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WRELADS - THE AUSTRALIAN LASER DEPTH SOUNDING SYSTEM

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ABSTRACT

In 1972 in response to a request from the Royal Australian Navy, the Weapons Research Establishment of the Department of Supply began investigations into techniques that might be employed to increase the speed, and reduce the cost, of conducting hydrographic surveys of Australia's Continental Shelf. Resulting from these investigations it was apparent that only airborne laser techniques gave promise of any substantial manpower and cost economies while at the same time providing positive validation of data obtained.

Initially the target was to produce a system with an assured depth measuring capacity of about 30 metres in clear water, an accuracy in depth of one metre or better, a complete swept path of at least 200 metres and a speed of advance of 100 knots; navigational accuracy was to equal that currently obtained with medium range radio position fixing systems. So far all these requirements have either been met or bettered.

This paper firstly highlights the problem confronting the Royal Australian Navy's Hydrographic Service; it then traces the history of the WRELADS project as it is now known, through the initial development of a profiling prototype (WRELADS I) to the current scanning prototype (WRELADS II). The current state of development is fully described and further development milestones leading to an expected "in service" date of June 1981 are discussed.

The paper then details the concept of operations with an example of a proposed practical application of these concepts and concludes with a brief statement regarding the incorporation of WRELADS data into the Hydrographic Office data bank and an identification of currently unresolved problems.

INTRODUCTION

Until the end of the first quarter of this century the only method of depth sounding available to hydrographers was the lead and line. However, during the 1920s great interest was shown by the Hydrographic Services of many nations in the use of reflected sound to measure depth. The American, R. A. FESSENDEN, in the course of developing an iceberg detector subsequent to the *Titanic* disaster, is sometimes considered to have "discovered" the acoustic depth sounder. Again in 1920 Dr. LANGEVIN introduced his ultra-sonic appliance which was to be used by both the Italian and Swedish navies. The British Admiralty developed hammer and hydrophone systems, and in February 1930 they made their first trials with the magneto-striction oscillator.

Since that time the technology of the acoustic echo sounder has improved continuously with equipments becoming more accurate, reliable, and providing better definition, particularly in deep water. Nevertheless, the current echo sounder remains substantially a profiling device.

Much work has been done in recent years to supplement the single profile and inform the hydrographer of what lies "between the lines". Conventional sonar has been used to detect obstacles which are then subjected to further sounding; Side Scan Sonar has been developed to provide high resolution "Sonographs" of the sea bed on either side of a sounding line, and these can to a certain degree be used to compute the height of features. Multi-transducer arrays, both towed and fixed, provide either closer line spacing or total saturation of the bottom by vertical soundings. Finally, switchable beam sector scanning sonars can be used both to detect obstacles in a swathe ahead of a ship and compute their height.

All the foregoing equipments require surface vessels to carry them, and thus the speed of acquisition of the data needed to produce the hydrographic chart is limited by the speed of such vessels.

In an effort to increase the speed of coverage of a given area and at the same to provide total coverage much consideration has been given to remote sensing. The use of aerial photographs photogrammetically has been tried with limited success, and since the first LANDSAT in 1972 multi-spectral scanning imagery has been used to provide water detail. The NASA/Cousteau Bathymetry Experiment of 1975 readily springs to mind.

Still the use of imagery, either photographic or MSS, also has severe limitations at present. Leaving aside the problem of definition in the case of the latter, both systems are passive and rely upon interpretation of reflectance or radiance. It must be accepted that misinterpretation can result in depths being too deep, too shallow, or on occasions shoals, particularly those of limited extent, being missed altogether.

Although more work will be undertaken in this field particularly in the area of multiple images to provide reinforcement, and undoubtedly definition will improve, it is considered that the unambiguous requirement of the Hydrographer can only be met with an active system in which depths are actually *measured* rather than *deduced.*

Such a system is the Laser Airborne Depth Sounder (WRELADS) currently entering the final stages of development at the Defence Research Centre (DRC) at Salisbury in South Australia.

WRELADS

Australia has always been faced with an immense hydrographic task. With a continental shelf of some 660,000 square nautical miles, and only about one half surveyed to acceptable or temporarily acceptable standards, she is confronted with at least 49 years of work with the current hydrographic resources. The rate of progress must be quickened.

In 1972 the Hydrographer, R.A.N. asked the Weapons Research Establishment (as the DRC was then called) to investigate possible means of increasing the rate of acquisition of hydrographic data. Airborne laser techniques were considered feasible, and a specification (figure 1) was drawn up which was considered realistic.

FUNCTIONAL SPECIFICATION

Depth measuring capability	2 — 30 metres
Accuracy of depth soundings	1 metre
Position of depth sounding	25 metres
Across track swath width	200 metres
Mean spacing of soundings	10× 10 metre grid
Aircraft speed	70 metres/s

Fig. 1

Initial research and development on the project was carried out during 1974/75 which led to feasibility trials in June 1975. In 1975/76 the WRELADS programme was initiated (figure 2) and WRELADS I, an experimental system, was constructed (figure 3).

Full flight testing of WRELADS I was carried out in South Australian gulf waters in November-December of 1976 and in North Queensland waters in June 1977 (figure 4).

WRELADS I will not be dealt with further except to describe the principle of the laser operation and highlight the most important results of the programme.

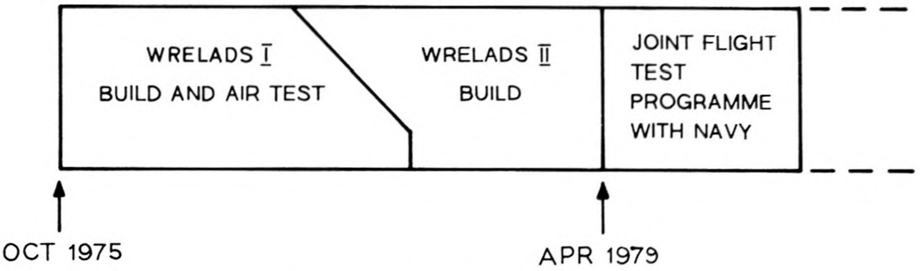


FIG. 2. — WRELADS programme.

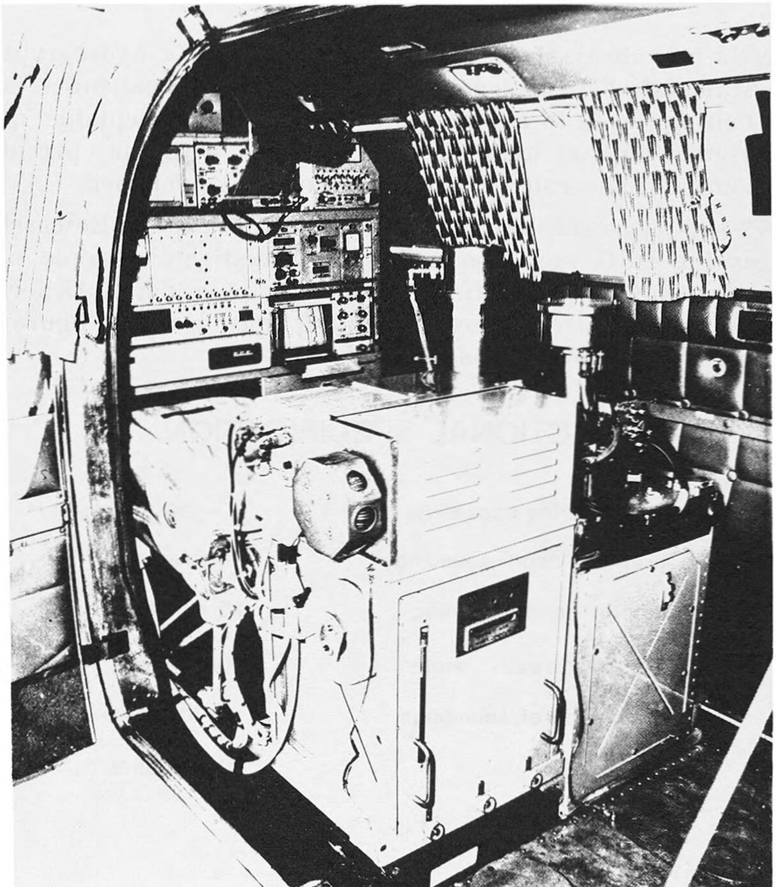


FIG. 3. — WRELADS I in "Beechcraft" Queenair.

