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INDAPS,
INTEGRATED NAVIGATION, DATA ACQUISITION AND PROCESSING SYSTEM

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ABSTRACT

In 1974, the Hydrographic Development Group, Central Region, undertook the design and implementation of a second-generation hydrographic data acquisition and processing system. This system, INDAPS, which has been employed in two production surveys during 1974 and 1975, features computer-controlled acquisition, filtering and recording of data, on-line navigation and error detection, and high-speed processing using FORTRAN as a programming language. This paper outlines the philosophy behind the system, its evolution and current development, and its field implementation.

INTRODUCTION

Highly successful production surveys using the Hydrographic Acquisition And Processing System (HAAPS) were carried out by the Canadian Hydrographic Service, Central Region, in 1972 and 1973 [1]. As a result of benefits shown in the areas of increased speed and accuracy at reduced costs, it was decided, in the fall of 1973, that additional equipment should be procured. Since HAAPS did not benefit from recent developments in computer and integrated-circuit technology, it was felt that a superior system could be procured at comparable cost.

Specifications were prepared for a system that would use a minicomputer to acquire and record data as well as perform a navigation function aboard the survey vessel. A similar computer, also in the field, but considerably faster than that used with HAAPS, would be used to further process and plot the data. Since the functions of data acquisition, processing and navigation were to be combined in a single system, it was given the acronym INDAPS (Integrated Navigation, Data Acquisition and Processing System). The equipment was provided by Canadian Applied Technology of Toronto. Software was developed by the Hydrographic Development Group and the system was integrated with the survey instruments and tested in the spring of 1974. Since that time, the system has been used on three surveys over two field seasons and has seen further development to improve its capabilities.

This paper describes the philosophy behind the system, the hardware, the software, the development, implementation and use of the system in survey operations.

SYSTEM DESIGN CONSIDERATIONS

Experience with HAAPS combined with an infusion of new ideas led to a design philosophy for hydrographic systems that resulted in INDAPS. The requirements for such systems, as seen by the authors, but somewhat modified as a result of INDAPS field use, are presented in the paragraphs that follow.

Data quality is best assured by processing hydrographic data in the field as soon as possible after it is acquired, *unless* the acquisition system is guaranteed to produce error-free, computer-readable data. The data should be processed to the form of a rough field sheet, plotted on a small incremental plotter and contoured manually as an aid to error detection. Data processing should be handled by one individual, preferably an experienced hydrographer with a sound knowledge of computer operations and programming, who is given the responsibility for the accuracy and completeness of the survey.

"On-line" processing, where depths are selected and plotted as the vessel follows survey lines, is not considered desirable for several reasons. Normally, some survey parameters are uncertain at the time of acquisition, hence the data produced will not be final. Revisions in water level data or radio position monitor corrections, for example, are very common and would necessitate re-processing the day's work.

Furthermore, if processing is to be accomplished on-line, the complexity of the launch equipment must be increased accordingly with the addition of plotters and high speed data terminals. Off-line processing permits the use of a high order computer language such as FORTRAN in the processing programs. This allows a suitably trained hydrographer to have intimate knowledge of the depth selection and position processing operations. He can then assess the suitability of the techniques and modify them, if necessary, to meet the particular requirements of the survey.

The data processing system must be fast in order to handle the data acquired by three or four systems. It must have efficient methods for editing processed data and, ideally, should also function as the data acquisition system for the vessel.

Although the data acquisition system should be kept simple, it must produce reliable, computer-readable data. Input data should be checked for validity by using filters and prediction models. These techniques are most effective if the data rates are kept relatively high and a reduced data set is selected for recording. Recordings should be subjected to read-after-write checks to detect errors, and the machine should be capable of re-writing records that are found to contain errors. Features like these are too complex to incorporate into fixed-logic data loggers, hence a small computer should be used to control the process.

Full utilization of the computer's speed and other capabilities operating in a data acquisition system can best be achieved with software written in assembly language. This will ensure that sufficient time is available to execute complex routines and keep memory requirements to a minimum. Hydrographers are not expected to be skilled in assembly language programming so this task should be left to an expert familiar with hydrography working in close concert with hydrographers. This has two obvious implications. Firstly, the hydrographer will not understand the acquisition process as well as he would programs written in FORTRAN. Decisions in the program that affect the nature of the data selected should, therefore, be kept to a minimum in the acquisition system and saved for the processing, where the hydrographer can control them. Secondly, the hydrographer must decide whether this work should be done under contract or by an expert hired to work in the organization. The latter is a very desirable solution as it permits greater involvement with the original system design and it facilitates incorporation of improvements to the system as a result of field experience.

Selection of a good data recording medium is essential to the success of a hydrographic data system. Paper tape, as used in HAAPS for processed output and in other systems for raw data recording, is slow, awkward to use and store, and is prone to errors in punching and reading. Data editing involving transfer from one paper tape to another was found to be particularly troublesome. Magnetic tapes demonstrated good reliability in HAAPS but have several drawbacks. The tape transports are large and expensive if features such as high speed and read-after-write capabilities are included. In addition, the tapes require considerable storage space and can be difficult to load on a rolling launch.

The 3-M Digital Data Cartridge was judged to be an excellent medium for hydrographic applications. It has a high data rate, a read-after-write capability and is loaded simply by plugging it into a drive that is small, rugged and inexpensive. The cartridge contains a reel-to-reel magnetic tape that can store up to two million bytes of data, easily sufficient for the data or program storage requirements of a typical survey operation.

The acquisition computer has an additional advantage in that it can be used to convert radio position data to geographic co-ordinates. From this, information can be derived to direct the helmsman along pre-planned survey lines. With a suitable navigation display, the lines are easy to follow and can reduce the survey time by up to 25% over that taken when hyperbolic lines are followed.

HARDWARE DESCRIPTION

The equipment is housed in four slide-mounted modules in a standard 19″ rack. All cabling, including power, is coupled through quick-disconnect connectors to facilitate replacement of the unit in the event of a failure. Plug-in circuit boards and sub-modules are utilized throughout as a further aid to servicing and maintenance.

Interdata Model 70 and 74 computers were modified for use in the system by installing power connectors, an external bus adaptor, slide mounts and protection for the back plane wire-wrap pins. Both are 16 bit micro-programmed processors with large powerful user instruction sets and can be used interchangeably for acquisition operations. The model 70, which is used for processing applications, includes, in addition, hardware floating point arithmetic to reduce execution time.

