A SURVEY INFORMATION PROCESSING SYSTEM FOR HYDROGRAPHER

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ABSTRACT

HMS ROEBUCK, the Royal Navy's latest coastal survey vessel, is equipped with an advanced data logging and processing system. The system is designed to aid all aspects of hydrographic survey from planning to final fair sheet production. It includes a variety of graphics displays which enables the surveyor to monitor on-line the data being collected. Sophisticated computer processing and cartographic capabilities allow the final data to be presented with a new degree of flexibility in a variety of forms.

INTRODUCTION

The Fair Sheets recording the results of hydrographic surveys undertaken by the surveying service of the Royal Navy are a principal source of field data for Admiralty charts. They are themselves a cartographic product which forms an archived public record. Although there have been many developments in both surveying equipment and techniques, the painstaking preparation and presentation of these documents has remained a highly labour-intensive activity largely unchanged for the last 100 years.

Initially, the use of automation to assist in the progress of coastal surveys touched only on the areas of position computation and plotting the ship's track. However, with the impetus from oil and gas exploration a new generation of computer-based navigation and surveying systems has become available in the commercial sector. The construction of a new coastal survey vessel, HMS ROEBUCK, launched in November 1985, has allowed the Hydrographic Department to take advantage of these advances and install the Royal Navy's first automated logging and processing system for bathymetric surveys. Designated the Survey Information Processing System (SIPS) it has been developed to suit Hydrographer's particular needs in association with Qubit UK Ltd as Ministry of Defence contractor.

The objectives are to improve survey accuracy and presentation; to ease the handling of the voluminous amount of data involved; and to reduce the repetitive aspects thereby allowing the surveyor to spend more time on the exacting task of quality control of the survey. This paper concentrates on the way the System's graphic and cartographic capabilities help achieve these aims for the surveyor at sea.

EQUIPMENT

SIPS is designed to provide a real-time aid to navigation, data logging and onboard processing. To meet this task it is divided into two subsystems, one for data acquisition and one for data processing.

Data Logging System (DLS)

This is located on the bridge and is centered around a Hewlett Packard HP1000 mini-computer. There is an A0-size flatbed plotter, a terminal and two strategically mounted high-resolution colour displays: one for the officer of the watch, another for the helmsman. The computer is interfaced to a wide variety of navigation and surveying sensors, such as depth measuring echo-sounders, heave compensator, gyro compass, logs, sonar and a variety of electronic position fixing equipment (Fig 1). Observations from all these inputs are logged onto magnetic tape cartridges for transfer to the Data Processing System.

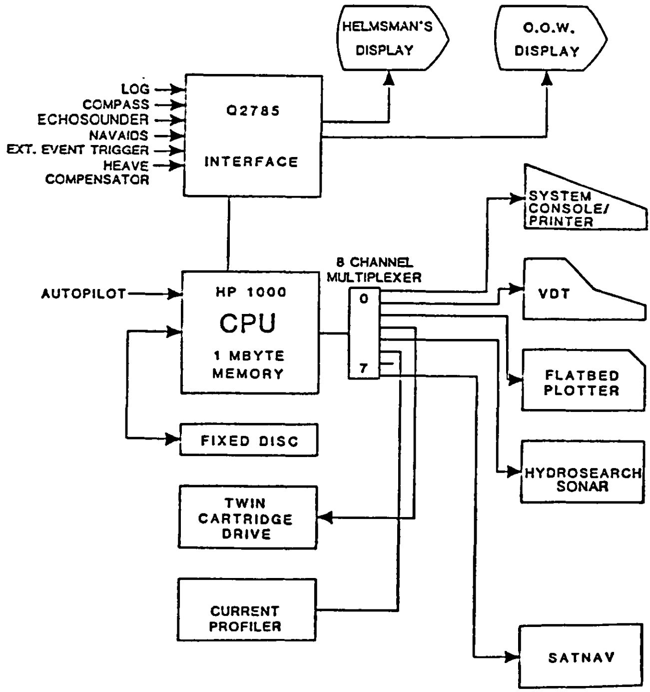

Fig 1 Data Logging System (DLS)

Data Processing System (DPS)

This is based around a separate, identical mini-computer located in the chartroom. It differs from the DLS in having a faster A0-size drum plotter, a high-resolution graphics terminal and a digitising table (Fig 2). The output is a set of processed data on cartridges and a variety of hardcopy cartographic products.