WRELADS I was designed as flexible equipment for investigating problems relevant to WRELADS II, a second generation system designed to meet the Naval requirement. The trials programme was most successful; a total of 48 sorties was flown involving 148 hours of flight time, and much useful design information was generated.

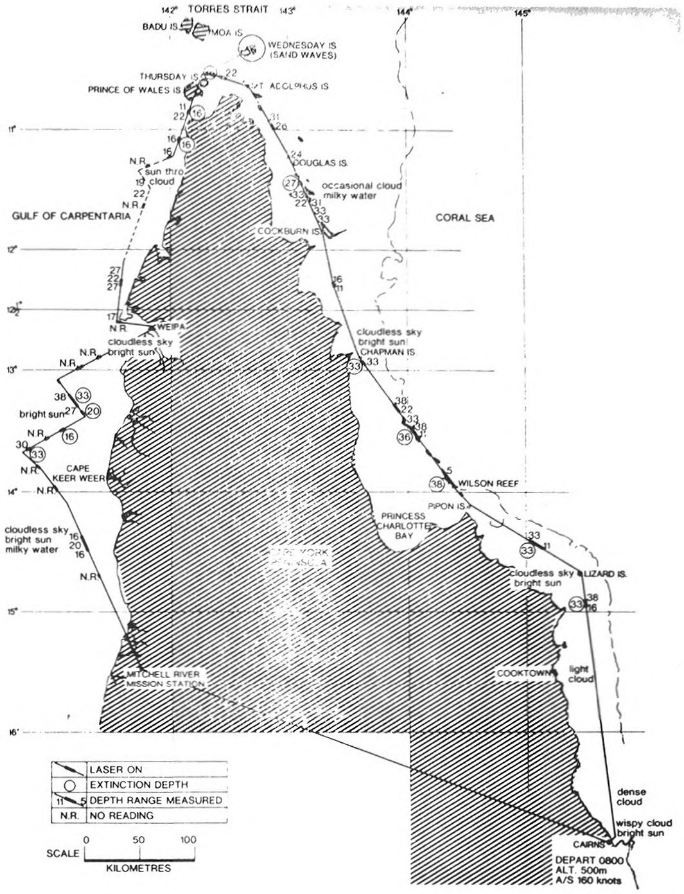


FIG. 4. — WRELADS I : Performance in Northern Queensland coastal waters.

WRELADS I — Principle of Operation

The airborne system consists of a neodymium doped yttrium aluminium garnet (Nd:YAG) laser, Q-switched to produce short duration output pulses. Two receivers detect respectively a signal reflected from the surface and a signal reflected from the sea bottom. Depths are calculated from the measured time interval between these two events.

Figure 5 illustrates the laser beam geometry which produces the simultaneous transmission of two pulses at different wave lengths; a low energy relatively wide angle infrared beam at wavelength of 1,064 nm and a high energy narrow angle green beam at wavelength of 532 nm. The infrared beam provides the surface return and the green laser beam the bottom return.

The principal advantage arising from this two beam approach, when compared to a single beam and single receiver solution, is that each subsystem can be optimized, without compromise, for its particular function.

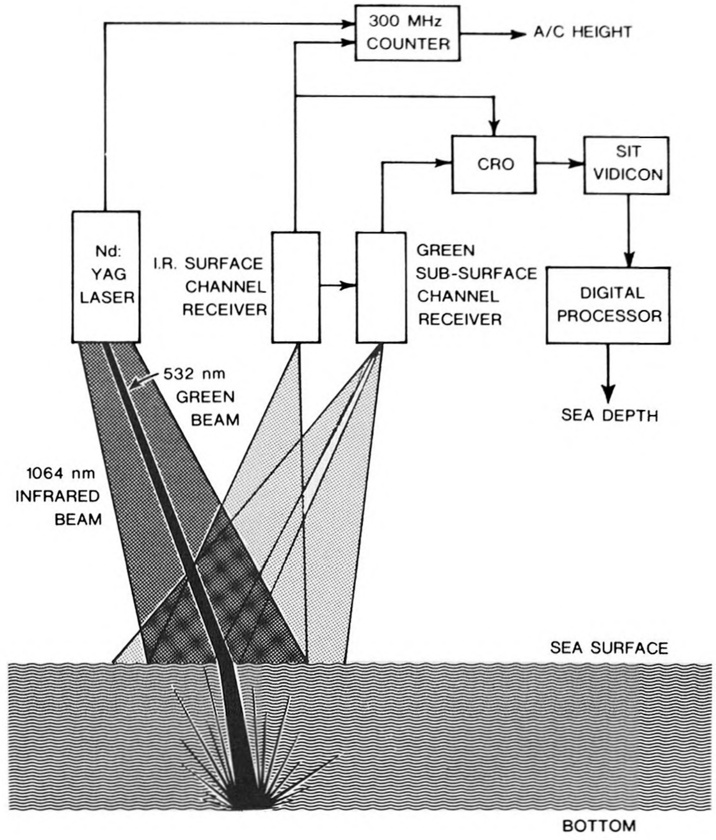


FIG. 5. — Laser beam geometry.

The purpose of the green channel is to detect photons reflected from the sea bottom; however there are two inherent detection problems. The first relates to the dynamic range of return signals which arise from bottom reflections in shallow water compared to those in deep water; this can approach $10^4:1$. The second problem arises due to the presence of the following noise components (figure 6):

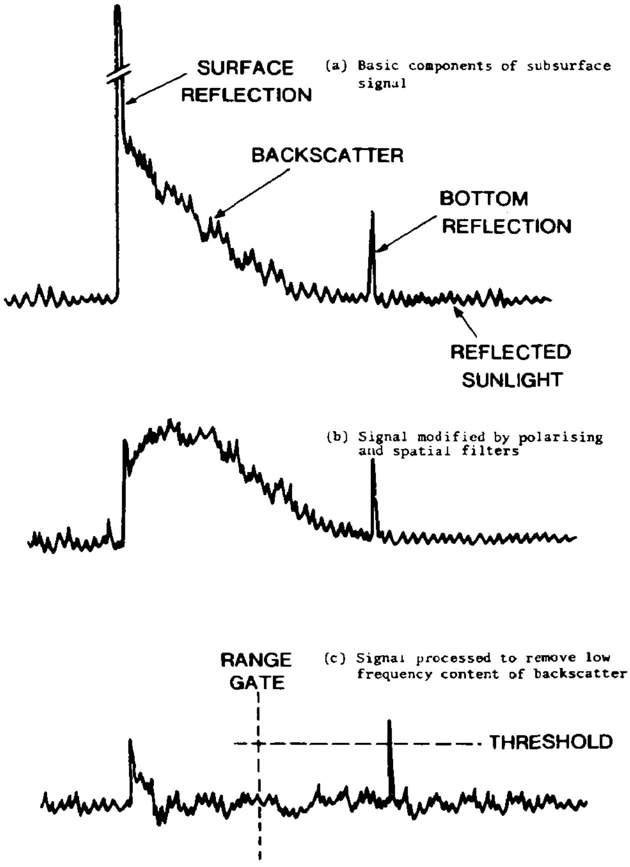
(a) Sun and sky light reflected from the surface, bulk water and sea bottom.

(b) Specular surface reflection of the green laser beam (note that this component is not required since the infrared beam is used to sense the sea surface).

