerge in the near future as an outcome of the international convention on the Law of the Sea, there is, undoubtedly, a growing realization amongst the decision makers in developing countries of the importance of having adequate modern charts. These are not only important for navigation and the exploration and exploitation of the resources lying within the maritime zones of coastal states but are required by a variety of users including legal experts, fishermen, engineers concerned with coastal and undersea works, sea-bed mining operators, as well as pollution control agencies.

A study conducted some time back for the United Nations Economic

and Social Council on the subject of hydrography and nautical charting shows that among countries who do not have a national capability in hydrographic surveying, the coastal areas of at least 60 % of these states are covered by either low density or incomplete surveys which, in many cases, date from the 1830s to 1910.

Against this background we may like to consider some of the requirements projected in the draft Articles before the Law of the Sea Conference, particularly those that relate to the delimitation of boundaries, including the exclusive economic zone.

In brief, the draft Articles require the charting of baselines or the limits derived therefrom and the boundaries, or the provision of a list of coordinates. Furthermore the term "large or adequate scale charts officially recognized by the coastal state" is used in various Articles, and it is specified that due publicity should be given to these charts and copies be deposited with the Secretary General of the United Nations.

The need for establishing hydrographic facilities in the developing nations of the world has been stressed time and again in various international forums notably the United Nations Regional Cartographic Conferences for Africa, for the Americas, and for Asia and the Pacific.

In establishing national hydrographic services there are a number of factors which have to be considered, and some salient aspects are listed below :

1. It is necessary to determine the appropriate authority, within the government, under which the future hydrographic service is to be formed. Traditionally, in many countries, including developing countries, the hydrographic services have formed part of the Naval Defence Establishment. This has many obvious advantages in that trained manpower is available to operate the vessels and to maintain them. It is also comparatively easy to draw on personnel with adequate sea experience for specialization in hydrography. However, in varying conditions it may be found convenient to constitute the service within the Marine Transport or Ports Department or as part of an agency entrusted with topographic and geodetic surveys. The latter course has distinct advantages in that most developing countries have fairly well established Land Survey departments; hence, personnel (both sea surveyors and cartographic staff) who have a good background can be drawn from the existing cadre for further training. There is also the advantage of an existing technical and administrative machinery.

2. There is the need to formulate a suitable project for the creation of a hydrographic service; such a project report should ideally lay down plans for each phase both in the long and the short term and include :

— recruitment of project staff;
— training in different phases;
— procurement of surveying craft;
— assessment of equipment and its procurement;
— award of contracts;
— proposals for a programme of activity;
— surveying and cartographic establishment of administrative machinery.

The preparation of a project report will, undoubtedly, require the services of an expert who must not only have a thorough technical knowledge in hydrography but must also be familiar with conditions obtaining in developing countries and the domestic resources which can support the project.

The services of an expert could be obtained by bilateral arrangements with a country that has a large hydrographic department, or through an international agency such as the United Nations Organization for Technical Cooperation (UNOTC), or through the IHB which could suggest names from amongst the panel maintained in the Bureau.

The selection and training of personnel is a key area which requires very careful consideration. However, I regret to have to say that frequently this is not fully appreciated, and it is somehow assumed that hydrographic surveyors can be trained in a few months "on the job" or by undergoing a short course at a training centre. Another aspect concerns the selection of personnel, as it often happens that students sent for training do not have an adequate academic background or language proficiency to follow the course, and in yet other cases they just find themselves unable to adjust to a sea environment. All these are causes of frustration, for the student as well as the staff imparting the training.

Member States of the IHO have rendered invaluable assistance in the training of personnel from developing countries, and much of this assistance has been provided on a bilateral basis. Although there are differences in the structuring of training courses, most of the programmes are comprehensive and cover theory as well as the practical aspects of hydrographic surveying. The comprehensive courses last at least one year and require that the student have a good academic background in mathematics and the sciences and be proficient in the language in which the training is given.

Training within the framework of Regional Hydrographic Groupings has been highly successful in some areas, and it is being increasingly recognised that training given in the developing country itself in the environment of the geographic region is comparatively more effective, since common language, prevailing economic and environmental conditions, customs and traditions all have an influence on training. In addition to these factors are the all-important financial considerations, arising from the costs involved in travel and subsistence in a far-off expensive country.

I believe that another contributing factor is that personnel trained in sophisticated methods frequently find it difficult to adjust to working conditions obtaining in developing countries, where resources are very limited and the equipment often outmoded by modern standards.

Modern techniques and equipment provide the capability for accelerating hydrographic surveys and in extending these to a considerable distance from the coast. They also provide the facility to continue survey operations round the clock. In addition, there are available today various types of data acquisition and processing systems.

I venture to suggest that in developing countries it is all the more important that very careful planning is done in the acquisition of modern

instrumentation, whether it be for creating a new hydrographic service or expanding the existing facilities within an established department.

In the planning stages any advice or assistance in the form of user reports rendered by a well established hydrographic department would be of invaluable help, particularly if the department could give an overall assessment of the operational utility of the system.

