

TECHNOLOGICAL ADVANCES AND THE SEA SURVEYOR

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This paper was delivered at the Opening Session of the sixty-sixth Annual Meeting of the Canadian Institute of Surveyors, Ottawa, 24-27 April 1973, where the theme was "The practising surveyor and the new technology".

During the 19th century there were few changes in technology in the hydrographic field. The sextant and station-pointers for fixing the position of the craft and the lead and line for sounding were in use at the end of the century as they had been at the beginning. The invention of wire-sounding machines during the last quarter of the century for ocean sounding in advance of cable-laying operations was the only major innovation.

In the second and third quarters of the present century we have seen two major explosions in hydrographic technology and are at present experiencing a third. The first resulted from the invention of echo-sounding, the second from the development of electromagnetic and other electronic methods of ship-fixing, whilst the third, possibly the most difficult for the surveyor to cope with, has been brought about by the advent of the computer and results from our efforts to combine echo-sounding and electronic fixing data within a logging system capable of reproducing on-line or off-line plots and bathymetry, with the hope that this will lead to more rapid and more accurate compilation of sea surveys.

It is of course an over-simplification to speak of three separate technological advances, for even as we are developing survey systems capable of reproducing in graphic or printed form the combined results of electronic fixing and echo-sounding, improvements and innovations are developing in these latter equipments themselves. Some are improvements in quality of output, whilst others, such as digitisation of echo-soundings, are necessary in order to make the equipments compatible with a logging system.

However, I think it is helpful in studying the present complex situation if we consider three separate technical explosions, or as we could call them, revolutions. Further, I think it also helpful to look at the first two revolutions and see something of their history before we grapple with the third, if only to bring home to ourselves how quickly things have moved in the last 50 years and how they are presently accelerating.

As President of the Directing Committee of the International Hydrographic Bureau I make no excuse in stressing the part the Bureau has played throughout its 50 years of existence, by carrying revolutionary tidings and disseminating details of the developing technology among the maritime nations of the world.

Special Publication No. 1, published by the Bureau in 1923, was the first of five subsequent publications which recorded the developments in echo-sounding, making them widely known among hydrographic surveyors. The use of echo-sounding techniques for surveying first became evident in the U.S.A., U.K., France and Germany in the early post-war (1914-18) years, being the direct results of efforts which had been made during the war to locate submarines by sonic methods. In 1923 S.P. No. 1 reported unhappily that most nations were still treating the new echo-sounding developments as confidential, —“ no doubt as the result of the recent war ”. However, the author was able to give some details of the Marti System which employed sound made by detonation and was used successfully by the French Hydrographic Office to obtain a line of deep soundings from Marseilles to Philippeville, and of Prof. LANGEVIN's method of sounding by 'Hertzian waves'. “ In spite of the results of the Langevin apparatus ” writes the French Hydrographer of the time “ we are certain that we shall succeed in sounding by means of much more simple acoustic arrangements, having discovered that a light blow with a hammer on the hull of a ship transmits to the water sufficient sonorous energy to make the echo from the bottom of the sea audible to depths of 200 metres. The Scientific Research Department of the French Navy is now employed in the perfection of a sounding apparatus based on this principle. ”

The German Behm depth indicator is also described. “ The whole instrument can be worked from the bridge of a vessel and consists of a rifle, loaded with a detonator signal, two microphones fitted, below the waterline, to the side of the ship, and a recorder on the bridge ”. The first technological revolution had begun.

Sixteen years later the final Special Publication on echo-sounding (S.P. No. 33) was published, entitled “ A Summary of Echo Sounding Apparatus ”. The author was then able to record many different types of echo-sounder in use at sea, broken down into categories according to their sonic sources — hammer blows, audible frequency transmissions and inaudible frequency transmissions, the latter including magnetostriction machines among which were numbered the “ Silent Supersonic Echo Sounder of the British Admiralty ”, made by HUGHES and Son.