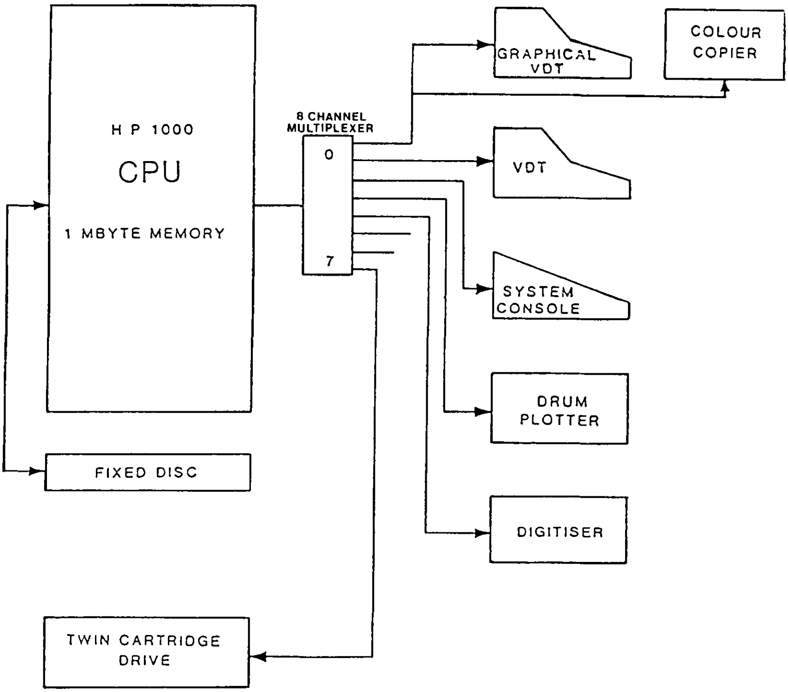

Fig 2 Data Processing System

SYSTEM DISPLAYS AND OUTPUT

The use of SIPS divides into four functional areas: survey planning, surveying (real-time navigation and logging), data analysis and reduction, and presentation of results. Displays can be either ephemeral on one of the video monitors or onto hardcopy. Hardcopy documents can be generated in the planning phase and predominate in the final presentation of the results of the survey. The visual displays are used principally whilst navigating, when constant updating is required, and for interactive editing during data processing.

Survey Planning

The planning phase can be carried out on either system but normally will be done on the chartroom equipment. The lines along which the ship will survey are automatically generated in grid terms, given the area to be surveyed, the spacing between the lines, and the first line to be run. Files are created of, for example, hazards, features requiring investigation, navigation marks and the coastline, using either the digitising table or by keyboard entry. Symbols are drawn from a library of standard Admiralty-style chart symbols. Base sheets, optionally with navigation lattices, can be plotted with this information.

Whilst none of this is particularly novel onshore, onboard it gives the ship significant operational flexibility both in the production of planning documents and in the way information can be displayed. Additionally, amendments to the surveying plan can always be made on-line without disrupting the main task of logging.

Surveying; Real-time Navigation and Logging

Data collection for a routine bathymetric survey may well involve the simultaneous collection of data from up to a dozen different sensors. Monitoring the incoming data in the past has been limited to spot checking the reading of an individual piece of equipment and the production of a trackplot on a plotter. SIPS firstly records the raw readings from these sensors for later processing and secondly, it integrates and processes the data on-line, presenting relevant information to the surveyor. The presentation is achieved by means of a series of textual and graphical displays. Textual displays are used to summarise the data currently flowing into SIPS. A series of graphical displays affords an easily assimilated summary of navigation information, coupled with the more critical data from the sensors such as depth, course and speed.

The principal display that will be used by the helmsman is the left/right indicator (Fig 3).It provides the ship's track superimposed onto the planned profile, against which the ship's position has to be constantly monitored. Meanwhile, the Officer-of-the-Watch can be evaluating the accuracy of the position fix using an error ellipse display (Fig 4) which gives a visual presentation of the lines of position emanating from the various navigational aids. Position fixing remains one of the main problems in hydrographic surveying and demands constant checking. SIPS provides the information for the surveyor to judge its reliability and then to take steps to obtain the best position calculation for the ship.

