SURVEY INFORMATION PROCESSING SYSTEMS IN THE ROYAL NAVY

BY

LIEUTENANT-COMMANDER D. C. BOUTLE, MA, RN
(Hydrographic Department, Whitehall)

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ABSTRACT

Trials on the Royal Navy's first automated logging and processing system for bathymetric surveys, which is installed in HMS *Roebuck*, commenced in 1986. Since then various other systems have been procured for use by all other units of the Surveying Flotilla involved in such surveys, a training system has been provided at the Royal Naval Hydrographic School, and a processing system is installed at the Hydrographic Office. In this article the developments of these systems are presented, and their performances are assessed.

Background

The first Automatic Data Logging System to be used at sea by the Royal Navy was installed in HMS *Hecate* in 1967. Systems were installed into the three other ships of the Class, and a training system was supplied to the Royal Naval Hydrographic School. Upgraded by various software and hardware modifications over the years, the system remains in service, still meeting Hydrographer's data logging requirements for ocean surveys. However until HMS *Roebuck* was accepted into service in 1986, the use of automation to assist in the progress of coastal surveys was restricted to computation of position, track guidance, and the plotting of the ship's track.

Introduction

The Royal Navy's first automated data logging and processing system for bathymetric surveys was installed in HMS *Roebuck* during her construction. Designated the Survey Information Processing System (SIPS) it was developed to suit Hydrographer's particular needs in association with Qubit UK Ltd as Ministry of Defence contractor. This system, referred to as SIPS 1, entered service in 1986. The requirement for similar systems to be fitted to the other coastal survey vessels during their major refits was recognized. The normal procurement procedures of competitive tender were followed for three ship systems, together with a training system and Hydrographic Office system, and eventually the contract for SIPS Mark II (SIPS 2) was awarded to Qubit in July 1988. Meanwhile another less powerful system, the Small Ships Surveying System (S4), had been developed for Hydrographer by Qubit after competitive tender. In early 1988 this was fitted into two chartered vessels, manned by Naval Parties surveying in coastal waters, and into the 15-metre launch, HMSML *Gleaner*. Other related systems have since been procured for use in 9-metre survey motor boats, the Ocean Survey Ships, and at the Hydrographic Office, Taunton.

Philosophy

Throughout the procurement of SIPS 1 and related systems, the main objectives in using such computer-based surveying systems were:

(*a*) The achievement of an overall increase in survey accuracy and thoroughness.

(*b*) The provision of improved quality control over survey data at all stages.

(*c*) The speeding up of the data processing task, thereby reducing the time taken to render surveys to the Hydrographic Department.

In general, it was considered that data logging and processing systems should:

(*a*) Collect and record all raw data.

(*b*) Allow the surveyor to maintain full control over all stages of automatic processing.

(*c*) Improve the quality of survey records.

Also it was considered that wherever possible, without significantly constraining their capabilities, new equipments should have the highest level of compatibility with existing systems.

SIPS 1

Descriptions of SIPS 1 may be found in various papers, including those of The Second International Hydrographic Technical Conference 1984[1], Auto-carto '86[2], and in the International Hydrographic Review, in 1988[3]. FIG. 1 illustrates its component parts.

Prolonged trials, designed to prove the functionality of all the features of the software and the various modes of operation continued until mid-1987. Although shortcomings in the documentation were identified, it was found that the Data Logging System (DLS) generally performed well. The operation of the Data Processing System (DPS) however was found to be slow, but, nevertheless, the reduction of a day's data could be achieved within 24 hours. A certificate of clearance for use for SIPS 1, initially with software version 1·2, was issued in September 1987. Since then it has been used for surveying with occasional updates to the software, version 1·5 being issued in July 1989.

Performance

Time elapsed meters were fitted to SIPS 1 and used together with Availability, Reliability and Maintainability (ARM) log books to assess the performance of the system since its clearance for use. Hardware defects have been few, and have not presented any major losses of surveying time, partly due to a comprehensive outfit of on-board spares. A fibre optic link, designed to provide a reversionary mode of operation by swapping equivalent DLS/DPS hardware items, has not been needed, only being used during trials. System freezes were at first quite frequent but greater operator familiarity, leading to fewer keying errors, and modifications to software resulted in the DPS operating faster and in far fewer entries in the ARM log in 1989. The lengthening mean time between failures indicated a satisfactory growth in system reliability.