Peripheral equipment is coupled to the computer via an external multiplex bus using standardized 8-bit parallel interfaces. The interface hardware is housed in a slide-mounted card cage separate from the computer. Standardization is achieved by wiring each interface assembly to accommodate the hardware necessary to drive all available peripherals. Cards are then added to accommodate the desired configuration. Figure 1 shows a block diagram of the combined data acquisition and processing system. When used for acquisition, or when a system is configured solely for acquisition, no use is made of the Keyboard CRT, the Line Printer or the Plotter.

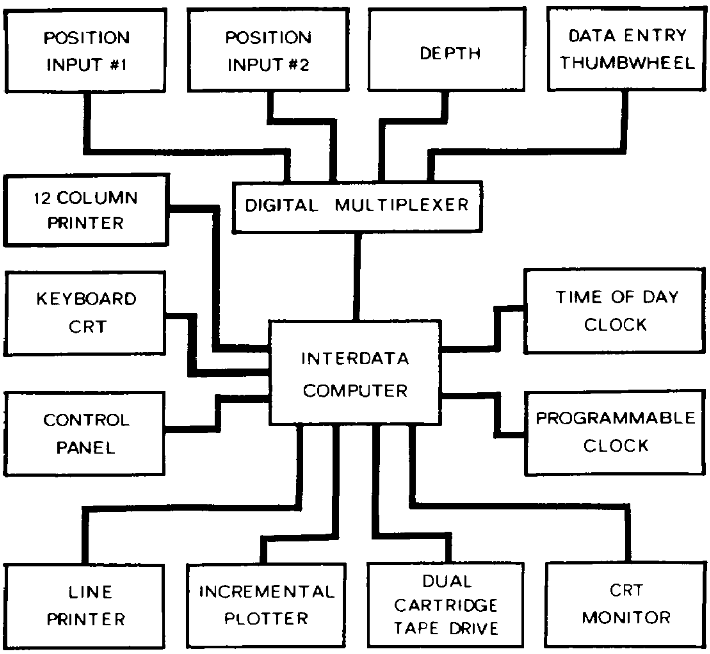

FIG. 1. — INDAPS data logger/processor block diagram.

The control panel, used to control the system during acquisition, consists of: two banks of six thumbwheel switches for entering administrative and control data to the computer, eight lights and a sonalert to indicate program and alarm status, and eight push buttons to activate various program functions.

The clock provides both time of day and timing to trigger data selection and recording processes.

The 12-column Printer provides the operator with a record of administrative data, error conditions and periodic samples of depth and radio position data. It prints twelve characters per line at a maximum rate of three lines per second. If a system has a line printer, it is used for this function and the 12-column printer is replaced with a second cartridge drive.

The CRT monitor is an eight line by eight column alphanumeric display that is used to display pertinent data to the operator and the helmsman. The characters are 1 cm square and can be read easily from a distance of 5 metres. This type of display was selected in preference to solid state read-outs as it is a more versatile computer peripheral.

The Cartridge Drive is a Canadian Applied Technology Model 8500 that uses 3M DC300A Data Cartridges which hold 91.5 m (300 feet) of 6.35 mm ($\frac{1}{4}$ inch) magnetic tape. The cartridge drive permits the recording of data on four separate tracks. The recording format is serial phase-encoded at 630 bits per cm (1600 bpi). The tape is driven by a single capstan at 63.5 cm per second (25 inches per second) in read or write modes and at 228.6 cm per second (90 inches per second) in file search or rewind modes. The drive is capable of reading and file searching forwards or backwards. A read-after-write head is provided for error checking in write mode and a Cyclic Redundancy Check character is written with each record, for comparison during read and write operations.

When used for processing, a dual version of the cartridge drive is provided to permit operation of processing programs that require input and output cartridge files.

Operator interaction with the computer during processing is via the Keyboard/CRT console. The system uses an ADDS 580 terminal that displays 24 lines of data with up to 80 characters per line. Data is transferred, one character at a time, using a standard EIA RS-232C serial interface at a rate of 9600 baud. Data that would take 2 minutes to list on a teletype can be displayed on the CRT in one second.

Where a permanent record is required, the system makes use of a Centronics model 306 printer. It is a 5×7 dot matrix impact printer capable of printing 100 characters per second.

The system can use either a Houston DP-3 or Calcomp 563 incremental plotter. Both have a 0.1 mm step size and operate at 300 steps per second.

Figures 2 and 3 show a Logger/Processor and a Data Logger, respectively, as installed on survey vessels during the 1975 Lake Huron survey. Figure 4 is a photograph of the video display used in navigation.

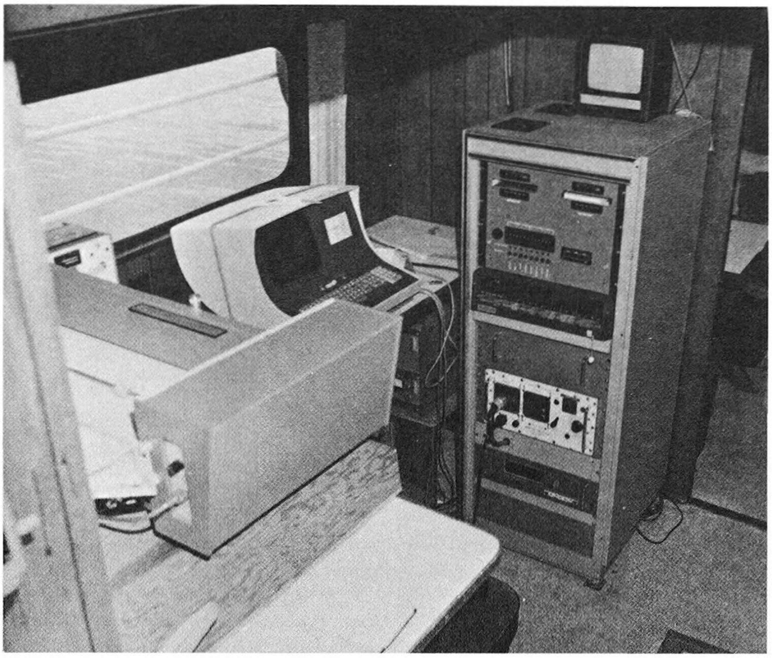

Fig. 2. — INDAPS logger/processor installed on a survey vessel.