S.P. No. 33 carried an echo-sounding bibliography of 375 references; its date of publication was August 1939. Although much perfection of echo-sounding still lay ahead, the first technological revolution was really complete on the eve of World War II, which in its turn was to provide the impetus for the second revolution, that concerned with electronic fixing methods.

In 1942, Mr Harvey SCHWARZ of the Decca Record Company placed before the British Admiralty his proposals for fixing a ship at sea by electronic means. One master station and two slave stations, widely placed ashore in positions of known and exact location, enabled a vessel with

a receiver and recording decometers to fix her position as frequently as she wished.

The system relied upon phase comparison between the signal transmitted by the master and that sent out by the two slaves when triggered by the master signal. The phase comparisons read from the decometers were plotted with reference to predrawn hyperbolae on the chart. The system was first used operationally by ships of the allied navies making their landfalls off the Normandy invasion beaches on 6th June 1944.

Once the war was over the surveyor realised that he required his own transportable Decca chain with two stations he could locate by triangulation, and from each of these the master station, carried onboard the ship, could measure the direct distance on the earth's surface. Conveniently for the surveyor, easily plotted circles replaced hyperbolae as position lines.

Such a system was developed by Decca in the late forties, the Lambda system with lane identification following soon after.

The measurement of pulse transit times, from which wartime radar was developed, led to the building of a ranging system by the Radio Corporation of America for the control positioning of aircraft during long-range bombing missions. This system too was adapted by hydrographic surveyors after the war, a ship-fitted transmitter being used to send out signals to shore-based and accurately located active transponders. An indicator in the ship measured the elapsed time between transmitted pulse and receipt of the returning signal to give a two-range fix. The Coast and Geodetic Survey of the United States were the first major users of this system which they called Shoran.

Over the years the phase comparison systems may be said to have largely led the field for use in hydrographic work. The introduction of solid state components enabling more portable and simpler equipment to be made for the shore stations has enabled the sea surveyor to cut down on wasteful time and manpower required in establishing, manning and recovering these stations.

So we have seen Decca Lambda, Hi-Fix, Sea-Fix, Raydist, Hydrodist and MRB 201 developed to meet the sea surveyors' needs, whilst at the same time pulse systems such as Motorola and Artemis may be considered as short range descendants of Shoran.

During the 1950s and 60s the IHB has tried to help the practical surveyor by disseminating information on developing fixing equipments, just as it did during the echo-sounding revolution of the 1920s and 30s.

S.P. 39 was first published in July 1956 and gave details of four radio navigation systems and eight survey systems, with operational reports on six of the latter. By the time the 2nd edition was published in 1965 there were twelve survey systems to be described, whilst since 1960 annual supplements to the International Hydrographic Review had been published to carry the objective operational reports of newly developed systems which had been received from seagoing users.

Since 1965 S.P. 39 has been published in loose-leaf form. Since 1967 the annual supplements to the Review have been discontinued and such

operational reports or results of field trials as are received in the Bureau are published in the monthly *I.H. Bulletin* thus reaching the surveyor with the minimum of delay.

A glance at the annual index in the December number of the *I.H. Bulletin* under 'Operational Assessments of Equipment' will, in future, quickly show what equipment has been covered in the Bulletin during the year.

Electronic fixing equipments are expensive, and, with the exception of the survey craft in which they are carried, usually represent the largest material investment in field operations in national and commercial hydrographic offices. The proliferation of new systems and modifications to existing equipments pose difficult problems for a survey organisation, with limited funds, faced with the need for purchasing a fixing system best suited to the specific tasks. Lacking Research and Development staff, all that the average surveying manager can do is to classify his task, possibly within one of the four navigational zones set out by ANDERSON in his FIG paper. Here may be selected the range and accuracy requirements for each of four zones — inshore, coastal, off-shore and deep sea. Then access to a list of systems together with operational proof that such requirements have been achieved is most useful.

Having selected a system most surveyors are then faced with the need to justify the cost of acquiring it, the possibility of obtaining the requisite frequency clearances in the areas in operation and the compatibility of such equipment with any future data-logging plans the organisation may have in mind. Finally, it is not infrequent that a national purchasing policy prevents the Government-employed surveyor from obtaining the equipment he considers most ideally suited to his needs and his purse.