Fleet Weapon Acceptance of SIPS 1, its full acceptance into naval service, was achieved in September 1990 with software version 1·5. One remaining shortcoming in SIPS 1 was the time taken to transfer data from the DLS to the DPS. This was remedied with the issue of software version 1·6 in March 1991 which incorporated the fibre optic link as a permanent data highway from DLS to DPS, thereby permitting the direct transfer of data files from one system to the other instead of using tape cartridges which had also been identified in the ARM assessment as a weak point in the system.

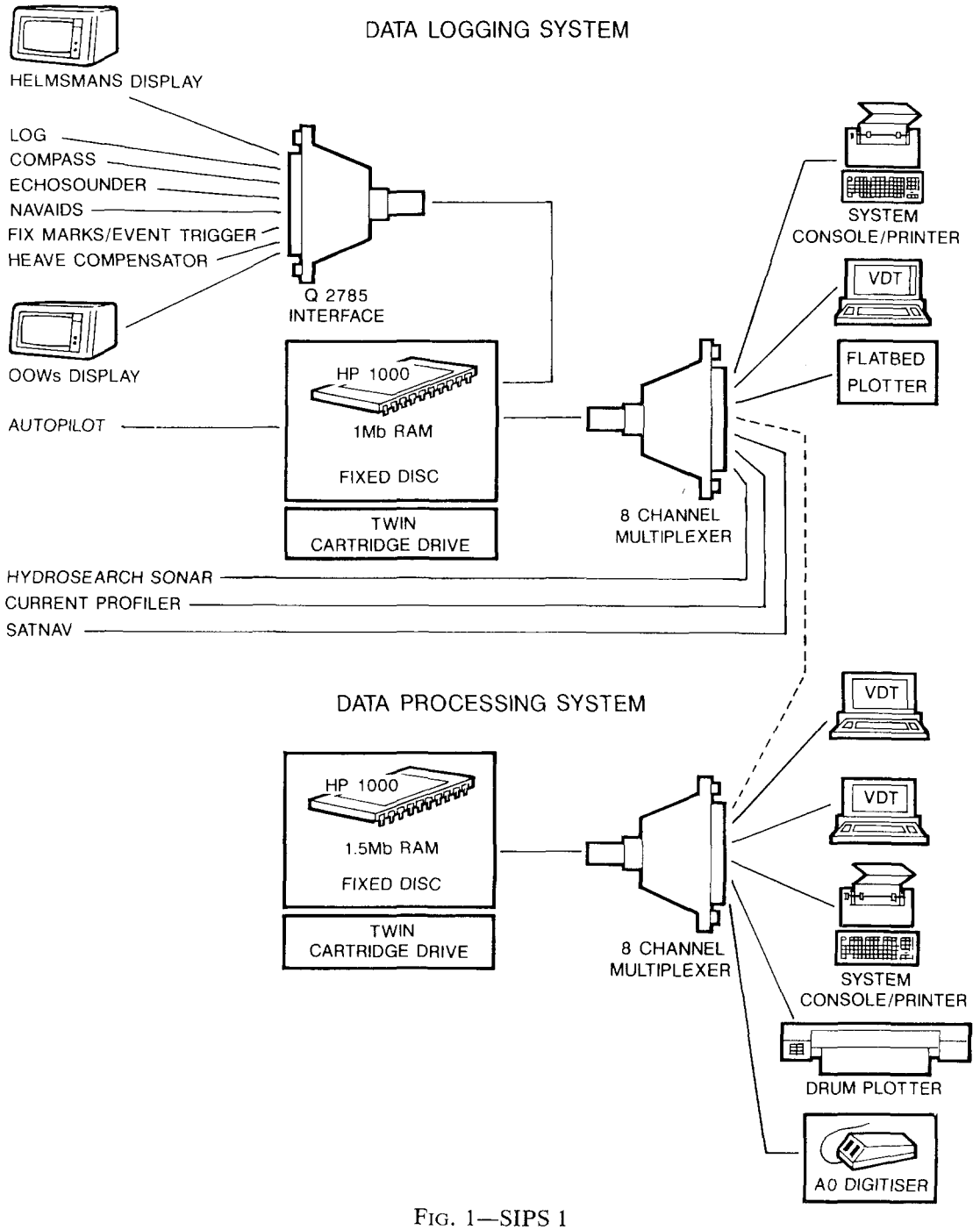

FIG. 1—SIPS 1

SIPS 2 and S4

Procurement

During 1987 a Cardinal Point Specification was prepared for SIPS 2. This detailed the requirement for the systems for each BULLDOG Class coastal survey vessel (SIPS-H), a training system (SIPS-T) and a processing and development system for the Hydrographic Office (SIPS-HD). Meanwhile that autumn a technical