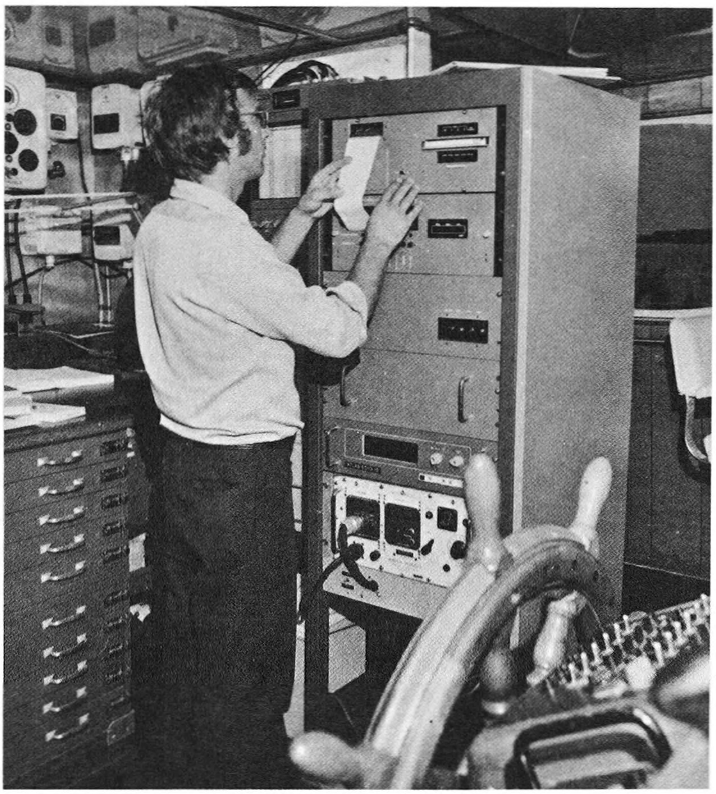

Fig. 3. — INDAPS data logger installed on a survey vessel.

FIG. 4. — Video display used for navigation.

DATA ACQUISITION SOFTWARE

Program Description

The INDAPS system is organized into several functional software components, as illustrated in figure 5. These are: System initialization, Data input and quality control, Selection, Recording, Display and Navigation.

System initialization occurs only once — to initiate the overall data acquisition process. The other five functions can be considered as separate processes executing concurrently. Communication between processes is via various data buffers in computer memory.

The initialization process must be executed before data acquisition can begin. Its purpose is to load survey data from cartridge tape and from the thumbwheels, to set the time-of-day clock to current real time, to initialize all buffers used by the system, and to initialize and enable the sensors (Position and Depth digitizers).

Data is obtained from the sensors asynchronously; that is, independently and without regard to time. When data is available at any one of them, the input process is signalled, via an interrupt, and execution begins. Data is read from the sensor, checked for illegal characters, and stored in the appropriate data buffer. This process is repeated as required, such that all valid data available from the sensors will be presented to the selection process.

Position values are stored in the data buffer as read, but depth data is

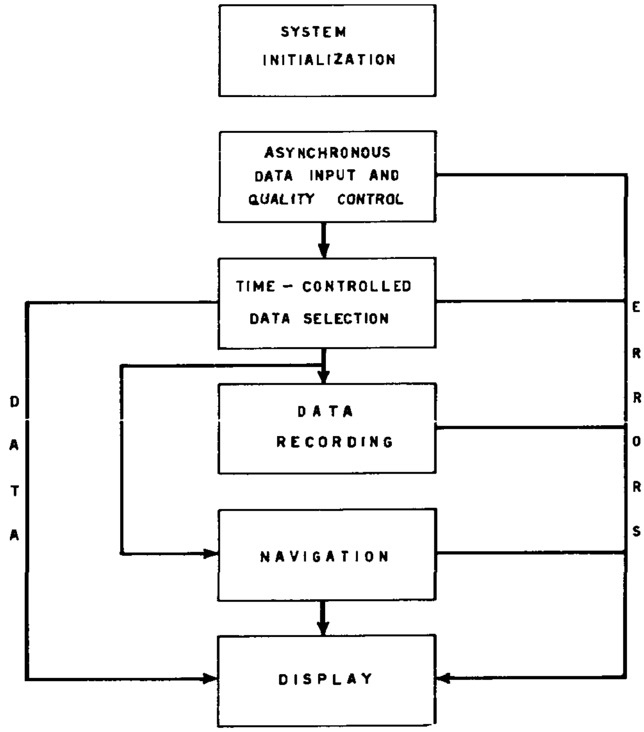

FIG. 5. — INDAPS data acquisition processes.

filtered by software means before being accepted. This filter consists of a tracking depth gate which rejects values that fall outside its limits. Tracking is accomplished by re-adjusting the position of the gate each time a depth value is accepted. The gate width remains constant and is specified by the hydrographer at system initialization time.

Provision is also made for sudden changes in bottom topography which cause an apparent, continuing, invalid depth data condition. If a specified number of consecutive depth values are outside gate limits, but are consistent among themselves, the bottom is considered to have changed suddenly. In this case, the apparently out-of-gate depths are accepted as valid data and the range gate is re-established to meet the new conditions. In this manner, invalid data (false digitization of the bottom) will be rejected while rapidly changing bottom topography will be accommodated.

At periodic intervals in time, the data selection process is executed. Its purpose is to select or derive one appropriate data item from the data available to it in each of the data buffers. Selected values (Pattern 1, Pattern 2 and Depth) are stored in the output buffer used by the recording process. Positioning data is derived by averaging the values collected during the time interval, and depth data is selected by choosing the shoalest value in the depth buffer. If no data is available in one of the buffers, it means that the corresponding sensor is producing data with illegal characters, data that is out of range, or no data at all. This error condition will be detected and communicated to the hydrographer.

One other quality check is performed on data from the Minifix positioning system as part of the selection process. With Minifix (and any other phase comparison positioning system) it is possible to obtain a lane jump, a sudden change in the integer part of one or both pattern values. A lane jump is detected if the apparent distance travelled during the time interval is greater than the distance which could have been travelled at the maximum velocity of the ship or launch. If one occurs, an error message and the last positioning value known to be correct are communicated to the hydrographer allowing him to make the necessary adjustments to the positioning system.

The purpose of the recording process is to write data from the output buffer to cartridge tape at periodic intervals. A read-after-write function is exercised, thereby ensuring that data is recorded correctly. A double buffering technique is used to permit error recovery in the event that a recording error is detected. If an irrecoverable output error occurs, the hydrographer is notified and no attempt is made to write data from the next output buffer. To reduce the possibility of overwriting data which should be retained for future use and to simplify operation of the system, data is always recorded on one specific track of the cartridge. The data recording process also causes the first data entry in the output buffer to be displayed.