Once purchased, for financial reasons, the selected equipment must suffice for a long time despite the arrival on the scene of new systems which would have been more suitable.

Of course the surveyor thinks largely of his own particular requirements, but at the IHB one becomes aware of the very great differences which exist between one Member State and another in the quality and quantity of technological know-how; this wide range is further extended when one considers developing nations, not yet members of the International Hydrographic Organization, but who are approaching us for advice in setting up modest survey units to chart their own waters. To encourage the latter to adopt expensive electronic systems, which they will be unable to maintain, before their surveyors have mastered the sextant, station pointers and echo-sounder is, I believe, irresponsible.

Once the stage is reached when a developing unit is ready to adopt an electronic fixing system, simplicity of operation and low maintenance requirements are important factors when selecting the right equipment for the tasks envisaged, which may of course entail a long range capability if the continental shelf is to be delineated.

My final point here is that wide dissemination of the manufacturer's details of every new or modified system of electronic fixing, together with

objective operational reports from actual users under varying conditions is essential if the I.H. Organization is to play a useful part in guiding the world's hydrographic surveyors through the maze of modern technology. We need both the manufacturers' and the users' active help in this work to which we are attaching great importance.

With the growing use of data acquisition systems and computers everywhere in the early 1960s it was of course inevitable that the sea surveyor should see in their use a way of completely automating his work. This would lead to faster and more complete acquisition of hydrographic and descriptive oceanographic data, to be transferred ashore to be there converted to a navigational chart or oceanographic data sheet by yet more automatic means such as flat-bed scribing machines, tape operated type-setting machines, etc.

The concept was new and exciting, and in the excitement there has always been a danger that the need for absolute accuracy and the need for the seaman's eye in the compilation of a navigational chart would be overlooked. How far and how successfully have we travelled along what Admiral van WEELDE, the Netherlands' Hydrographer, has aptly named "the slithery road towards automation" !

At the present time there are probably not more than a dozen hydrographic services in the world who are really grappling to master the automation problem at sea. To attempt to estimate the amount of money which has been spent in these efforts, and how much of it has poured down non-productive gullies into the sea, would be an unrewarding exercise. Such a waste was inevitable if the sea surveyor is ever to pass from the slithery side road onto the three lane highway of full automation, along which he will have to travel far and fast before our knowledge of the world's oceans and seas will be sufficient to meet the ever-growing needs, not only of navigation, but also of controlled exploitation of the seabed in both national and international fields.

To find out how we are getting along is difficult, for the glossy handouts of the manufacturers and often smoothly presented papers by surveyors on national systems, illustrated with slides of impressive black boxes and intricate block diagrams, give the impression that all is going splendidly. Nevertheless, we so often find that when we are privileged to see a system in action some vital element is out of order and a chat with the officer conducting the survey often reveals a sad lack of confidence in automation.

On yet other occasions, for reasons of expediency in, perhaps, a remote area, faulty automation has to be set aside in favour of traditional methods. However, there is nothing new in this and we have to recognize that seldom, if ever, can surveying ships be set aside for long, purely for trials and experimentation with new systems. In the mid-thirties I recall many times, whilst boat sounding, getting out the leadlines when the echosounder broke down. The Captain would not have thanked me at night-fall if, with a blank fieldboard in my hand, I had told him I had spent the day with a screw-driver inside the echo sounding machine.

A good assessment of progress towards automation is a paper by

ROBERTS and WEEKS presented at the FIG Conference in Wiesbaden in 1971. The story is told from 1960 to 1970 which led to the emergence of Hydroplot (U.S.C. & G. Survey), Hysurch (U.S.N.), HAAPS (Canada) and the commercial Autocarta. During this evolutionary period such decisions as the use of magnetic or paper tape, whether the computer was to be sited onboard or ashore, and what form of echo-sounding digitisation to adopt had to be made by the developers according to their respective needs which have led to an interesting diversity of approach.