requirement for S4 was prepared by Hydrographer, for three systems, one for each of two Naval Parties and the third for HMSML *Gleaner*. Each requirement went out separately to competitive tender and in each case, after separate assessment, the contract was awarded to Qubit.

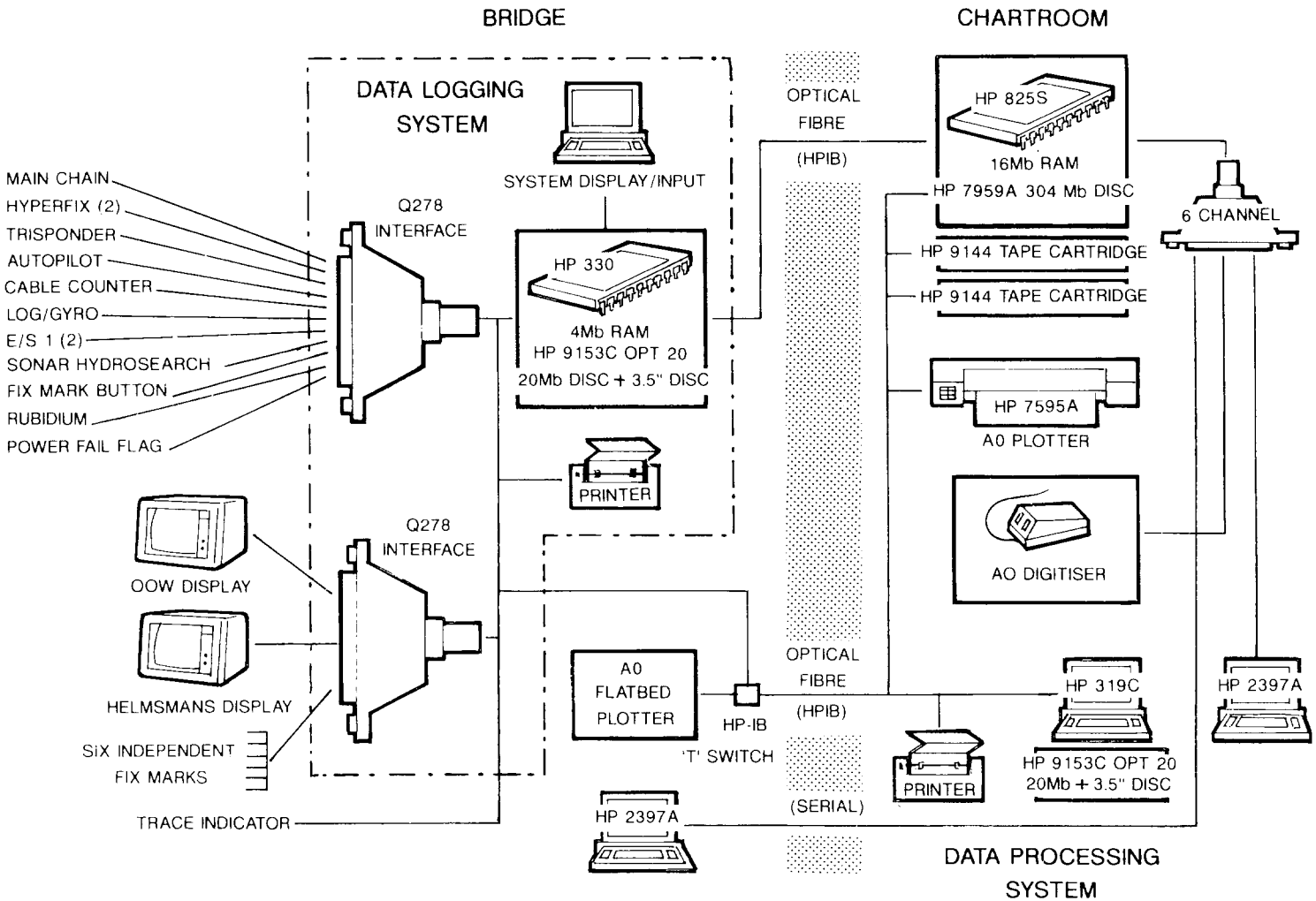
BRIDGE
CHARTROOM
DATA LOGGING SYSTEM
SYSTEM DISPLAY/INPUT
MAIN CHAIN
HYPERFIX (2)
TRISPONDER
AUTOPILOT
CABLE COUNTER
LOG/GYRO
E/S 1 (2)
SONAR HYDROSEARCH
FIX MARK BUTTON
RUBIDIUM
POWER FAIL FLAG
Q278 INTERFACE
HP 330
4Mb RAM
HP 9153C OPT 20
20Mb DISC + 3.5" DISC
PRINTER
OPTICAL FIBRE (HPIB)
HP 825S
16Mb RAM
HP 7959A 304 Mb DISC
6 CHANNEL
HP 9144 TAPE CARTRIDGE
HP 9144 TAPE CARTRIDGE
HP 7595A
A0 PLOTTER
AO DIGITISER
OOW DISPLAY
Q278 INTERFACE
HELMSMANS DISPLAY
SIX INDEPENDENT FIX MARKS
TRACE INDICATOR
A0 FLATBED PLOTTER
HP-IB
'T' SWITCH
OPTICAL FIBRE (HPIB)
HP 319C
HP 2397A
PRINTER
HP 9153C OPT 20
20Mb + 3.5" DISC
(SERIAL)
HP 2397A
DATA PROCESSING SYSTEM