(c) Backscatter due to the propagation of laser light through water.

No more need be said than that these problems were successfully overcome by signal processing and the use of polarising and special filters.

A significant parameter for airborne investigation was system performance with the laser beams inclined to the vertical. This was done in the November to December trials by banking the aircraft, causing both the green and infrared beams to be inclined. Although useful, this simple technique introduced operational problems because reliable surface reflections could not be obtained when the aircraft was banked. Therefore,


(a) Basic components of subsurface signal

(b) Signal modified by polarising and spatial filters

(c) Signal processed to remove low frequency content of backscatter

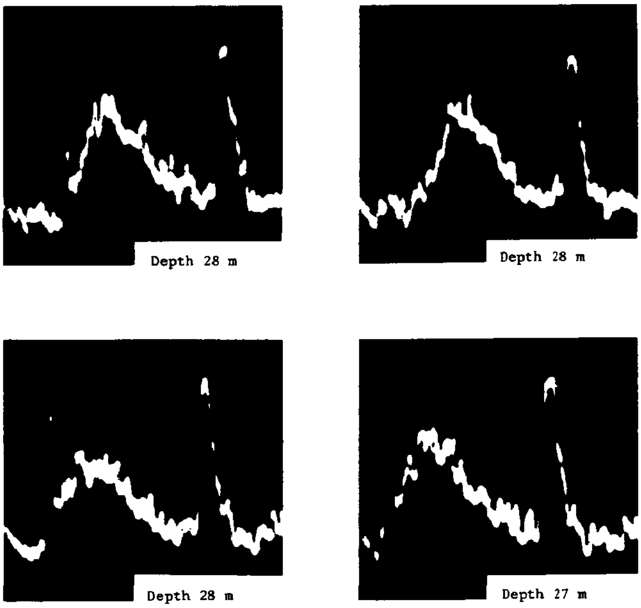
Fig 6. — Suppression of noise components.

in the June trials, an improved arrangement was used involving prisms to deflect the axis of the green beam relative to the infrared beam.

Results

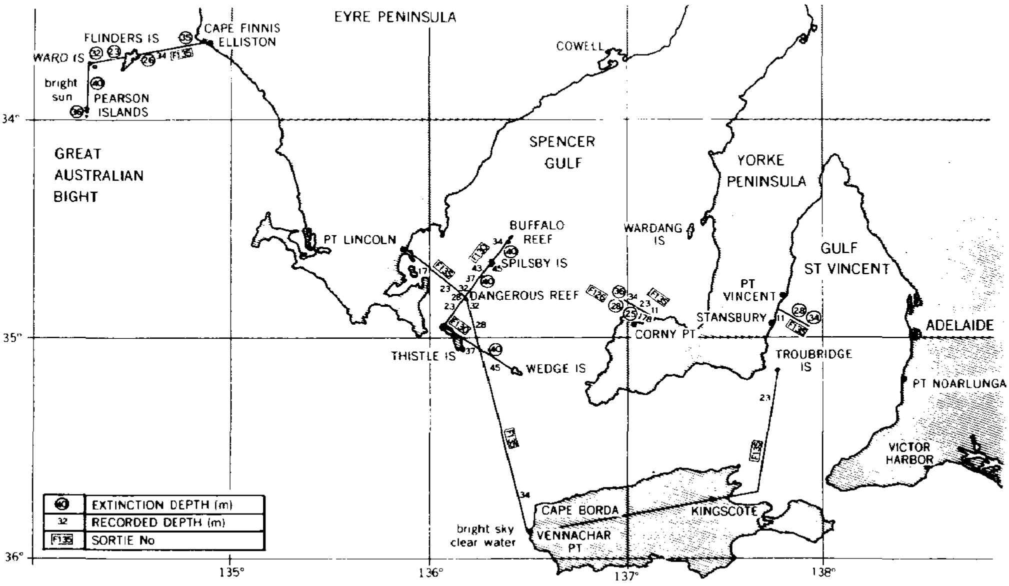
Overall, the results of the WRELADS I flight trials were most encouraging, and without doubt showed that a scanning system could be produced to meet the required operational parameters. Depth penetration was better than expected (figure 7).

Extinction depths (the depth at which the ratio of bottom reflection to limiting noise is unity) by day of 30-40 metres were consistently obtained in "clear" water, with depths of 15-20 and sometimes 30 metres in less clear water. "NR" indicates that no bottom returns at all were recorded. This could mean that the water was relatively shallow but very turbid, that it was clear but very deep, or any combination which exceeded the capability of the system. During the one night trial carried out an extinction depth of 60 metres was obtained (figs. 8, 9 and 5).



Trial —— 135
Date —— 17.12.76
Location —— Pt. Lincoln. No cloud. Time 11.00 hours
Altitude —— 500 m with beam inclined at 15° to vertical
F.O.V. —— 30/4.
E.H.T. —— 1300 V

FIG. 7. — Typical bottom returns in South Australian Waters.



⑩	EXTINCTION DEPTH (m)
32	RECORDED DEPTH (m)
F135	SORTIE No

FIG. 8. — WRELADS I : Performance in South Australian coastal waters.

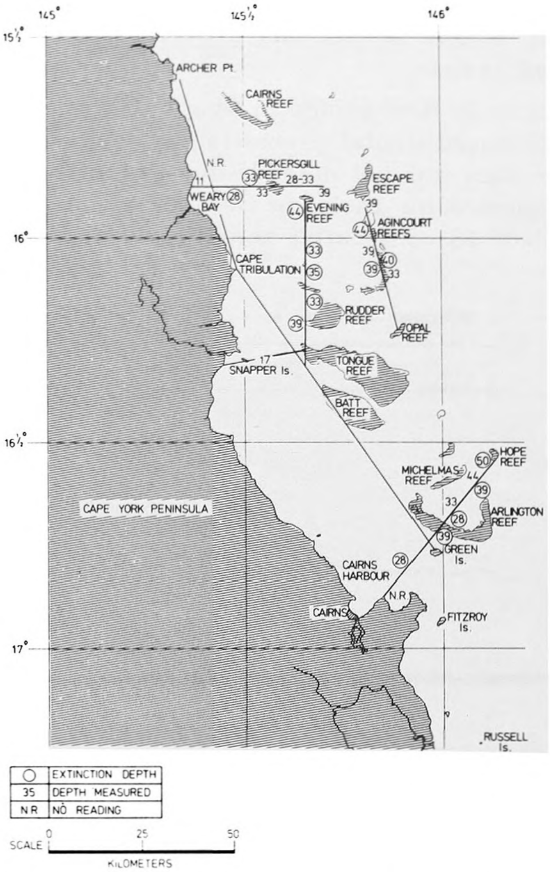


FIG. 9. — WRELADS I : Performance in region off Cairns, June 1977.

In very shallow water the problem is to identify the bottom reflection amongst the specular surface reflections. It would appear that at present a water depth of 2 metres is the minimum depth in which the system will function.

The results of the beam inclination experiments were also fundamental to the concept of the scanning system, and it was found that up to 20° inclination there was little effect on the extinction depths. This is because the sea bottom introduces a diffuse reflection not particularly sensitive to small angular displacements.

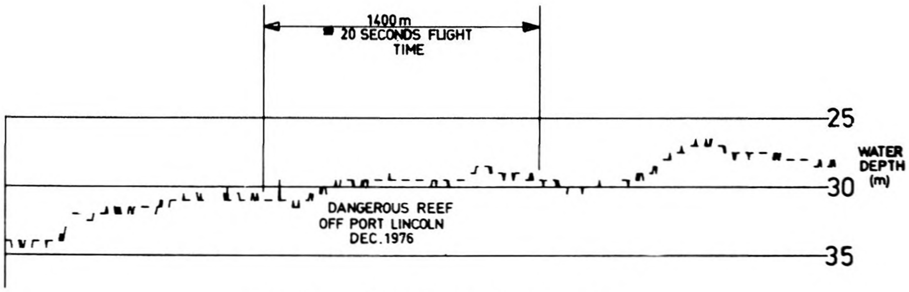


FIG. 10. — Dangerous Reef profile.