The U.K. approach to shipboard survey operation has been described by Commander MACKAY in 1971 at the Commonwealth Survey Conference. The resulting system is somewhat different to those referred to above. Known as the Marconi Elliott Hydroplot it was designed particularly to meet the requirements of ocean surveys when gravity and magnetics are being recorded continually, in addition to bathymetry, over long periods during both day and night, during which two long range fixing systems are in simultaneous use so that they may be used to monitor each other.

This system has been particularly successful in the gravity field where the computer, an Elliott 920B, is able to smooth the irregularities of the fixing systems continually over the previous 15 minutes before applying the Eotvos correction which relies on very accurate assessments of speed and course; to this the computer also applies the International Gravity value for the latitude in order to compute the Free Air anomaly.

Owing to the cautious approach by British naval surveyors to the digitisation of echo-soundings, still preferring personal inspection of the trace, there have not been significant advances in the bathymetric field. The change now made from a drum type plotter to a flat bed Kingmatic plotter on the bridge enables the surveyor to view the whole survey area at once and the automatic plotting of surveying fixes is now a very satisfactory part of this ocean survey system.

Germany and the Netherlands are also proceeding with automated survey systems, details of which, as yet unpublished, have been supplied to the Bureau so that we may pass them on to India to help them in planning a system for a new survey ship.

Recent papers in the *I.H. Review* have described a Danish System, the U.S. 'Hydas' and 'Hysurch' and the system in *Protea* the new South African survey ship. What we need most of all are operational reports for the Bulletin; such reports may in the short run entail some ruffling of national feathers or maker's pride, but in the long run will be to the benefit of the world's sea surveyors as a whole in selecting the systems, or parts of systems most applicable to their tasks.

Computers and logging systems are incapable of logical thought, they simply carry out with great rapidity instructions given to them and store great quantities of data. The surveyor will, we hope, always remain more important than the equipment he uses and the most modern equipment must still be regarded as a surveying tool.

Looking back over the 50 years covered by this paper one sees how inevitably and comparatively rapidly surveying equipment now becomes obsolescent. The surveyor himself also becomes obsolescent either by

reaching retiring age which is inevitable, or by becoming mentally obsolescent long before old age takes over. To avoid premature obsolescence, it is necessary, among other things, to keep up with current literature.

ROBILLARD in his paper 'Technical Obsolescence — A Surveyor's Dilemma', reprinted in the July 1973 issue of the *I.H. Review*, points out that there are 100 000 published articles on surveying each year, only a small fraction of which are of interest to one surveyor. It is here that the Librarian, in those establishments lucky enough to have one, plays a vital role in winnowing the chaff and bringing the corn to the attention of the busy surveyor.

And it is here on a world-wide scale that we believe that the Bureau with its Library, at present woefully lacking in modern technological papers and publications, could make a considerable contribution by bringing to the notice of the IHO Members items of importance to hydrographic surveyors by mentioning them, translating them and perhaps publishing them in the *Bulletin* or the *Review* as appropriate.

To continue on the theme of the Surveyor : in the world to day there are two types of surveyor employed by different national hydrographic offices, whilst in the commercial field both types are often working together. By and large in those organisations which are part of the national navy, the ship's deck officers, from the Captain downwards, are naval officers, the OOW on the bridge being in charge of both the ship's safety and the surveying operations; in many other countries certified merchant service officers are in charge of the ship which they navigate according to the requirements of the qualified surveyors.

There are merits in both systems which were argued out at the FIG meeting in Wiesbaden, as amusingly reported by McCULLOCH at the 11th Canadian Hydrographic Conference. Further unpublished discussion took place in the Hydrographic Committee of the Royal Institution of Chartered Surveyors (U.K.) at the Shrivenham Conference of Land Surveyors (April 1972), and no doubt it will be frequently discussed again. I believe that the gradual influx of university graduates into most modern navies will slowly blur the differences between these two systems; it is interesting to hear that already it is the practice in H.M. Naval Surveying ships operating in the densely populated traffic lanes of the Channel to maintain two OOWs, one in charge of navigation and ship safety, the other, coping with the surveying. Despite progress in automation I believe the day is still far distant when the OOW will be able to leave the electronic equipment to cope with the survey unaided while he navigates the ship.