The navigation process is executed immediately after completion of the selection process; that is, once every time interval. Its function is to create and display, on the CRT monitor, navigation information for the helmsman and the hydrographer.

The display process is executed when requested by one of the other processes. Its function is to print error messages, data, navigation information, and special messages. The CRT monitor is used to display current information such as position, depth, and navigation data, while the printer is used to display error messages and a limited amount of data for verification purposes.

Errors detected in all phases of data acquisition can be classified into two types: warning and fatal. The first tells the hydrographer that data is becoming unreliable or sparse or that an unusual (but not necessarily serious) condition has arisen. Fatal errors indicate that a part of the system is no longer performing acceptably and that the data acquisition process has halted. Among the error conditions detected are: lack of radio position data for 2 or more time intervals, no depth data for 10 time intervals, clock drift, and various errors related to cartridge tape and to operating procedures.

Operating Modes

As outlined previously, a number of different operations are performed when using an INDAPS system in the field. These are: system initialization, data acquisition, selection, recording, error detection, data display, navigation, testing and trouble-shooting. Since these operations interact, it was necessary, for ease of use, to define four modes of operation: INIT, IDLE, PAUSE, and RUN. The appropriate operating mode is initiated with a control panel push button.

The first operation on the system is an initialization sequence during which various software parameters (pointers, counters, etc.) are initialized and various survey variables and administrative data such as depth filtering criteria, recording interval, clock time, and navigation information are entered. This mode is entered automatically when the system is turned on, or after a power failure and restore has occurred. Survey parameters and administrative data are loaded either from cartridge tape or from the thumbwheels, or both.

During the IDLE mode, all system functions except data recording, Minifix lane jump detection, and navigation take place. However, all warning and error messages are suppressed, making this an ideal mode for testing and troubleshooting. Since error response is inhibited, technical personnel can adjust, remove, or replace sensors and display the data being collected without terminating the acquisition process.

The third operating mode, PAUSE, enables all system functions except the recording of data on tape. This mode is used by the hydrographer to check data rates and quality and to verify that valid data is being collected.

The RUN mode is used for normal survey operations. All system processes occur including the recording of data on cartridge magnetic tape.

Operation

On a typical survey day, the hydrographer must first load survey parameters into the computer. This process is illustrated in figure 6. Some of the parameters have recently been loaded from cartridge tape while others are being entered via the thumbwheels. When this process is complete, he will enter IDLE to verify sensor output, enter PAUSE for a quality control check on input data and, finally, load a cartridge tape and enter RUN to commence surveying. If, for any reason, surveying must be

FIG. 6. — Hydrographer entering survey parameters into an INDAPS system.

suspended temporarily, the hydrographer may enter IDLE or PAUSE mode, as required.

NAVIGATION

Radio positioning systems that generate hyperbolic lines of position pose a problem to the surveyor who wishes to optimize survey efficiency and effectiveness. While it is convenient to follow the lines of position using a left-right indicator as an aid to steering the survey craft, this advantage is offset by the inefficient pattern of lines that must be run to obtain adequate coverage. Figure 7 illustrates a survey pattern of this type.

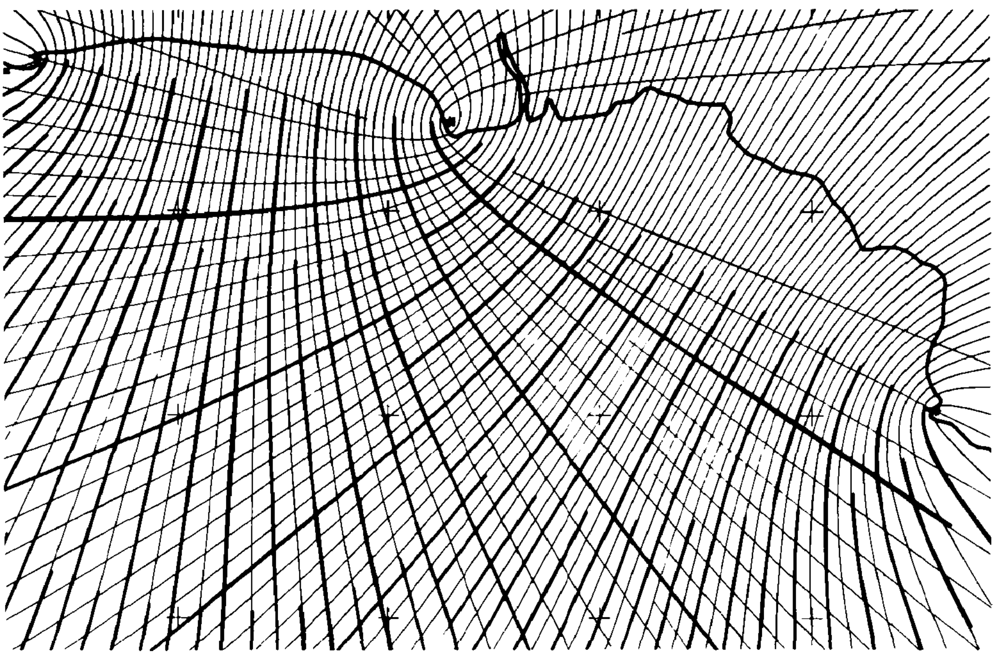

FIG. 7. — Conventional surveying practice. The hea.y lines indicate pattern lines to be followed to obtain adequate coverage.

Parallel, straight-line surveying accomplishes the same coverage with fewer, less complex lines. (Figure 8). Unfortunately, with conventional survey equipment, this necessitates conning the vessel by plotting, and deriving the heading required to stay on line. This problem is further compounded by rough seas, cross-winds and currents.

INDAPS combines the best of both systems by allowing the vessel to follow straight lines, using the computer to calculate the position of the vessel and to derive steering information for the helmsman. This both reduces the manpower required to operate the survey craft and optimizes the survey pattern to reduce the cost of the survey.