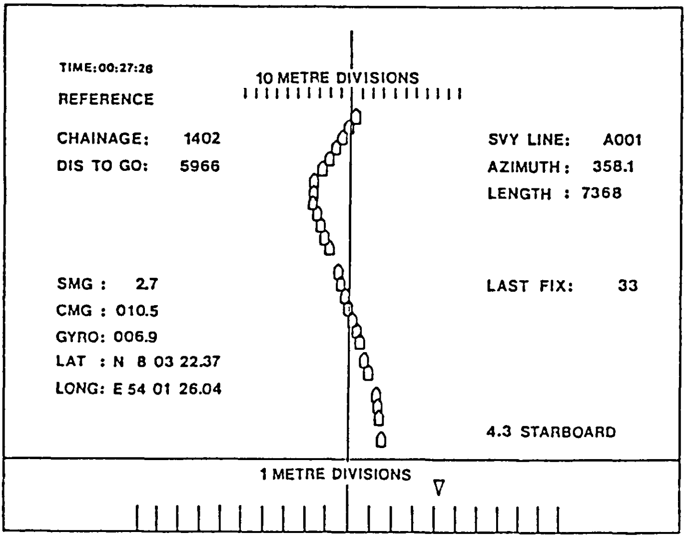

Fig 3 Left/Right Indicator Display

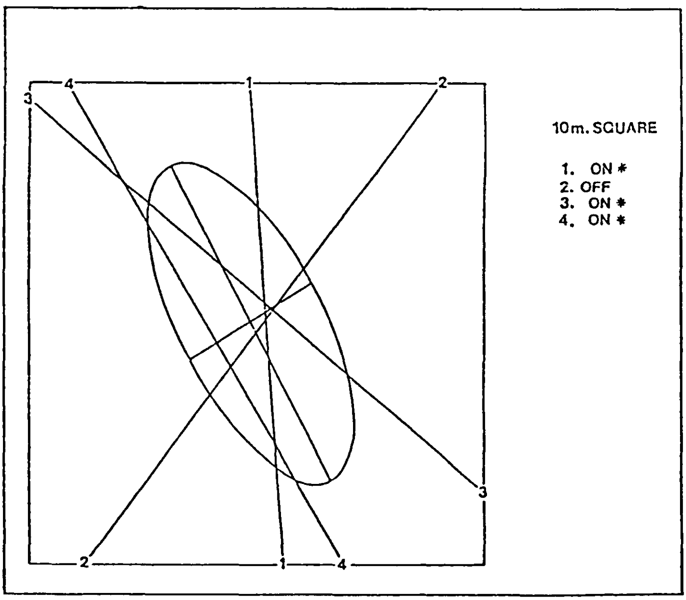

Fig 4 Error Ellipse Display

The information input during the planning stage, such as hazards, the coastline and shoals requiring investigation, can be displayed on the screen, together with the survey lines to be followed or the track already completed. Alternatively a target display can be chosen centred on, for instance, a wreck or natural submarine feature requiring investigation (Fig 5). This display includes a series of range circles centred on the pre-selected point at the chosen scale. Again, cartographic information on file can be added to the ship's position. For investigation of wrecks a very large scale can be selected and as well as the ship's position that of a second ship's position (required in wreck sweeping) or a towed sonar can also be displayed. All this aids the precise manoeuvring necessary in this type of operation.

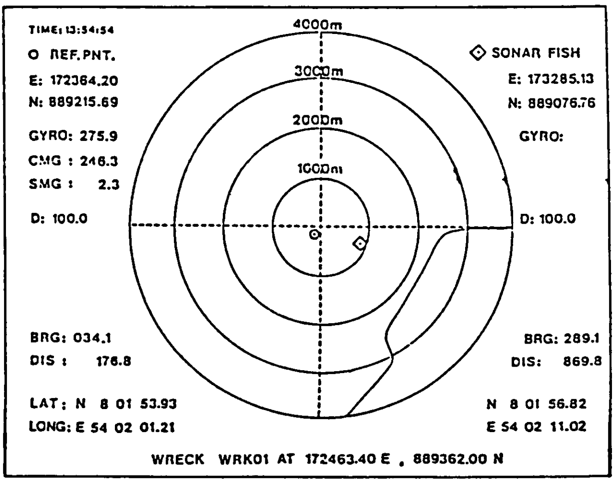

Fig 5 Target Display

In practice these displays are also backed up by a continuous small-scale hardcopy plot of the ship's track, plotted together with any wreck contacts discovered, but it is the visual display unit that has now become the focal point for the surveyor on the bridge.