Most electronic systems are highly reliable and fairly easy to maintain, particularly with the present trend towards replacement of individual units and modules in the event of equipment failure. However, these are highly complicated systems which call for a substantial inventory of spare parts and maintenance personnel. In any event it should be recognized that a proper backup facility in technical personnel is essential in a developing country where it is very unlikely that the manufacturer will be in a position to provide maintenance services.

In the planning of equipment, another factor which should be recognized is that advances in technology will probably be made by the national land mapping and geodetic departments. Cooperation with, and the utilization of the facilities of, such institutions could eliminate a great deal of duplication of effort and financial outlay. For instance for data processing, electronic computers and plotters already installed could be used, as well as the cartographic and printing facility available from another national agency.

I shall deal briefly with technical assistance available under the United Nations. In this context I would like to point out that U.N. assistance applies equally to the creation of new hydrographic services and to the strengthening of existing hydrographic departments.

It will be noted that there are a number of resolutions which have been adopted by successive U.N. Regional Conferences on the subject of financial assistance in hydrographic surveying activity and the training of personnel. The texts of these resolutions are contained in the reports of the sixth, seventh and eighth Conferences for Asia and the Far East and reproduced in IHB Circular Letter 18/1976.

Incidentally, representation at these Conferences is not limited to the region, but is on a global basis.

In brief, the resolutions urge developing countries to give urgent consideration to expanding their hydrographic capabilities, if necessary, by applying for assistance and other aid available through the United Nations. There are also resolutions dealing with assistance in the award of scholarships for training in hydrography. In the context of assistance through the UN, I believe it would be helpful if I were to outline the UNDP procedures :

The United Nations Development Programme (UNDP) is the UN's major agency for international technical cooperation. It is primarily a financing, over-all programming and monitoring organization with Resident Representatives in 108 countries. The bulk of the field work and the projects that UNDP supports are actually executed by the specialized agencies of the UN development system. These agencies help governments to plan individual projects within their "Country Programmes" for UNDP assist-

ance. As a rule they recruit international experts, purchase equipment and procure specialized contract services needed for project execution.

The procedure for programming UNDP assistance to developing countries is :

a) Each developing country assisted is allotted an Indicative Planning Figure (IPF) over a five year cycle, the current cycle being 1977-81; the IPF represents the magnitude of resources expected to be made available from the UNDP to a given country.

b) With its IPF as a guide, each government draws up a "Country Programme" outlining its priorities for UNDP assistance and allocating its share of UNDP resources among those priorities. The Country Programme formulation is discussed with the UNDP's Resident Representative, and is then submitted for approval to the Governing Council.

c) The preparation of individual project requests is made usually in consultation with advisers from the UN System, and these delineate each project's main objective, its duration, its cost and the respective responsibilities of the government and the UNDP.

Under the new decentralized system, almost all projects are approved under the Resident Representative's powers. New projects can be added at any time during the period established for a Country Programme so long as they are aimed at helping to achieve the selected development objectives and can be accommodated within the available resources.

There is another aspect which might be of particular interest to hydrographic services interested in expanding their facilities through UN assistance. A government may propose to the Resident Representative that it execute the project, in which case the government designates its own department or agency (for instance the hydrographic department) as the executing agency. In this case the designated agency must fulfill certain conditions relative to its technical and managerial capabilities e.g. its experience in executing similar projects, the depth of its technical knowledge, its links with national and international sources of expertise, etc.

Very briefly, I will sum up by saying that if you are interested in UNDP assistance, the first step is to have your project included as a priority item within the "Country Programme". This will mean approaching your national planning commission and perhaps discussing the requirements with the UNDP's Resident Representative.

In addition to the technical assistance available through the United Nations, I believe that it is equally relevant to stress the importance of assistance available through bilateral arrangements between states. Most industrialized nations have created technical assistance programmes, funded through varying sources, and intended to provide developing nations with aid in training, equipment and services. We are all fully aware of the fact that generally there are considerable financial restraints within the budgets of hydrographic departments, and rarely is it possible for these to provide any assistance directly; however, there are nevertheless the possibilities that such assistance could be made available through the overall national aid programmes.

In this paper I have tried to outline a few of the general aspects connected with the development of hydrography in the third world countries and I hope that some of the points will be of assistance in formulating plans and projects.

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ESTABLISHMENT OF THE SINGAPORE HYDROGRAPHIC DEPARTMENT

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ABSTRACT

The Hydrographic Department of the Port of Singapore Authority (PSA) was founded on lst October 1971 and has over this short period become an important department within the organisation. It has been called upon to advise on problems pertaining to fields as diverse as navigation/ pilotage, Port development schemes, dredging, hydraulic studies and territorial water claims. These six years have witnessed considerable changes, and multifarious activities besides, obviously, physical expansion. Responding to the needs of rapid development of Port facilities, the Hydrographic Department has grown beyond the periphery of normal and conventional activities.

HISTORICAL

The Port of Singapore Authority was established in 1964 and took over the functions of the erstwhile Singapore Harbour Board. The Authority was made responsible *inter alia* for provision and maintenance of efficient port services and facilities, regulation and control of navigation within the Port and approaches thereto, and conservancy of its waters.