The following bottom profiles are good examples of the performance of the development system:

(a) The Dangerous Reef profile in figure 10 was recorded in real time by the on-board digital processing system. Continuous recording of profile data was not possible due to limited recording capacity; in consequence for each one second period the recorded pattern consisted of 13 consecutive soundings followed by a gap.

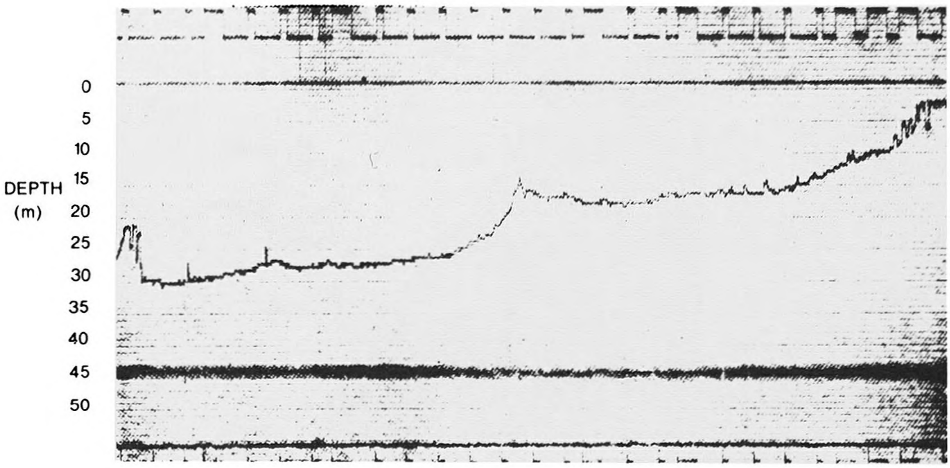


FIG. 11. — Ribbon Reef profile.

(b) The Ribbon Reef profile shown in figure 11 illustrates rapid changes in depth which can occur in reef waters. On the right hand side a slope of 1 in 25 is indicated, in the centre a slope of 1 in 5 and on the left hand a vertical 8 m reef edge.

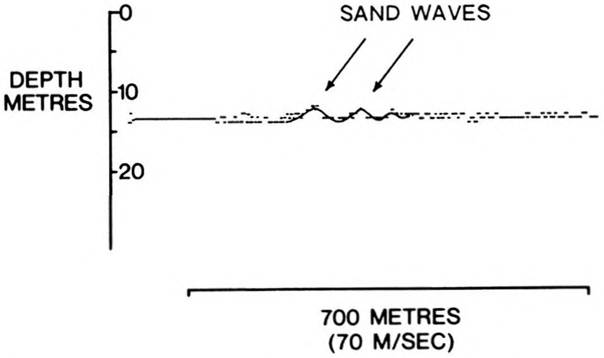


FIG. 12. — Bottom profile off Wednesday Island, Torres Strait.

(c) The third profile, shown in figure 12, was recorded in Torres Strait off Wednesday Island. Of particular interest in this region is a sandwave field, probably established by standing waves arising from the fast tidal flow in the area and confirmed by surface vessel acoustic depth sounders. It is understood that the field consists of sand ridges spaced 60-100 m apart, with crest to trough measurements of 2 to 3 m. The recorded profile does indicate that the edge of this sandwave field was sounded.

WRELADS II

WRELADS II will be the first prototype operational system. It will couple together a scanning laser and a position fixing system capable of not only providing positional information for the soundings but also navigational guidance for the pilot (figure 13).

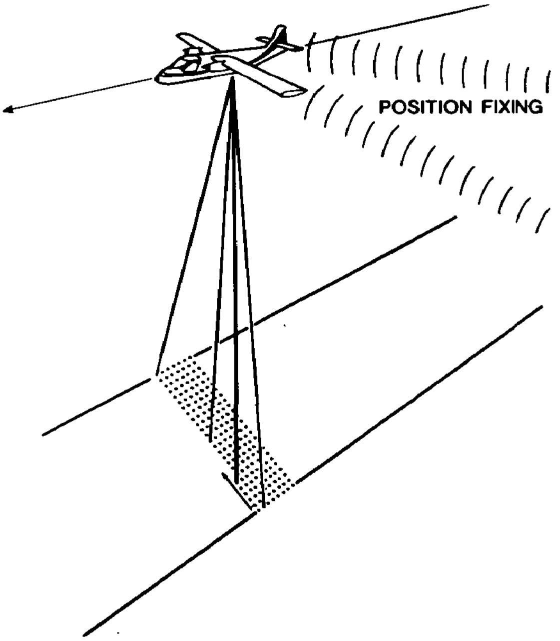


Fig. 13. — WRELADS II.

It will sweep a swathe 268 metres wide at a speed of 70 metres/second (135 kt) and in one second will provide 84 spot soundings (of 1-2 metres diameter) on a 10 metre by 20 metre grid. Later in the programme a faster laser will be introduced which will operate at 168 pps providing a 10 × 10 metre sounding grid. For comparison a single shipborne echo sounder whose swept width is about 10 metres at 5 metres/second (12 knots) contains 10 soundings which saturate the area.

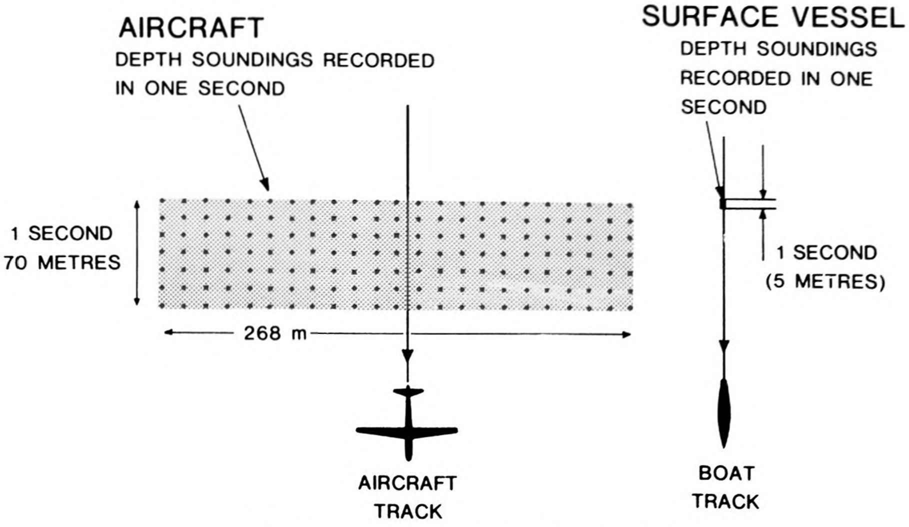


FIG. 14. — WRELADS II : Swept area.

Design Concept

At the present time it is not considered that depth sounding from an aircraft can be fully automated. In consequence, WRELADS II has been designed with an operator in the loop who will optimize the system for depth measurement (figure 15).