At the 10th International Hydrographic Conference a Resolution (K 29.2) was adopted on the training of hydrographers, and this has resulted in the setting up of a working group, under the chairmanship of the Dominion Hydrographer (Canada), which will attempt to draw up a standard curriculum for an intermediate level training course with the aim of reaching an international basic standard of excellence.

Drawing up such a curriculum to cope with widely different types of basic education will not be an easy task, and I would suggest that in view of the present state of technology in sea surveying the basic standard

of excellence will necessarily include a sound working knowledge of computers and associated hard and soft ware likely to be involved in automated surveying at sea in the 1970s and 80s.

Only if the modern surveyor is well trained to think in modern terms of technology will he avoid personal obsolescence and thus keep ahead of his new equipments which have not the brains to avoid their own inevitable obsolescence.

REFERENCES

- [1] *IHB* Special Publication No. 1 'Echo Sounding', Dec. 1923.
- [2] *IHB* Special Publication No. 3 'Echo Sounding', Oct. 1924.
- [3] *IHB* Special Publication No. 4 'Echo Sounding', March 1925.
- [4] *IHB* Special Publication No. 14 'Echo Sounding IV', Aug. 1926.
- [5] *IHB* Special Publication No. 33 'A Summary of Echo Sounding Apparatus', Aug. 1939.
- [6] *IHB* Special Publication No. 39 'Radio Aids to Maritime Navigation and Hydrography', July 1956.
- [7] *IHB* Special Publication No. 39 Radio Aids to Maritime Navigation and Hydrography, 2nd Edition 1965, Reprinted 1969.
- [8] 'Hydrographic Automation — A Progress Report', W.J.M. ROBERTS and C.G. McQ. WEEKS — International Congress of Surveyors, Sept. 1971.
- [9] 'NOS Hydroplot/Hydrolog System', Captain Clinton D. UPHAM — 11th Annual Canadian Hydrographic Conference, Feb/March 1972, Vol. I.
- [10] 'Hydas and Hysurch Systems U.S. Navy Oceanographic Office', R.J. BEATON — 11th Annual Canadian Hydrographic Conference, Feb/March 1972, Vol. I.
- [11] 'Systems used aboard Parizeau — 1971', S. HUGGETT — 11th Annual Canadian Hydrographic Conference, Feb/March 1972, Vol. I.
- [12] 'Autocarta X — A Fully Automated Hydrographic Data Handling System' — Decca Survey Systems, Inc., Houston, Texas, Revised April 1972.
- [13] 'An Automatic Data-logging System at Sea in HMS Hecla', R.W. SUDWEEKS.
- [14] 'The Automation of Hydrographic Surveying(1)', J.M. MACKAY — Commonwealth Survey Officers Conference 1971.
- [15] 'The New Danish DK/SQN-1 Echo-sounding and data processing system', I. ENGELMANN — *I.H. Review*, Vol. L, No. 1, January 1973.
- [16] 'Hydas and Hysurch — The present and future in hydrographic survey systems at the U.S. Naval Oceanographic Office', F.L. SLATTERY — *I.H. Review*, Vol. L, No. 1, January 1973.

- [17] 'New South African Survey Vessel SAS Protea', J.C. WALTERS — I.H. Review, Vol. XLIX, No. 2, July 1972.
- [18] 'Technical Obsolescence — A Surveyor's Dilemma', W.G. ROBIL-LARD — Surveying and Mapping (U.S.), Sept. 1972.
- [19] 'Impressions of Hydrographic Surveying Overseas', T.D.W. McCUL-LOCH — 11th Annual Canadian Hydrographic Conference, Feb/March 1972, Vol. I.

(Manuscript submitted in English).