Singapore's emphasis on export-oriented marine industries in the 1960s brought in its wake an urgent need for additional wharf facilities. New refineries required deep water oil terminals for import of crude oil, and berths for export of finished products. Consequently, demands were made for fresh surveys of port waters for the planning, design and eventual construction of new port facilities. This was the compelling reason for setting up a hydrographic service in December 1965 to cater for such needs. Hitherto all hydrographic surveys had been carried out by the British Navy.

The Hydrographic Section was formed in December 1965 within the Port Master's Department, with a Conservator in charge. A retired hydro-

graphic surveyor from the British Navy was appointed as the first Conservator. He in turn recruited a Trainee Assistant Conservator with a 2nd Mate's Foreign-Going Certificate of Competency and five technicians all with education to 'O' level — three of these last were trained locally for field work and two for cartographic work. By way of equipment the section had a 40 ft wooden-hull launch fitted with an echo sounder, as well as some current meters, a few survey sextants and station pointers.

No firm guidelines were given to this section about its immediate and future role, and the work done involved mainly sounding surveys of areas earmarked for development. Within 2½ years of its formation both the Conservator and the trainee left the service. Some months later a Canadian officer with some marine background was appointed, but he too left within a year and the section was temporarily headed by a graduate in land surveying. Due to lack of continuity and the non-availability of a professional hydrographer the section could not make much progress.

In August 1970 the PSA obtained from India the services of the author under the Colombo Plan Technical Assistance Scheme. The Terms of Reference included the establishment of a national hydrographic department with adequate hydrographic capabilities to cater for all requirements of the Port, industry and the Government. The staff then included two Assistant Conservators (both graduates in land surveying), three survey technicians, one cartographer and a clerical assistant. None of these had any formal training in hydrography or any marine background.

Having assessed the immediate needs of the Port and of industry, and their likely requirements for the next 5-7 years, the author submitted in December 1970 to the PSA management a comprehensive report together with his recommendations for phased expansion of the section into a Department, for training of personnel, acquisition of suitable equipment, recruitment policy and for the institutional and organisational structure in relation to other Departments within and outside the Port Authority. These recommendations were accepted by the management and the author was requested to implement them.

DEVELOPMENT

Singapore's territorial waters surrounding the main island and the offshore islands and reefs cover an area of about 225 sq. miles — the greatest east-west distance being about 30 miles. Situated almost on the equator, Singapore never experiences cyclones and their accompanying rough weather conditions. These factors led to a decision to develop shore-based survey parties provided with adequately equipped small survey craft. This obviated the need to invest in a large sea-going survey vessel and thus also the necessity for personnel with marine background and qualifications. Hydrographic activity is highly capital intensive; the labour element in hydrography is small but the cost of ships and equipment is high.

The survey craft acquired therefore comprised a 22 metre steel-hull twin-screw survey vessel certified for plying within local trade limits, and two 14 metre wooden-hull survey launches for work in relatively sheltered