Emphasis will be placed on making depth decisions in real time, and these will be recorded together with the signal information on which

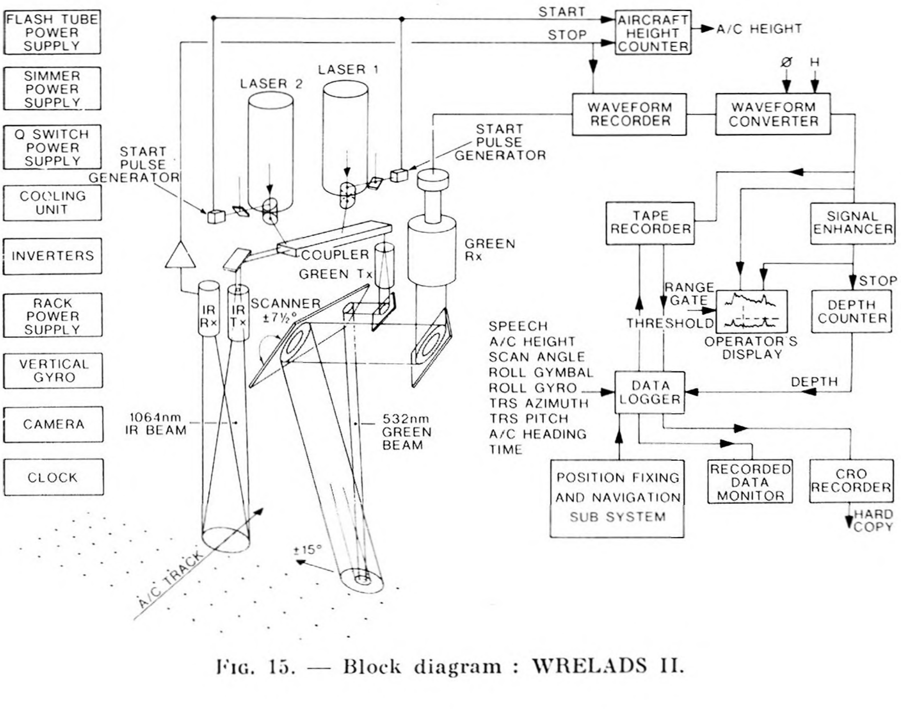


FIG. 15. — Block diagram : WRELADS II.

they are based. The production of valid data in real time in the aircraft will enable the operator to monitor the system continuously for optimum performance; however the recorded depth data will not be the final answer. The recorded signal information will be re-processed in a shore-based Ground Processing Facility post mission when it will be combined with observed tidal information and position fixing monitor corrections (if applicable) to provide the final smooth data tape.

A need also exists for the field operators, subsequent to a flight, to have some record of system performance and to be aware of navigational aspects, e.g., the ground tracks actually flown, gaps in coverage, areas of interest, shoals, etc.

Such information will be supplied by a high bandwidth hard copy machine (a fibre optic coupled faceplate, CRO recorder). This will provide sampled data of most recorded parameters, i.e., bottom signal returns, sea depth, position fixing co-ordinates, aircraft height and maps showing intended and actual ground tracks. This UV paper record will be available to the operators; it should permit validation of the day's work and also provide a basis for planning the next day's operation.

Airborne Equipment

Figure 16 shows the WRELADS II C47 installation which comprises the following assemblies:
Navigation Rack;
Depth Sounder Rack;

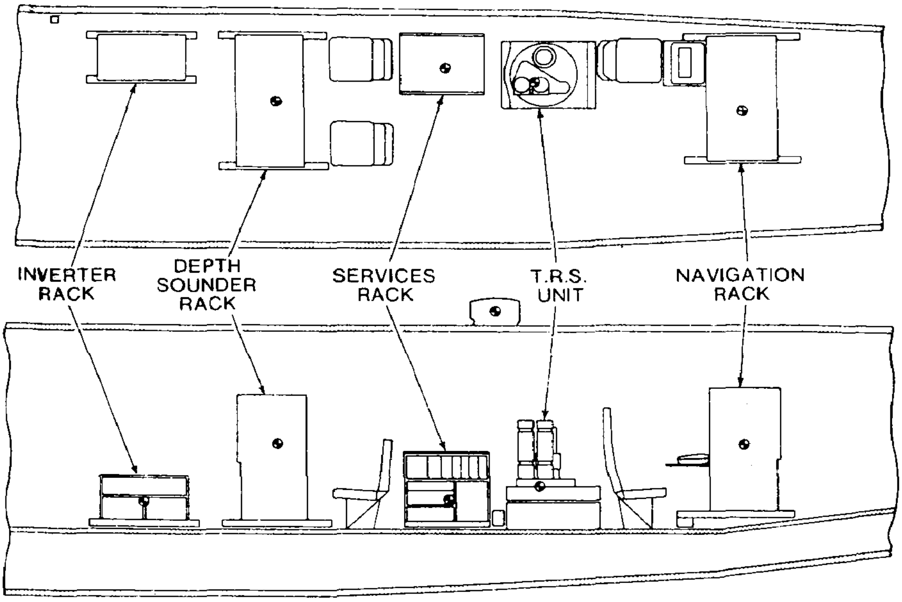


Fig. 16. — WRELADS II : installation in C47.

Services Rack;
Transmitters, Receivers and Scanner Assembly (TRS);
Fuselage-mounted Heat Exchanger.

Two operators are required, one designated the Leadsman is responsible for all aspects of the depth sounding part of the system. The second operator will be the hydrographer who will be in charge of the operation and be responsible for position fixing and navigation.

Major Components and Elements of the System

A block diagram showing the complete system with some indication of interconnections is shown in figure 15. Some of the major components and elements of the system, with particular emphasis on those associated with data logging and operator's displays for field use, will now be described.

Scanning Geometry

The green beam is transversely scanned through ± 15° at 7 scans per second to provide a rectangular scan pattern with a grid spacing between depth soundings of 10 × 20 metres. The infrared (IR) beam is held vertical and serves as the datum for depth measurements. Correction is made to

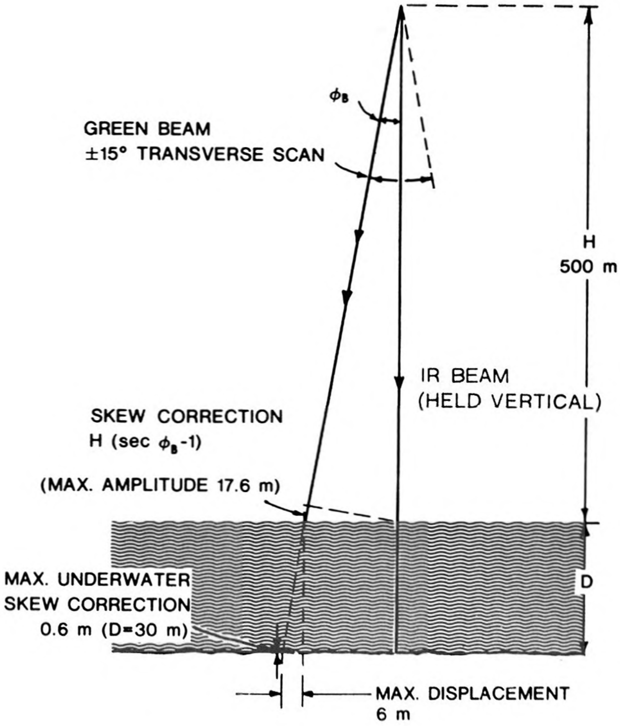


FIG. 17. — Scanning geometry.

the time interval between the IR surface reflection and the green bottom reflection to compensate for beam inclination. The final correction is made to correct for beam inclination in the water.

Although WRELADS I only used one neodymium doped yttrium aluminium garnet (Nd:YAG) laser with a pulse repetition rate of 25 pps, the transmitter used in WRELADS II comprises two Q-switched frequency doubled Nd:YAG lasers each operating at 42 pps. The lasers are serially time multiplexed to provide a composite output at 84 pps. Each laser will have the following characteristics:

Output: 532 nm	1 megawatt
1,064 nm	0.2 megawatt
Pulse repetition rate	42 pps
Pulse rise time (1,064 nm)	3 nanoseconds
Pulse width FWHM (532 nm)	7 nanoseconds
Pump energy	15 joules.

Development to improve the laser is continuing and work is currently proceeding on a new laser configuration to operate at a pulse repetition rate of 168 pps and a peak power of 1 megawatt. All subsystems of WRELADS II have been designed to accommodate this pulse rate.