Together, these displays provide regularly refreshed information for controlling and scrutinising the survey processes as the survey progresses. The variety of display options enables the surveyor at sea, for the first time, to monitor the quality of his observations properly using quantitative data.

Data Analysis and Reduction

The extraction of depths from analogue echo-traces and their reduction to a common vertical datum are exacting and time-consuming. The depths are then in time-honoured fashion 'inked-in', first on collector tracings then on final 'fair sheets'. A further disadvantage is that there is inevitably a degradation in accuracy resulting from some of the subjective procedures and the manual transcription of data. This can now be eliminated by manipulating the raw digital survey data. With the introduction of computer processing the aim is to remove some of the sources of error and to speed up the production of the final survey results.

Depths may have to be logged at 10 values per second to ensure pinnacles are not missed. The result is a vast amount of data which inevitably contains spurious or redundant information. The object of processing is to produce a reduced, valid, manageable data set. Procedures are still being refined but the underlying philosophy is that they should achieve a balance between software and human intervention. The surveyor has the opportunity to select parameters for the various filters used in the processing, and subsequently has the ability to verify and edit the computer's choice.

The first element to be processed is the ship's position. The values used can be those computed whilst logging, but as raw data is collected there is the option, for example, to re-configure or adjust calibration values. Once a 'best position' has been computed the ship's track can be smoothed to remove spikes in the data, for instance those caused by outside radio interference or perhaps the malfunction of a particular shore transmitter. The results are viewed on the screen, checked and, if necessary, interactively edited before the optimum track is plotted onto a base sheet.

Armed with the best ship's track the next stage is to remove erroneous return signals, caused perhaps by fish or aeration, from the logged bathymetry.

The data is processed by viewing the depth profile on a graphics terminal. The horizontal and vertical scales can be adjusted to suit the variation in, and density of, the data. The computer has a 'first go' at finding the errant returns, but the software is not left totally to its own devices. The operator has to set values used in the selection algorithms. This choice affects the effectiveness of the automation and gives the surveyor more control, or at least the feeling of having more control. Additionally there is the option of editing the automatic selection, by moving a cursor along the profile and tagging or deselecting soundings. At the very least the software draws attention to areas of data that require special consideration.

At this stage one of the prime objectives has been achieved. There is now a file containing only accurate positional and valid depth information. The bathymetry has been corrected for the ship's heave and the file contains the appropriate tidal values required to reduce the observed depths to a common vertical datum. However the data has still to be presented in conventional forms for both the end-users and for the surveyor's own use in quality control. The profiles that have been viewed on the screen can be plotted out, either on a large scale to overlay the echo-trace or on a small scale for a whole survey line's worth of data. If the information is required in plan form, the depth dataset has to be reduced still further to plot it at a reasonable scale. Chart-making and surveys are based on the principle of presenting shoal depths critical for navigation. This has to be reconciled with giving as representative a picture of the seabed as is possible. Further software routines aim to do this firstly by selecting minimum and maximum soundings within a 'window' set by the operator. Having chosen the scale of plot and sounding size, 'infill' depths are then selected, or depths are removed if there is likely to be a clash. As before, the surveyor can view the profiles on the screen (or plot the profiles) and edit the choice of soundings if necessary.

So far these methods have only dealt with data along individual lines. A normal survey has areas of intense investigation, as well as check lines run perpendicular to the normal survey direction. This extra information may contain critical depths which are required in the final data set. Another software routine compares soundings in two dimensions from adjacent or crossing survey lines, selecting the shoal soundings where there would be a clash at the chosen plot scale.

So we now have the means firstly to achieve valid data, and secondly to reduce the information into a manageable dataset. This is the starting point for the conventional cartographic products.