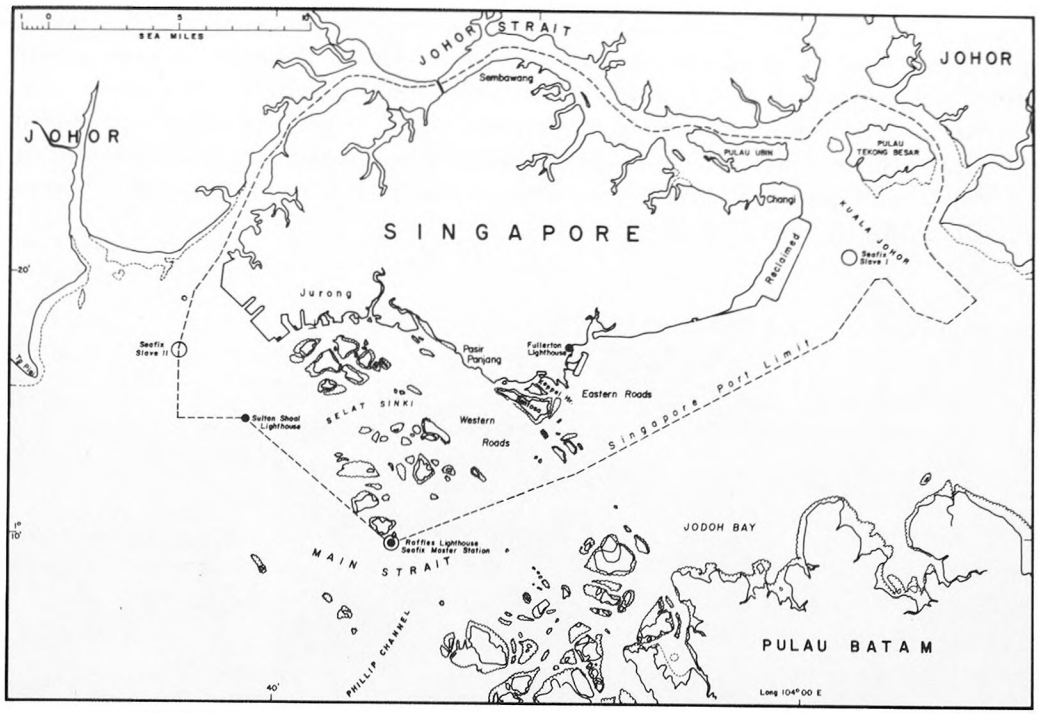

FIG. 1

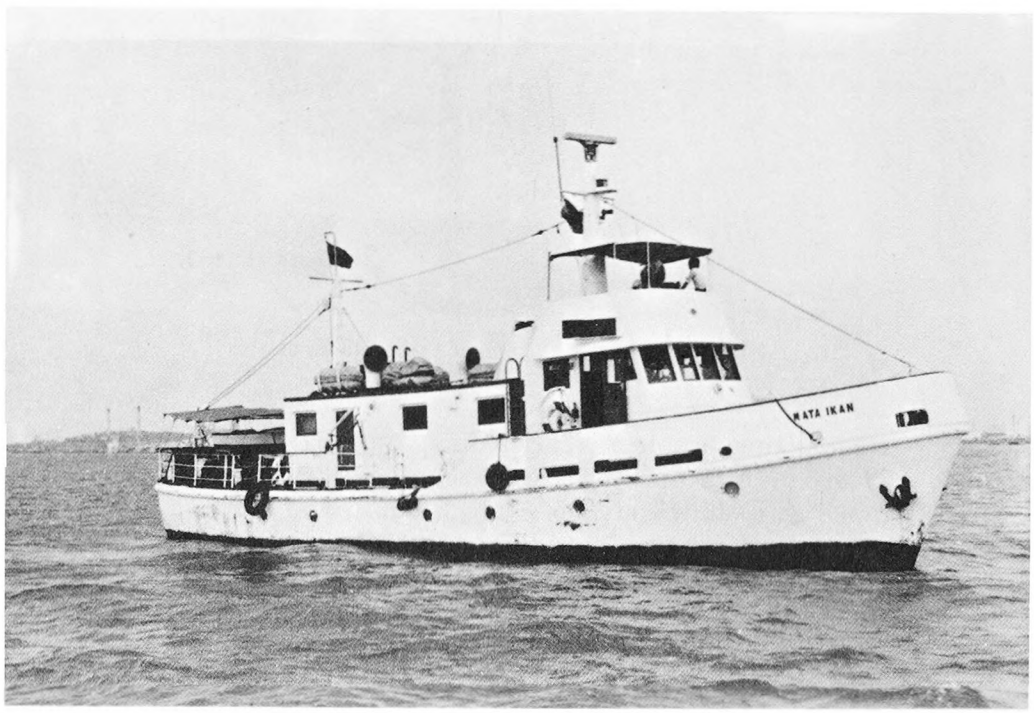

FIG. 2. — The Motor Vessel *Mata Ikan*.

areas. The larger vessel (*Mata Ikan*, fig. 2), requires officers duly certified for local trade, but all the other launches are manned by local seamen trained as helmsmen and as serangs.

It was realised that though the whole survey area was in sight of land, position fixing by visual control was not possible in most areas even a few miles away from the mainland due to poor visibility, industrial smog, and — last but not least — due to numerous ships at anchor which obscured the main shore control points. Apart from these considerations, the output of work was minimal, due to the laborious and time-consuming process of surveying by visual methods.

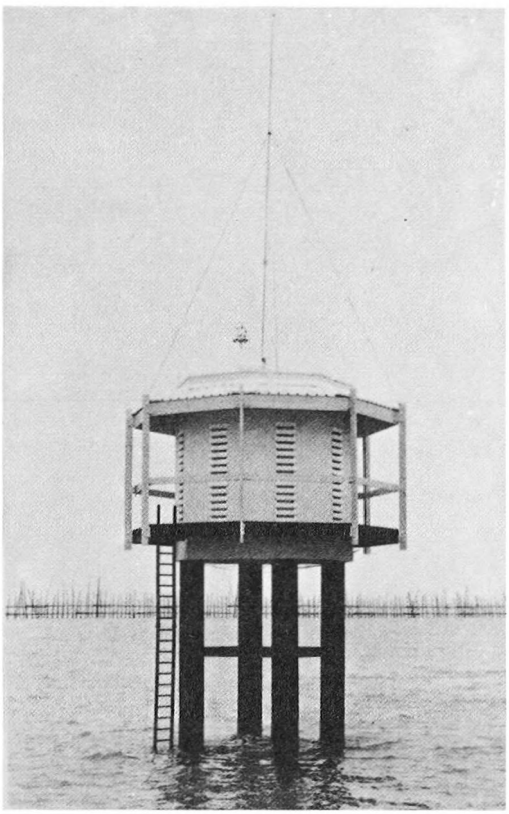

FIG. 3. — A slave station of the permanent Sea-Fix chain.

To overcome this problem a permanent Sea-Fix chain was installed in 1972-1973 to cover the survey area (excluding the Johor Straits). The Master Station was installed at Raffles Lighthouse and slave stations were established at sea on specially built structures supported on piles (fig. 3). These slave stations, located at the eastern and western ends of Port waters, were built on shoal patches so as to protect them from damage by passing vessels. The Master Station works off 24 volt batteries kept on float-charge by the Lighthouse generators. The slave stations are equipped with their own Telan thermo-generators — direct butane to electricity type. The chain has been functional with minimum breakdown for the past 4-5 years, and has been used for surveying, dredging and fixing the positions of buoys. All survey vessels are fitted with Sea-Fix receivers and track plotters. The survey vessels also have gyro, radar, echo sounders, and a transit sonar for detecting wrecks and other obstacles.