Before the field season begins, a local transverse mercator grid of the survey area is created in order to provide the co-ordinate system needed

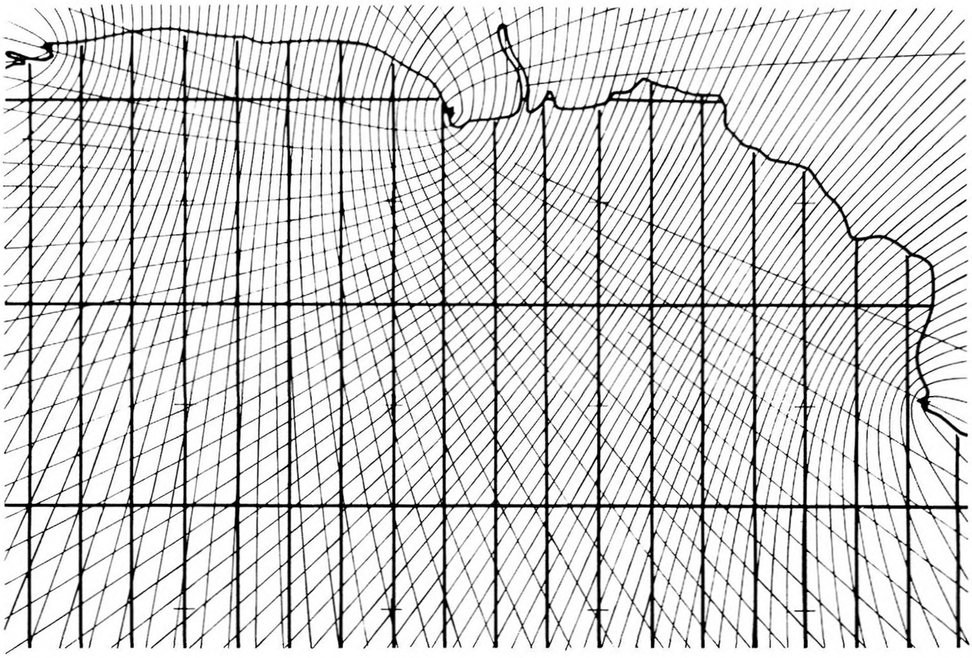

FIG. 8. — Straight line surveying practice. The heavy lines result in the same coverage as that illustrated in fig. 7 with 24% less distance travelled.

for navigation. Next, the set of parallel lines to be surveyed is outlined on this grid. A line in this set can be defined by specifying the co-ordinates of a point on the line and its bearing. All other lines in the family can then be described by specifying integer multiples of the distance between survey lines.

The helmsman steers his vessel along a specified survey line using directions from the video display. Steering information is updated as often as once per second, thereby providing an almost continuous indication of his position relative to the line. A push button on the control panel is used to terminate a line and automatically direct the helmsman to the next line to be surveyed.

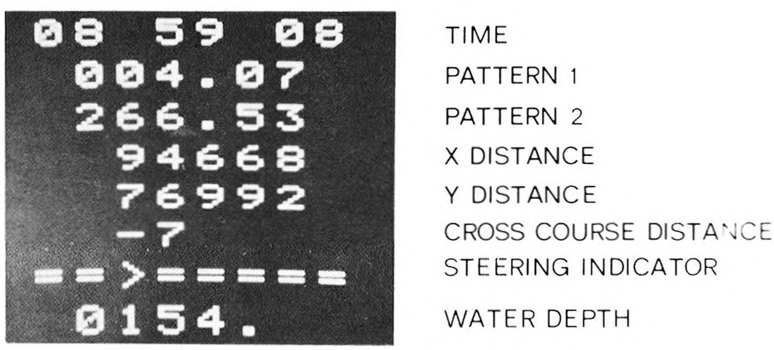

FIG. 9. — Typical video display showing the information available to the helmsman and the hydrographer.

Steering information provided on the video display (illustrated in figure 9) is in two forms: a number indicating the distance in metres to the survey line, and an arrow showing both the direction in which to steer and, by its position relative to the centre of the screen, an indication of distance off line.

DATA PROCESSING

Usually, a Logger/Processor is used in the evening to process both the data it collected during the day and the data acquired by other INDAPS data loggers on the survey. Because of the relatively high processing speed (30 to 50 minutes for 10 hours of sounding data) and the overall quality and reliability of the data, it is possible to defer processing to days when weather conditions prevent survey operations.

Processing programs are all written in FORTRAN IV and stored in ready-to-use form on cartridge tape. All execute in the environment provided by

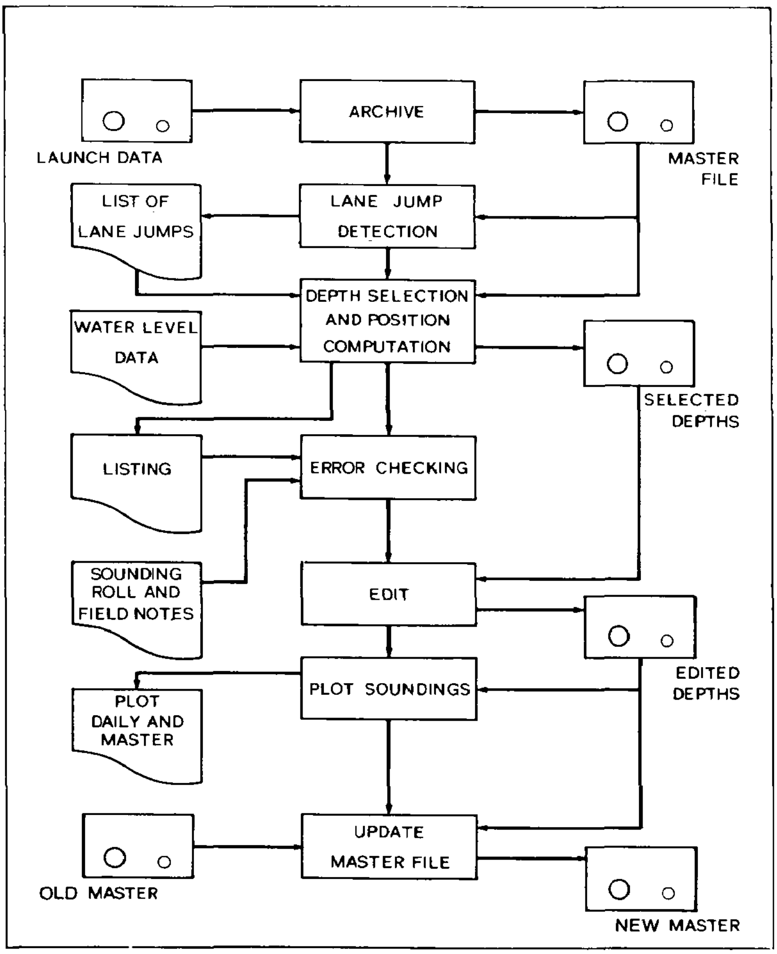

FIG. 10. — INDAPS data processing : flowchart.