Beam Stabilisation

Angular stabilisation has been provided together with drift angle compensation to ensure two design aims are met; first that the IR beam is held vertical and second that the transverse scan is always normal to and symmetrical about the ground track.

Signal Processing and Recording

The green subsurface signal will be processed and recorded for further analysis by the ground processing facility. To enable the most economical method of recording to be adopted, the original 200 MHz signals will be transformed to a 40 kHz "audio" bandwidth for recording purposes. The high frequency digitizer converts subsurface signal samples at 2 nanosecond intervals. This corresponds to a depth increment of approximately 0.2 metre.

The recorder selected for the task is an analogue/digital machine capable of recording all green signal returns, speech, and all digital data associated with the position fixing and depth sounding equipment. In order to establish confidence in the recording system and to provide a real time read-out, all recorded data will be read from the tape and displayed on a Recorded Data Monitor.

The final output of the signal processing system will also provide a well contrasted line display for real time processing to establish depth decisions. Such decisions rely on the operator selecting optimum range gate and threshold levels together with optimum filtering networks to eliminate the low frequency content of the signal and to enhance the bottom reflection.

Position Fixing

Argo DM 54 in the hyperbolic mode will be used for fixing the position of the aircraft, and figure 18 shows the proposed system. The PDP 11 mini computer backed up by additional solid state memory will carry out the following functions:

(a) Translate hyperbolic positional information to Australian Map Grid (AMG) co-ordinates;
(b) Predict present position for track plotting;
(c) Store intended tracks and actual tracks for display;
(d) Provide data for recording;
(e) Provide a moving map display for the pilot (figure 19).

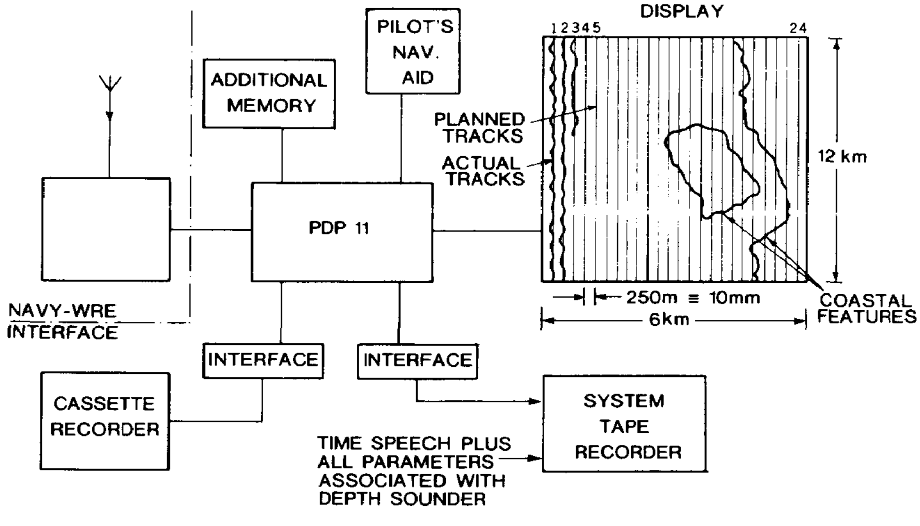


FIG. 18. — Navigation sub-system.

Data Logger

The function of this unit is as follows:

(a) To assemble all data for magnetic tape recording; this includes digital system data, analogue waveforms and position fixing inputs;
(b) To control the Magnetic Tape Recorder;
(c) To provide inputs for the Recorded Data Monitor;
(d) To provide inputs for the CRO Recorder.

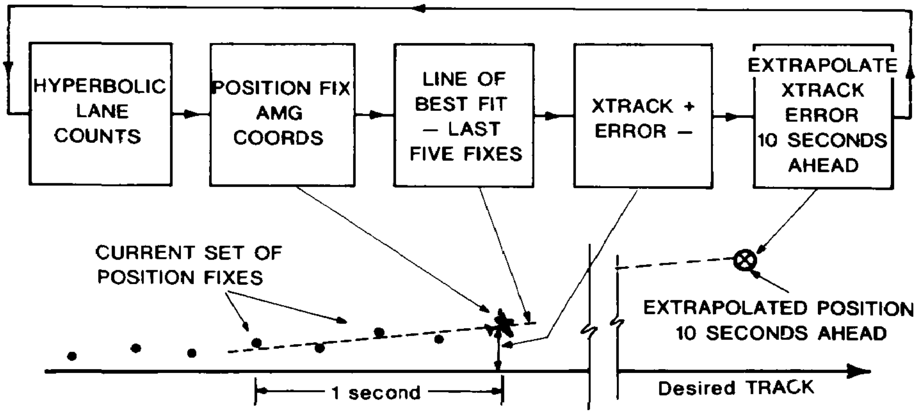


Fig. 19. — WRELADS II : pilot guidance.

Combined Audio-Digital Tape Recorder

It is this tape that will be re-processed by the ground processing facility. It can be likened to a combination of the present rough track plot, deck book and echo sounder roll.

Recorded Data Monitor

The purpose of the TV Data Monitor is to show data which has been recorded on magnetic tape. It is envisaged that this monitor will take on a most significant operational role. A fixed format is required showing samples of all digital and analogue data.

CRO Recorder

As discussed above a high bandwidth recording oscilloscope will be used to sample a wide range of data, e.g. subsurface waveforms, depth decisions, navigational data covering tracks flown and a wide range of housekeeping parameters.

The UV paper record from this recorder will provide the basis for planning the progression of the survey.

Final Development Phase

The culmination of the WRELADS II development programme will be the release to Navy and to industry in June 1981 of the documentation necessary to enable the production of two operational systems for the

Hydrographic Service of the Royal Australian Navy. It is anticipated that the successful contractors will also be capable of producing additional systems for local or overseas sale at an approximate cost of $ M 1.7. These costs do not include the positioning system or the aircraft. The development programme until June 1981 is shown in figure 20.

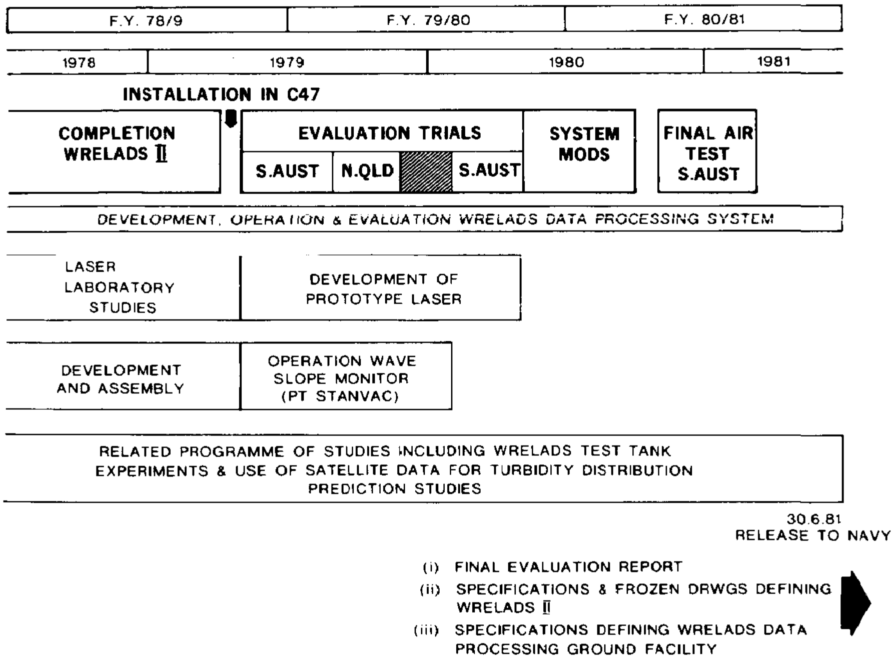


FIG. 20. — WRELADS II : final development programme.