As the equipment available in the old Conservator's Section was inadequate for the increased activities of the Department, additional modern equipment was acquired. Major items of equipment purchased included a complete Decca Sea-Fix Chain and shipborne receivers, Motorola Mini-Ranger Mk III, echo sounders with better resolution and range, a Tellurometer model CA-1000, a transit sonar, a coordinatograph, etc. Wherever possible the Department's officers were trained in maintenance of the equipment.

RECRUITMENT

Recruitment of personnel at a professional level is seldom possible in the field of hydrography. Due to non-availability of local training facilities it was not possible to recruit personnel at a very junior level and then train them in the various disciplines within the broad spectrum of hydrography. More as a matter of expediency therefore, recruitment of the different categories was from amongst candidates with suitable backgrounds. Thus in the grade of Assistant Hydrographer, two officers with marine background and qualifications (one with a Master's Foreign-Going Certificate, and the other with naval experience and qualifications) and two graduates in Land Surveying were appointed. Later another graduate in Mathematics and Physics was recruited. A new category of Technical Officer (Hydrography) was created, and six persons in possession of a diploma in Land Surveying were recruited in this grade, while twelve others with either an 'O' or 'A' level education in English, Mathematics and Science were recruited as Technicians (formerly known as Survey Recorders).

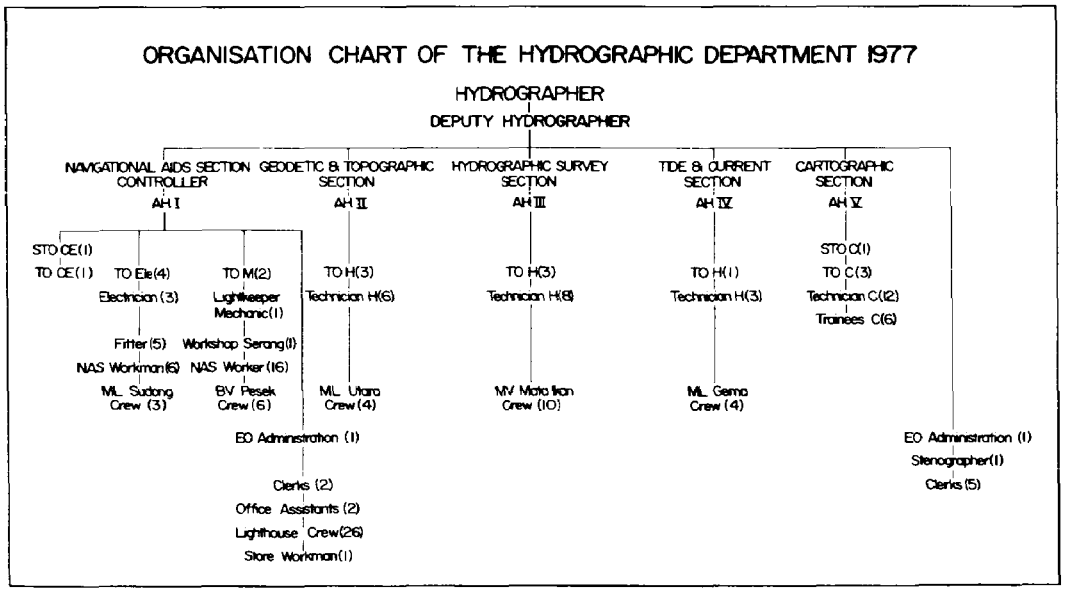

FIG. 4. — AH = Assistant Hydrographer; STO = Senior Technical Officer; TO = Technical Officer; CE = Civil Engineering; Ele = Electrical; M = Marine; H = Hydrography; C = Cartography; ML = Motor Launch; BV = Buoy Vessel. NAS = Navigational Aids Section; EO = Executive Officer. Figures within brackets indicate numbers of personnel.

Similarly, for the cartographic section, candidates with 'O' and 'A' level passes in English, Mathematics and Science were taken on as Technicians (Cartography) (previously designated as Tracers and Draftsmen). A new category of Technical Officer at a supervisory level was created, and those in possession of a diploma in Land Surveying or a degree in Geography were appointed at this grade. All recruitment was done in a phased manner which facilitated suitable training of the staff and automatically brought about a hierarchical system within the Department (See fig. 4). There was no difficulty in recruiting suitable personnel in the administrative section.

TRAINING

It is well known that hydrography embraces a multitude of disciplines. The development of highly sophisticated electronic equipment for various purposes has further added to the subjects a hydrographer must learn. The end product of any hydrographic activity is a nautical chart, the making of which requires expertise in seamanship, navigation, geodesy, mathematics, electronics and cartography. The various disciplines within the field of hydrography are all inter-dependent, and it is only by team work, common exertion and enterprise that the objective can be achieved.