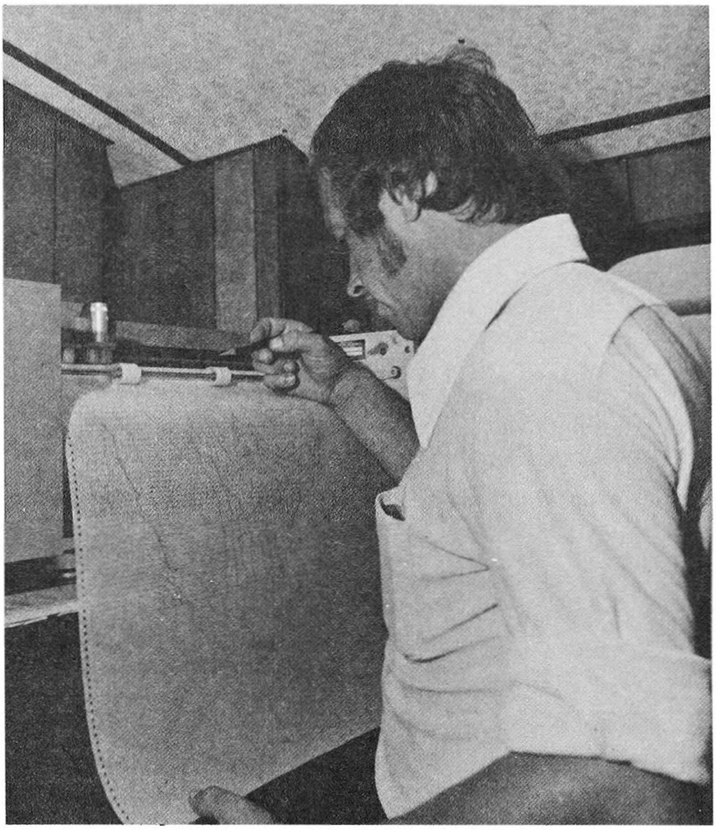

FIG. 11. — Rough field sheet created aboard a survey vessel.

Interdata's BOSS operating system which has been appropriately modified by Canadian Applied Technology to operate from cartridge tape.

Processing of survey data normally proceeds in several steps as outlined in the flowchart in figure 10.

First, the cartridge containing unprocessed sounding data is archived by copying it onto one track of a master cartridge tape. This results in a four-to-one reduction of the number of data cartridges to be retained for future use, and also allows the original cartridge to be re-used. Unprocessed data is archived in case reprocessing is required at a later date.

Second, a program is executed to identify those times (if any) where a Minifix lane jump has occurred. The magnitude of these lane jumps and the appropriate radio position monitor data are combined to prepare a list of Minifix corrections to be used when sounding data is processed. A list of water level corrections to be applied is also prepared at this time.

The third step is the execution of a program which selects depths that have hydrographic relevance from those recorded on the sounding data cartridge. This process consists of scanning the input data and selecting a depth, converting the corresponding radio position to geographic co-ordinates, recording this selected point on an output cartridge tape and listing it on the printer. Minifix and depth correction data are entered via the CRT console keyboard at appropriate times during program execution.

Fourth, the list of selected data is compared to the sounding roll to ensure that all significant bathymetric features have been selected and to verify the positions and depths chosen. If errors are found, an editing program is executed to correct the selected data cartridge tape.

Plotting the selected and edited data tape onto a field sheet base is the next step in the processing sequence. This plot is examined for errors and if any are found, the selected data tape is edited further. This process of editing and plotting is continued until the hydrographer is certain that the selected data is an adequate and accurate representation of survey area bathymetry. This data is then added to the selected data master cartridge tape.

Figure 11 shows a field sheet produced aboard a survey vessel during the 1975 survey of Lake Huron. The contour lines have been hand drawn by the hydrographer as an aid to error detection.

Several products of the data processing sequence are retained for future use. These are: the unprocessed data master tape, the list of selected data points, the plot of selected data points and the selected data master tape. At the end of the field season, the selected data master tape is transferred to standard 12.7 mm (½″) magnetic tape for further processing which eventually results in a final field sheet.

IMPLEMENTATION AND OPERATIONAL EXPERIENCE

Software development and system integration was followed in the spring of 1974 by a short operational field trial. INDAPS data acquisition systems were then installed aboard two 7.6 metre Bertram launches and a 23 metre charter vessel, *Lady Canadian*, for operation in Lake Winnipeg. Minifix positioning and Ross echo sounders were used for the survey and the data processing was carried out aboard *Lady Canadian* using a separate computer.

The launch operation was not successful, partly because of INDAPS but largely as a result of engine problems in the launches. Use of the launches was curtailed after many weeks of frustration with only 1 600 km of sounding completed, leaving the charter vessel to continue the survey. During the remainder of the season it sounded 3 000 km, following hyperbolic survey lines in the area shown in figure 12.

The system was not tested as extensively as had been hoped; however, enough experience was gained to allow development to proceed during the next winter. The ability of the computer to operate in the launch environment had been verified and the processing speed of the system had proven to be much superior to HAAPS.

During the first season of operation, equipment packaging was considerably different from the current configuration. Some modules, for example, were particularly difficult to replace and as a result considerable time was lost tracing and repairing faults. This shortcoming was cured prior to the 1975 field season.

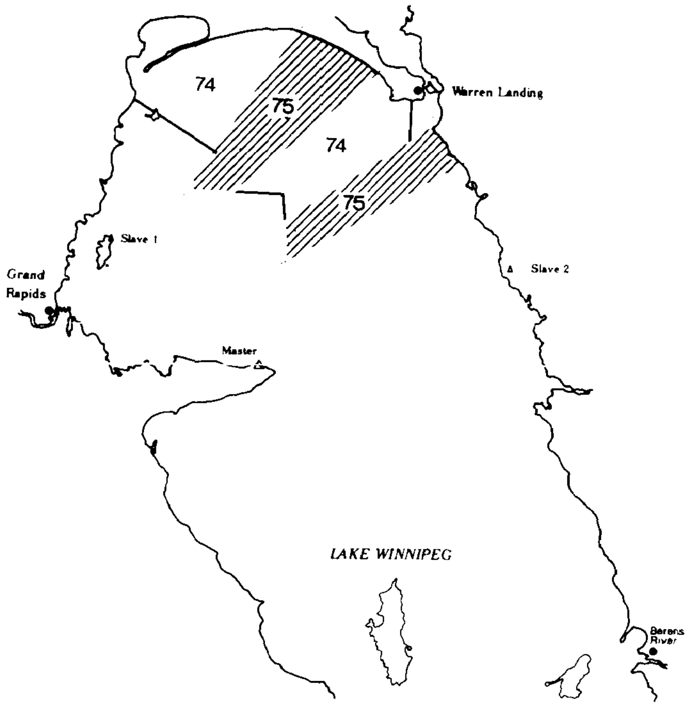

FIG. 12. — Area surveyed during 1974 and 1975 in Lake Winnipeg.