Presentation of Results

The currently accepted international convention on nautical charts is to show depths as individual spot values, supplemented by only a limited number of contours. This forms a constraint to which the presentation of hydrographic survey data must for the moment work, continuing to produce sheets of soundings for a chart compiler to use (Fig 6).

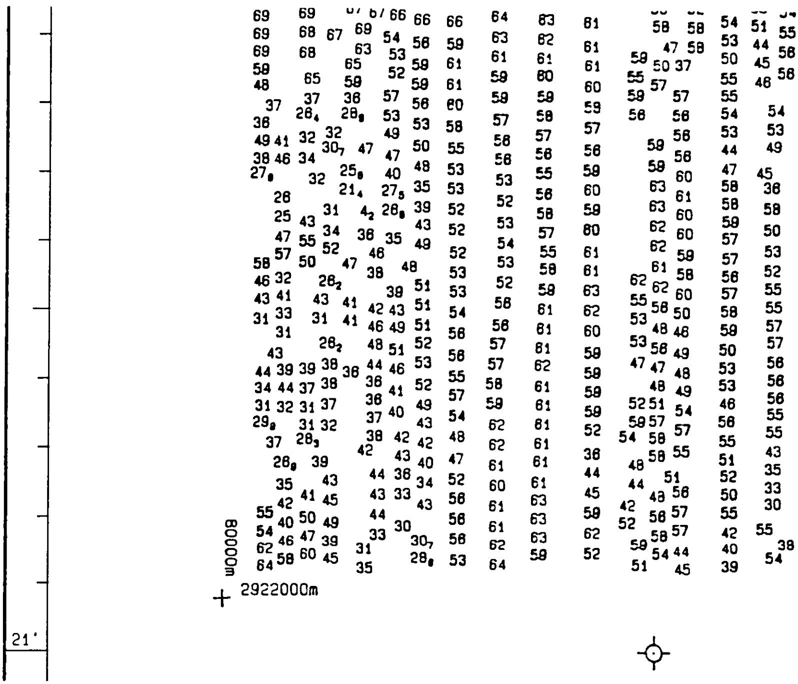

Fig 6 Automatically Plotted Survey Fair Sheet

Automated cartographic methods can enhance presentation, speed up production, give more precise and consistent results, and allow much more flexibility in the final product. The starting point is the base sheet which can be generated, as in the planning stage, complete with textual title information and features plotted with a range of Admiralty style symbols. The track of the ship and the projected track of a sonar fish (a body towed some distance behind the ship) can then be plotted, allowing the surveyor, and later the office, to assess the thoroughness of the survey and sonar coverage.

But it is in the plotting of bathymetry where most improvement lies. Depths can easily be plotted rapidly onboard not only at the required survey scale, but at enlarged scales in areas of detailed investigation, for example. The eight pen plotter allows the depths to be shown in colour bands which can be used to distinguish contours or highlight seabed features. Three-dimensional plots, viewed from whichever direction required, are produced either on the screen or paper. On a practical level these are an excellent 'long stop' for detecting spikes in the depths. At the Hydrographic Department they should aid the chart compiler in assessing the adequacy of his depth selection.

Other options allow surveys to be compared with previous work, plotting the result as a depth-difference choropleth chart; this is particularly useful in the sedimentation studies carried out by the Department. Of more use onboard is the comparison that can be done where survey lines intersect. Cross lines are run as a matter of course to check on the main sounding profiles; the system outputs a plot of depth differences at the line intersections. An excessive value flags the necessity to check, for instance, that the tidal adjustment is correct.

CONCLUSION

Our philosophy at present is determined by the crucial role the surveys play in safety at sea. The surveyor needs to maintain a watchful eye over all that the machine is doing, though in time experience with the system and the confidence that is built up, may reduce the amount of human intervention.

HMS ROEBUCK is currently undergoing extensive trials to refine the operating methods of SIPS. Undoubtedly SIPS will improve the accuracy of survey and greatly improve the flexibility with which the data can be presented. It is expected that certain timeconsuming tasks will be reduced allowing more time to be spent on quality control as well as speeding up the rendering of surveys. The final product will now include digital data ready for potential future exploitation.

The real-time video graphic and cartographic presentation of information is drastically changing life at sea for the surveyor. For the first time he will be provided with a proper measure of control over both his observations and the way they are presented.