It was obvious that personnel with different backgrounds and qualifications could not be trained in a common training course. Neither was it practicable nor essential to train the staff in all disciplines. Hence tailor-made courses were arranged, in order to make best use of the period of training and available resources without causing undue shortage in the manpower required for carrying out the day-to-day functions of the Department.

The Assistant Hydrographers with expertise and experience in geodesy were therefore trained in the nautical subjects and hydrography; and those with marine background were trained in geodesy and hydrography. All were sent overseas for such training. One officer completed an Intermediate Course in Hydrography at the R.N. Hydrographic School in Plymouth, UK; another successfully completed a year's course at the US Naval Oceanographic Office in the field of Hydrographic Engineering, and two received training in the Indian Naval Hydrographic School in Cochin.

The Technical Officers (Hydrography) were first trained within the Department for about a year in boatsounding and position determination by visual and electronic control and in other fields such as triangulation, tide level observations, etc. Thereafter, they were sent in turn to the Indian Naval Hydrographic School on a group course for 1st Class Survey Recorders. Technicians (Hydrography) were also given on-the-job training, and later sent to India for a 2nd Class Survey Recorders' Course.

Technical Officers and Technicians in the Cartographic Section were similarly trained in Nautical Cartography in the Indian Naval Hydrographic Office in Dehra Dun. Their level of training was determined taking into account their academic background, their current functions and their future role within the Department. These tailor-made courses were arranged

with the kind assistance offered by the Chief Hydrographer of India. The Department is much indebted to the Indian Hydrographer for his help in making this training available through the Colombo Plan Assistance Scheme. The personal interest that successive Indian Hydrographers, Rear Admiral D. C. KAPOOR and Rear Admiral F. L. FRASER, took in the training of some twenty officers in the past 6 years is gratefully acknowledged.

The Assistant Hydrographer, a Mathematics and Physics graduate who had prior experience in computer programming, was sent to the Institute of Oceanographic Sciences, Liverpool, for an eight-month course in Harmonic Analysis and Prediction of Tides. On his return to the Department in November 1976 he formed the Tides and Currents Section.

Two officers from another Department within the PSA were sent to the Decca Training School in UK for a course in maintenance of Decca Sea-Fix equipment. Together with our own staff, they maintain the Sea-Fix chain and other electronic equipment of the Department.

The Department took over the functions of the erstwhile Singapore Light Dues Board (SLDB) in March 1974. Hitherto the author in his capacity of Hydrographer had been a member of that Board, rendering technical assistance and advice in the establishment and maintenance of aids to navigation in Singapore waters. A new section known as the Navigational Aids Section (NAS) was formed in the Department in 1974 and with effect from 1st February 1975 the Department started issuing Notices to Mariners and Radio Navigational Warnings.

The NAS has three operational Engineering sub-sections — Civil, Marine-Mechanical, and Electrical Engineering — each with a Senior Technical Officer or Technical Officer in charge. Together, they maintain five lighthouses, sixty two beacons, and some sixty buoys.

Recruitment of Technical Officers in this section was from among candidates in possession of a diploma in their particular field. After initial on-the-job training these men were sent to Japan for training in their field with the Maritime Safety Agency (MSA). In addition to group training courses, the MSA also kindly made special attachments of our Trainees within their Department to suit Singapore's special requirements. To date four men have been trained in Japan, and they have contributed greatly towards the improvement of our Nav-aids.

In the continuing training programme, the emphasis has now shifted to advanced training, e.g. in automation as applied to hydrography and cartography.

With the return of our more senior Officers from their overseas training the Department was able to commence its formal training programme for new recruits and trainee technicians. This was a big step forward, in that in addition to practical on-the-job training, lectures in different subjects were given and examinations were introduced to ascertain the trainees' degree of comprehension and retention of know-how. This eventually culminated in the Department being able to offer training facilities to technicians from the Hydrographic Departments of neighbouring countries. To date four candidates from Thailand's Hydrographic Department have been trained as Survey Recorders and Cartographic Draftsmen.

FINANCE

At the inceptual stage it was pointed out to the PSA management that the Hydrographic Department could not be considered as a self-sustaining Department, as the revenue earned would normally fall short of the expenditure. On the other hand it was emphasised that hydrographic and hydraulic data were a prerequisite to ensuring safety of navigation, as well as for the future development of port facilities. There being no other hydrographic department, the only other alternative for getting such work done was to contract it out. The shortcomings and inadequacies of this option and the fact that this would not be in the long-term interests of the Port were appreciated. The Port management therefore accepted the recommendations that the entire cost of the Department be met out of the Port Dues collected by the PSA.

Consequent to the Department's taking over the installation and maintenance of aids to navigation within Singapore waters, the PSA started collection of Light Dues. Such dues form, however, part of the Port Dues and as such cannot be credited direct to the Department's revenue. These dues alone are more than sufficient to meet the entire cost of the Hydrographic Department.

However, the Department also earns revenue from the following sources : (a) Survey fees for hydrographic and tidal surveys carried out for the oil and shipping industry in the seabed areas leased by the industry; (b) sale of survey plans, charts and tide tables; (c) installation and maintenance of nav-aids owned by private developers exclusively for their use, and (d) consultancy services offered in conducting feasibility studies for both the private and public sector. The revenue thus earned amounts to approximately 35 % of the Department's total expenditure.