The navigation programs and display were also developed during this period and implemented for the 1975 surveys. Other software improvements included a depth tracking gate, improved lane jump detection and position filtering.

Training for hydrographers was undertaken in the form of FORTRAN programming, lectures on system operation, and experience on the system, processing data from the previous year. A test survey was conducted in the waters adjacent to Canada Centre for Inland Waters, the region's headquarters, prior to field operations.

Two surveys were conducted in 1975 using INDAPS, one in Lake Huron, the other a return to Lake Winnipeg. Each party was equipped with one system configured for acquisition and processing and another for acquisition alone.

The area surveyed in Lake Huron is shown in figure 13. The Minifix chain was first established on the Canadian side of the lake, then, when the eastern half was completed, operations were moved to the American shore. Atlas DESO 10 sounders with EDIG 10 digitizers operating at 210 kHz were used to obtain the digital depth data. East-West sounding lines with a spacing of 1 km were run with North-South check lines every 5 km. The acquisition/processing system was installed aboard the 24 metre survey vessel CSS *Advent* as shown in the photograph, figure 2. The acquisi-

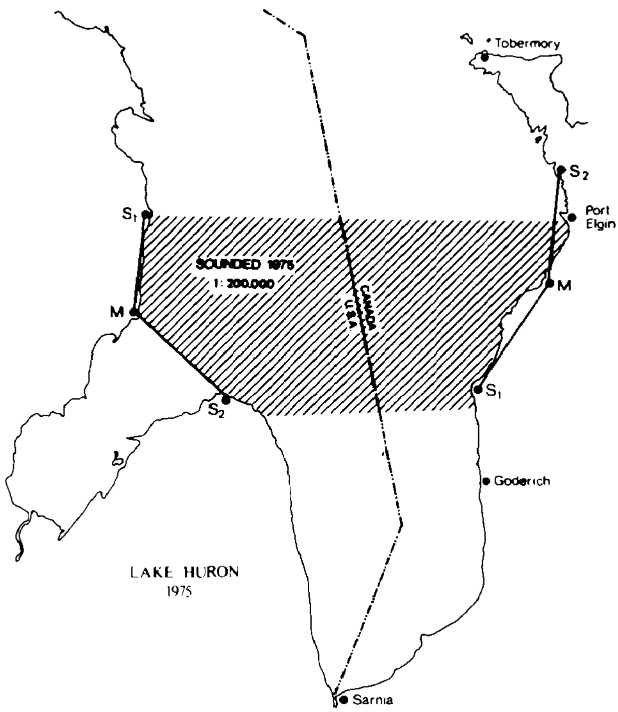

FIG. 13. — Area surveyed during 1975 in Lake Huron.

tion system was placed aboard a 10 metre diesel-powered fibreglass launch, the CSL *Nucleus,* that carried a crew of three including a hydrographer.

The survey operated out of Port Elgin, Ontario, located about 200 km from Canada Centre for Inland Waters. This close proximity permitted the equipment to be maintained by headquarters technicians and allowed development group personnel to respond directly to problems as they were encountered. This proved to be invaluable as a number of faults occurred early in the program which required visits to the field to rectify them. Each visit resulted in the prompt repair of the system and a worthwhile discussion of problems that had occurred when operating the system or processing the data. As equipment reliability improved and the hydrographers gained more experience, their confidence in the system grew and soon it was in full operational use.

Depth digitizers used with automatic data acquisition require strong bottom echoes, well in excess of the noise present in the system, for reliable operation. Silt, a common bottom material in Lake Huron where the water depth exceeds 150 metres, limited the sounding speed of the *Nucleus* to 10 knots because the weak returns were difficult to digitize. The launch was returned to the Centre and fitted with a transducer mounted in a pod beneath the keel to replace the flush mounted unit that had been in use. Considerable improvement was noted in the soundings and the speed could now be increased to over 15 knots. However, the *Nucleus* was also somewhat restricted by bad weather and, in early August, after having completed only 1 300 km of survey lines, was replaced by a small ship of 30 metres, the CSS *Bayfield.*

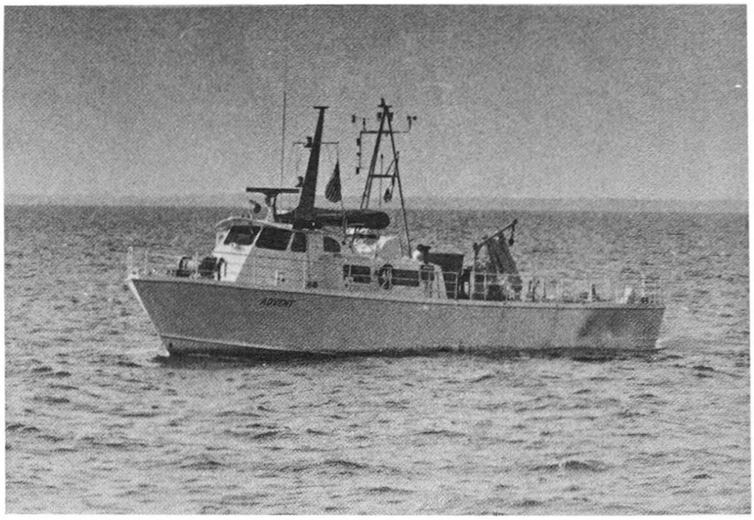

FIG. 14. — CSS *Advent* operating in U.S. waters.

The CSS *Advent* (Figure 14), carrying a crew of four plus a hydrographer, was operated an average of nine hours per day, returning to port each evening. Time actually spent acquiring survey data totalled 270 hours with an average of 5.4 hours per day. Although capable of cruising at 18 knots, the average speed while sounding was found to be 15 knots, partly because of the weather and partly, as with the *Nucleus*, to obtain reliable digitization in the deep, silt-filled basins common in the lake.