CONCEPT OF OPERATIONS

Aircraft Fit

WRELADS will be engineered for attachment to the standard seat rail fixings found in most civilian aircraft. It will require a cabin floor space 6.4 m × 1.5 m and will weigh about 850 kg. Seating at the consoles will be required for two operators and one/two trainees (figure 16). The electrical power requirements will be 250 amps at 28 V DC.

Any aircraft used will require the following structural modifications to the airframe:

(a) Provision of an aperture below the TRS Assembly, with a protective door;
(b) Installation of an external heat exchanger;
(c) Installation of an antenna.

WRELADS will be suitable for installation in C47, F27 or similar aircraft types possessing a capability to cruise at about 135 knots.

Capabilities and Limitations

Although it is difficult to predict precisely how WRELADS will eventually be used, a knowledge of its capabilities and limitations, together with those of the aircraft, the surface forces, and the demands of precision flying, can be used to produce a broad concept of operations.

Currently surveying ships deploy away from their home ports for three 10-11 week periods each year. It is considered that similar periods of deployment will be possible for the WRELADS flight. The flight will deploy to a civil airstrip convenient to the survey area. Such airstrips can be found throughout Australia at intervals of not more than 400 miles, and an allowance of two hours per daily sortie is allowed for transit to and from the survey grounds at 200 kt. In order to allow for weather, times of turning at the end of each line, and other unforeseen problems a further assumption is that the aircraft will be actually sounding five days per week, each day containing a five hour sortie of which three hours will be on task, i.e. collecting valid data.

With an accuracy of depth sounding with WRELADS of ± 1 metre it is obvious that in critical areas it will be necessary to carry out conventional examinations by echo sounder or wire sweep to obtain depths to ± 0.2 metre. Nevertheless in many areas such accuracy will not be necessary.

Because of the ability of WRELADS to rapidly sound out areas shallower than 30 metres, it will be possible to better utilise surface vessels in the deeper water where higher speeds are possible and wider line spacing can be accepted.

These considerations would tend to indicate that the most productive method of undertaking a survey of a general area will be by utilising a mix of the airborne laser system and several surface ships and their boats. Economy of effort will also be obtained by the common use of one fixing chain, albeit supplemented by additional fixed shore stations, common tidal information, and integrated logistic support.

The Task Unit

An idealised composition of a survey task unit for a survey of an area of both deep and shallow water would consist of:

1 WRELADS Flight;

1 *Flinders* Class Coastal Survey Vessel with 10 metre Survey Motor Boat;

2 Survey Motor Launches (Inshore Survey Vessels);

1 Landing Craft Heavy—for logistic support.

This unit would contain sufficient fixing equipment for 6 mobile, 6 fixed, and 1 monitor station; together with 4 tide gauges.

Operational Plan

In order to illustrate both the use of the proposed Task Unit and to highlight the increased productivity, a theoretical survey area in the lower portion of Spencer Gulf (South Australia) has been selected (figure 21).

The area outlined totals some 2,700 square nautical miles and is divided into two areas which would, in Australia, be surveyed at a basic scale of 1:25,000 and a central area which would be surveyed at 1:50,000. It should here be stated that the central and western areas were in fact surveyed at 1:150,000 and 1:50,000 in 1962/63; this work is only accepted as "temporarily adequate".

At the two scales above, and without any allowances for interlining or examination—two of the most time consuming aspects of any survey—about 30,000 miles of sounding will have to be steamed.

Although in theory this would take about 17-20 ship weeks it is approximately one half of the total output of the Royal Australian Navy's 2 hydrographic vessels and their 4 Survey Motor Boats for the year 1978!

As can be seen from figure 21, the area conveniently divides into a ship area in the centre and two aircraft areas. It should be noted however that the aircraft will undertake any work within the ship area where a large block of less than 30 metres exists (horizontal hatching).

Traditional methods of establishing and calibrating the fixing chain will be employed, and these operations together with the erection of tide gauges will be carried out by an advance party in the LCH prior to the commencement of aircraft operations. At the commencement of the survey, after initial calibration and surface vessel and aircraft checks, all surface vessels will commence work in the central area with the aircraft commencing in the eastern section.

Aircraft Operations

The aircraft will fly along pre-arranged lines similar to ships today. As WRELADS will provide total coverage the direction of sounding lines relative to the depth contours is of no consequence. In fact it is better for the lines to follow the general trend of the coast and thus remain in relatively slow changing depths to reduce the need to "re-tune" the equipment for differing signal strengths.

Flying parallel to the coastline is also less demanding for the aircrew.

With an operating speed of 135 knots and a flight path spacing of 200 metres the WRELADS aircraft will effectively cover about 220 square nautical miles of sounding each week. This area is shown by diagonal hatching on figure 21.

At the end of each sortie, or more likely at the end of each week, the magnetic tape output from the Combined Audio Digital Tape Recorder,

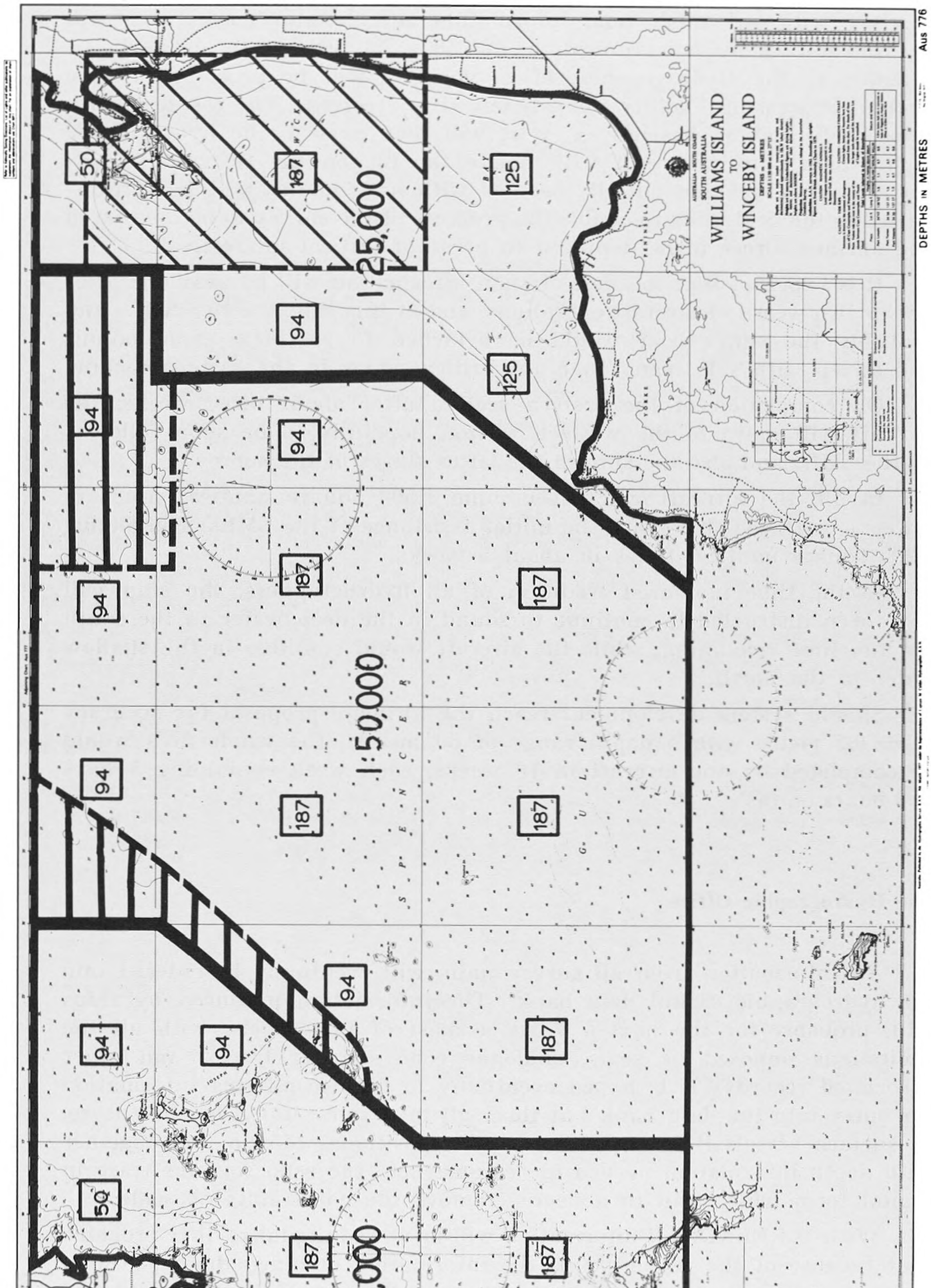


FIG. 21. — A theoretical survey area.