In the final analysis, it was the kind and favourable response of the Port of Singapore management to the Hydrographic Department's many requests that has made it possible for the Department to achieve its present capabilities.

WORK DONE

Initially, most hydrographic control was still in the form of field-computed values, and if it was adjusted at all this was by bits and pieces and it was not assembled as a homogeneous whole. Most of the control and other prominent landmarks and offshore features useful for navigation have now been triangulated and connected to the national geodetic network.

With the installation of the Sea-Fix chain and an increase in the number of survey parties the Department's output of work increased manifold. This has made it possible for us to resurvey 11 703 linear kilometres of Singapore's Port waters on scales ranging from 1:1 000 to 1:10 000. During the series of joint hydrographic surveys of the Malacca-Singapore Straits the Department's teams surveyed 4 369 linear kilometres in the Main Strait. The Department also undertook surveys in newly developed channels in Port Kelang, West Malaysia and at Muara Harbour in Brunei —

the author acting as Consultant to the Brunei Government to identify the causes of siltation in the Muara approach channels, and recommending certain measures to improve their navigability. These recommendations are now being implemented by PSA's Engineering Services Division.

Tide and Tidal Stream observations carried out at navigationally important locations have resulted in a better understanding of the tidal regime of port waters, and predictions thereof have had an immeasurable impact on pilotage, since by taking advantage of tidal rises, deeper draft vessels can now be accepted. Better programming of Very Large Crude Carrier (VLCC) berthing operations has resulted in savings of time and thus has become more economical. The Department now maintains seven permanent tidal stations. The tidal and current data was used for the construction in Poona, India of a scale hydraulics model of Singapore. The model has proved indispensable in planning port development schemes. All the hydraulic and oceanographic data required for the construction and 'proving' of the model were provided by the Department.

Much progress has also been made by the Cartographic Section in the past six years. The Department published its first nautical chart on 9 May 1975 (*) and is now busy in compiling three more charts of Singapore Strait at the same scale. Work is simultaneously progressing on large scale charts of the Port Waters. The standard symbols and abbreviations adopted by the IHO are used by the Department.

Being responsible for aids to navigation in Singapore waters, the Department has kept abreast of changes in this field. The gas lanterns on buoys and beacons have been replaced by lightweight battery-operated lanterns. A new type of Navaid was introduced when a Resilient Beacon was installed in Port waters in March 1974. This beacon comprises a steel box filled with concrete sinkers. A steel-cum-aluminium tower is connected at its heel to the steel box by a universal joint thus enabling the tower to oscillate a few degrees from the vertical. The tower carries a large cage-type daymark and a battery-operated light mounted on gimbals. This aid has the advantages of a rigid beacon, in that it maintains its position and is as conspicuous, while (unlike a buoy) it cannot drag, on account of its heavy anchor and mode of construction. Resilient Beacons have since been installed in other critical areas. (See fig. 5).

Apart from the above conventional tasks, the Department has carried out various other studies for specific requirements. A feasibility study was carried out for an oil refinery to advise the company of the ideal location and alignment of berths for 90 000 ton dwt tankers and for a pier for small-product use.

In 1970 the PSA proposed to reclaim an area of 90 hectares of low-lying reef along the western shore line. The existence of the water intake for a power station immediately eastward of the reclamation area gave rise to apprehension that this intake would silt up. A fluorescent tracer study carried out by the Department confirmed this fear and suitable measures were therefore taken to prevent the fill material from silting the eastern area.

(*) Singapore Strait, Port of Singapore, Anchorages and Navigational Aids, scale 1:50 000.

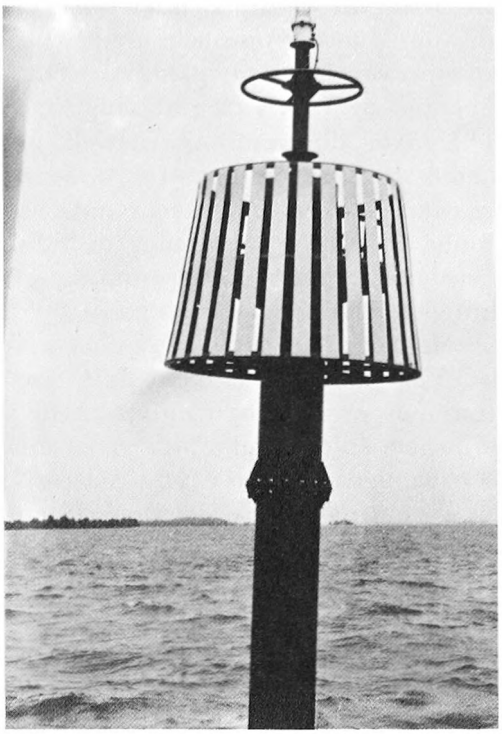

FIG. 5. — A Resilient Beacon.

In 1971 the Department, together with the Singapore Institute of Standards and Research, carried out radio-active tracer studies in the Eastern Roads. The study indicated bed-load movement towards the Container Port then under construction. To prevent such siltation the original design was modified and the eastern side was sheetpiled.