The CSS *Bayfield* (Figure 15) was employed on the survey for 20 days, sounding a total of 3 700 km. Designed for extended operations without returning to port, the *Bayfield* on several occasions continued to survey around the clock sometimes completing over 400 km of soundings per day.

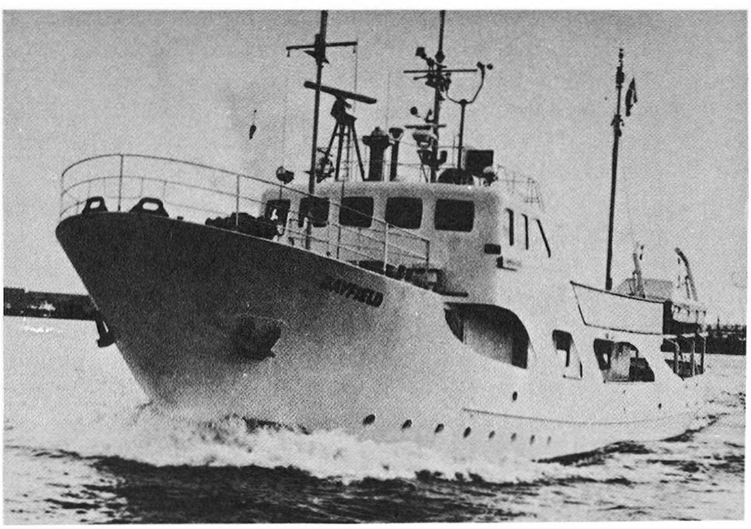

FIG. 15. — CSS *Bayfield*.

A field sheet at a scale of 1/200 000 containing over 12 000 selected soundings was drawn in final form for submission to chart production, thereby completing all objectives of the survey. Finished sheets of this type are drawn by a Gerber 22 flat bed plotter located at region headquarters.

In 1975, two chartered vessels were used for the survey of Lake Winnipeg, the *Lady Canadian* and a 27 metre ship, the *Lady Northland*. The results of the survey proved to be somewhat disappointing with numerous difficulties arising, of which some were related directly to INDAPS. Because of the remoteness of the survey area from headquarters, the same level and promptness of support as was provided to the Lake Huron survey could not be maintained. This problem could have been solved, in part, with more adequate training of the electronics technician assigned to the survey.

Severe aeration, especially in rough seas, produced poor soundings and, consequently, depth digitizing problems aboard the *Lady Northland*. This, in turn, made extensive editing of the selected data tapes necessary. In spite of these difficulties, the *Lady Northland* was able to sound a distance of 1 770 km during the field season.

Although the sounding equipment aboard the *Lady Canadian* operated more reliably, other electronics problems, compounded by the lack of maintenance training, limited the amount of sounding accomplished to a distance of 2 030 km.

The area surveyed during 1975 is illustrated in figure 12. In addition, a considerable number of check lines were surveyed across the north end of the lake. Data from surveys in 1973, 1974 and 1975 have now been combined to produce a field sheet of the area at a scale of 1/40 000.

CURRENT DEVELOPMENT

As a result of current development activity, the reliability and maintainability of the system will be further improved before 1976 field operations. For example, a particularly troublesome feature of the interface unit has been the possibility of misaligning the plug-in circuit boards with their connectors. As a result, a technician engaged in fault isolation by circuit board replacement could compound the problem of locating the fault by misaligning the replacement board. A new connector and keying arrangement is being implemented that will ensure positive alignment of the circuit boards and alleviate this problem.

The cartridge tape system frequently had read errors and occasionally demonstrated incompatibility between drives with the result that tapes created on one machine could not be read on the other. A set of alignment procedures, developed by the manufacturer during the 1975 field season, corrected this situation. Maintenance routines to be followed in 1976 will include periodic verification of all key parameters in the cartridge system to ensure reliable operation.

Prior to 1975 field operations, formal training of maintenance technicians was limited to manufacturer-conducted courses on maintenance of Interdata computers. Because of time constraints, the technicians were unable to acquire sufficient experience with the remainder of the system before the field season commenced. This problem was further aggravated by a lack of adequate system documentation. Much of the time lost in the Lake Winnipeg survey could be directly attributed to lack of training and experience, as minor problems that could have been corrected in minutes often resulted in days of lost time. Steps to correct this situation have now been taken. More technicians have attended Interdata training courses, instruction has been given in assembly language programming as an aid to fault finding, a formal training course is being given by Canadian Applied Technology, full documentation has been prepared, and the technicians have been given access to the systems to practice their maintenance procedures.

Major acquisition software changes, made between the 1974 and 1975 field seasons, resulted in a large number of procedural changes in the use of the system. Consequently, experience gained by hydrographers during 1974 was not readily applicable to 1975 operations. Since very few software changes are planned for 1976, this problem will not repeat itself and hydrographers will profit from their previous experience.

The depth-tracking gate implemented in the 1975 surveys featured automatic re-acquisition of lock in the event of a loss of signal or the occurrence of a discontinuity in the bottom. Because resolution of the difference between legitimate sudden changes in depth and digitization of echoes from fish is difficult, some compromise must be found between acquisition of false data and rejection of valid information. Unfortunately, the results to date favoured the acquisition of false information, so a modification to the program has been undertaken. The new system will require that the hydrographer judge what setting of the re-acquisition limit is best suited for the particular conditions of the survey and enter this value during system initialization.

Programs are being written to permit operation of the system with the Motorola Mini-Ranger III short-range positioning system. Unlike phase difference measurement systems where the lane count readings are constrained by the phase tracking loops in the receiver, this system provides ranges as discrete, independent samples. For this reason, the program will incorporate a range tracking system to facilitate rejection of erroneous data. To be effective, the navigation function must provide the helmsman with a position error each time period (usually once per second). Since the positioning system does not give an output when it has difficulty receiving the signals from its remote transponders, the program will predict the range for either or both channels and use this information to derive the navigation data.

A trial planned for early May 1976 will see INDAPS deployed in a tracked vehicle operating on the ice near Resolute in the Canadian Arctic. This trial, part of a program to evaluate techniques for obtaining soundings through the ice, will employ the Mini-Ranger navigation package and will acquire depths with a transducer coupled to the ice through a hydraulic ram.

The 1976 field program of the Canadian Hydrographic Service, Central Region, includes two surveys using INDAPS. We are expecting excellent results with total production far in excess of the two previous years.

REFERENCE

[1] MACDONALD G.D. : An automated hydrographic survey in James Bay, Canada. *Int. Hydrog. Review*, LII(2), July 1975, pp. 121-131.