together with any other tidal information and monitor corrections, will be transmitted by communication link e.g. landline, data network, or satellite, to the Hydrographic Office where it will be processed in the Ground Processing Facility immediately it is received. The resulting processed information, basically x, y, z, will then pass to the hydrographic digital data bank where it will update the file on the relevant survey. An up-to-date graphic output together with any queries will be retransmitted to the field units to enable the progress of the survey to be monitored and surface forces to be deployed to areas of critical interest.

It is expected that the first of such information will be available after one or two weeks of aircraft operations, and at this time the two SMLs and probably the ship's boat would be detached to complete examinations and sweep with side scan sonar any critical areas in the eastern section.

On completion of the eastern section after about three weeks, the aircraft will move to the western section hopefully to be soon followed by the SMLs and also the ship in the latter stages of the survey.

In all, the aircraft will cover some 1,500 square nautical miles in 6 weeks, with the ship (with the initial assistance of the SMLs) completing 1,200 square nautical miles in about 5 weeks.

In the time honoured tradition of all hydrographers, the ship will have been instructed to continue to sound in the deep water to the south for any time remaining, while the aircraft would continue in the shallow water to the north.

Should system development reach the ultimate proposal for accuracy of ± 0.2 metre with a depth range of 60 metres, the whole area would be completed by one aircraft in 10 weeks, each week containing 5 days of 3 hours on task !

The Hydrographic Office

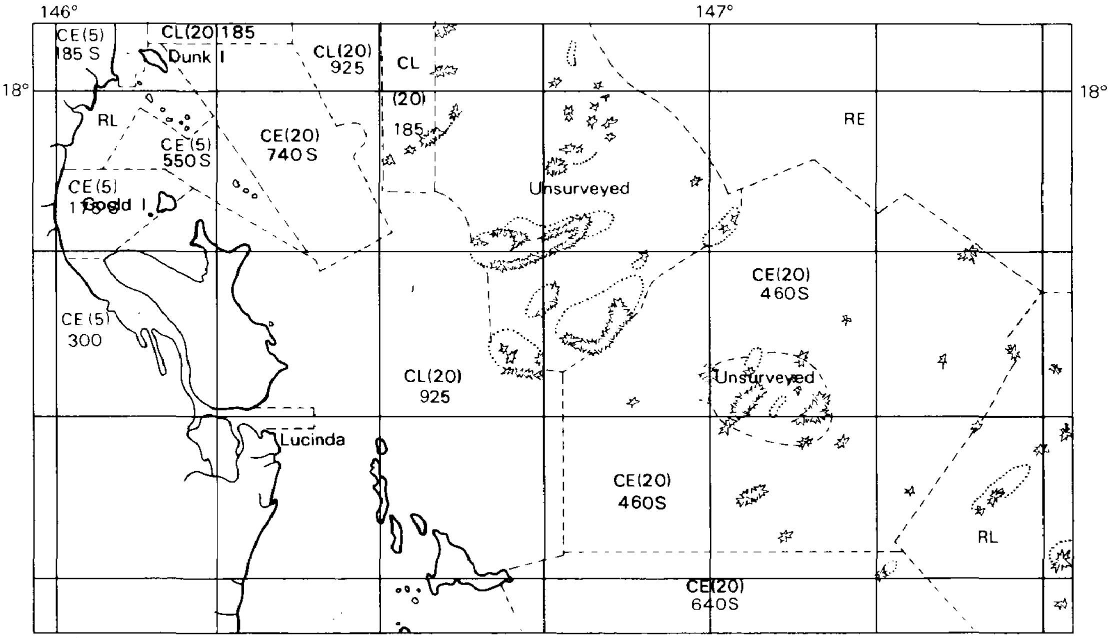
All information from all survey units will eventually be entered into the hydrographic digital data bank. The information produced by ships will, probably for the next 5 years, consist of fair sheets, with all the limitations imposed by scale, analogue echo sounder traces, and other associated records. It is hoped eventually to digitise all this information for entry into the data bank but this will take some time. In the future, in surface vessels it is hoped to acquire positional information together with depth information needed to "reconstruct" the echo sounder trace in digital form which will to a degree remove the constraints of scale.

With WRELADS *all* information will be stored digitally. It is probable that because of the reliability of the information obtained during ground processing it will not be necessary to keep the output of the Combined Audio Digital Tape Recorder for archival purposes; however this output may be retained for a minimum period until all queries on completion of a survey are resolved.

It is estimated that the amount of data transferred to the hydrographic digital data base after processing by the WRELADS Ground Processing Facility will be in the order of 4.6 × 10^{10} bits annually. Current methods of tape storage would require some 350 tapes—obviously an unacceptable solution. We will obviously have to look to today's "new" technology—the answer could be *one* laser disc!

PROBLEMS

There are three problem areas which are presently readily identifiable. The first has just been mentioned—the massive amount of data to be stored. Our present philosophy is to endeavour to retain the maximum amount of data and hope that new technology will enable us to meet this objective. If it does not, the question will then become one of non-storage, loss, destruction or whatever word is considered appropriate for the data



KEY TO SYMBOLS

R	Reconnaissance or incomplete survey
C	Controlled survey
L	Sounded by lead line
E	Sounded by Echo Sounder
(6)	Accuracy of soundings in decimetres
400	Distance apart of main lines of soundings
S	Sonar swept
Blue	Areas preferred for navigation having regard to charted depths

FIG. 22. — Typical chart reliability diagram.

that is not kept. Such a question is already exercising the minds of many Hydrographers in relation to the acquisition of data in digital form by current methods.

Secondly, there is the problem of turbid water. Investigations are being made into methods of monitoring and predicting periods of turbidity, or rather clarity, by the use of MSS imagery; nevertheless it is realised that there may be some coastal areas that can never be sounded by WRELADS.

Finally, the productivity of the aircraft may well be such that it will provide more work than the surface vessels can handle. It is considered that this can be resolved by the use of the current reliability diagram appearing on Australian charts (figure 22). Only those areas that are critical will be examined by surface vessels with a target accuracy of ± 0.2 metre. All other areas will be charted as ± 1.0 metre. Of course, should WRELADS achieve an accuracy of ± 0.2 metre the problem will not exist.

CONCLUSION

WRELADS will provide the Hydrographer with the most productive sounding system ever devised for use in coastal waters.

It will have as profound an effect on hydrography in the future as the introduction of the echo sounder in the past. It will demand innovative data handling techniques. Although output will be possible in the form we currently all accept (the sounding sheet at a particular scale) or in a form we may soon become more familiar with (a contour plot at a certain scale), it will only be by the use of digital data banks that the true worth of the system will be realised.

Subject to the successful enhancement of depth resolution of the system to ± 0.2 metre, acts of God, or the folly of man, we may well be able to say of the areas where WRELADS can be operated: "Next time is the last time."

REFERENCE

Abbot, R.H., Watts, G.J., Penny, M.F. (1978) : WRELADS I trials report. Defence Research Centre, Salisbury. Report No. ERL-0026-TR. August.