In 1973 the Hydrographer played a prominent role in bilateral talks with Indonesia on territorial waters, and later in the actual delineation of the territorial water boundary between Singapore and Indonesia in the Singapore Strait.

In 1974 the Hydrographer was invited to carry out a technical feasibility study of development of a port at Marivelles Bay in the Philippines. Channel dimensions, turning circles, berth alignments, quantums for initial and maintenance dredging, and programming and berthing of vessels in different seasons were some of the aspects studied, and appropriate recommendations were submitted.

In 1974-1975 the Department played a prominent role in the establishment in the southern part of the Port of a Single-Buoy-Mooring facility for VLCCs up to 300 000 tons deadweight. Special-purpose Navaids were designed and installed to provide a leading line for a VLCC to transit across the Main Strait, and to indicate to the VLCC distances from the SBM in her final approach towards it. In August 1977 the Department established a Shipping Control Semaphore (fig. 6) at Raffles Lighthouse to warn passing vessels of the intended movement of the VLCC across the Main Strait.

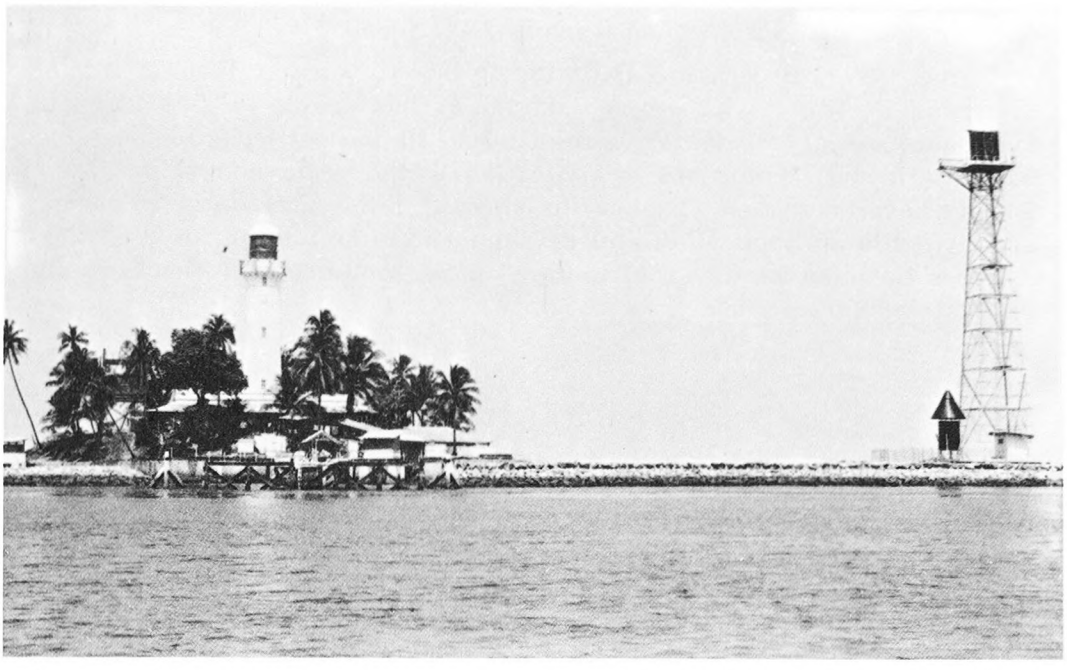

Fig. 6. — The new VLCC semaphore signal (right) with its cone-and-drum symbol, on Pulau Satumu close to Raffles Lighthouse.

When the Government of the Republic of Singapore joined the IHO in 1972 the Hydrographer was nominated as its official representative for all IHO matters. The Department also represents the Government in the International Association of Lighthouse Authorities (IALA). Officers of the Department have represented the Government in numerous technical meetings on subjects related to hydrography, navigation and Law of the Sea matters.

Due regard has always been paid to ensure happy co-ordination and cohesion amongst the staff. By providing incentives and upgrading their skills, it has been possible to maintain high morale among staff. Sustained interest and job satisfaction have been the essential ingredients for building up a closely-knit Department.

THE FUTURE

Now that most of the pressing demands of the public and private sector for fresh surveys and other studies have been successfully met, attention is being given to furthering our expertise and thereby providing other services. Local expertise is being developed in the field of harmonic analysis and predictions of tides and tidal streams. Repetition surveys of channels prone to siltation are planned to develop siltation patterns in order to monitor future changes and effect the necessary remedial measures to maintain the navigability of channels for present and future requirements.

Automation in field and cartographic processes is being considered to clear the back-log of work and to expedite publication of charts covering Singapore waters.

A new automated lighthouse is being constructed on the eastern shoreline to cater for shipping transiting the Straits.

The PSA Hydrographic Department has thus risen from a humble beginning in 1970 to its present status. It has grown in size, strength, experience and expertise. While rejoicing in its past, it looks to the future with confidence. Traditions of dedication to the profession and devotion to duty have taken root. By keeping abreast of the advance in technology and its optimum application and development to suit local circumstances, it hopes to make its due contribution to the well-being of the Port and the State of Singapore.