FIG. 2—SIPS 2

SIPS-H

The development of SIPS 2 proceeded in parallel with the Royal Australian Navy's HYDLAPS project, and is based on the same hardware, and much of the same software. In SIPS-H the DLS is based on a TRAC V work station and it is linked by fibre optic cable to the DPS to permit on-line transfer of data for processing. The DPS is centred on a powerful mini-computer, which is connected to three work stations. Using RISC technology and the HP-UX version of UNIX as its operating system, it is fully capable of multi-user, multi-tasking operation without significant time penalties. With the ready access to data from the DLS, there should be a significant saving of time in the processing of each day's work, and also in the production of fair records, both digital and the traditional graphical. A complete system is presented diagrammatically in FIG. 2.

The main features of the DLS in SIPS-H are:

(*a*) The logging of raw navigational data, and computation of position from up to 20 lines of position, using weighted least squares and allowing for antenna motion.

(*b*) The availability of a (C-O) model to apply varying corrections to each line of position automatically.

(*c*) A navaid calibration routine which caters for Trisponder and includes baseline crossing.

(*d*) The logging of depth data, corrected for heave, together with the heave value provided in real time by a TSS 320 compensator.

(*e*) The automatic creation of individual line files, ready for transfer to the DPS.

(*f*) The transfer of raw logged data and line files by fibre optic link to the DPS, where it is archieved to tape cartridge.

(*g*) The automatic cessation of logging, file closing and saving to disc in the event of a power failure of more than three minutes to the uninterrupted power supply, thereby safeguarding the data and leaving the surveyor free to deal with any emergency.

(*h*) The provision of track guidance information to the autopilot and helmsman, and quality control or positional data to the Officer of the Watch.

(*i*) The plotting of track information on an A0 plotter.

The main features of the DPS are:

(*a*) The ability to process data efficiently while tasked by all three work stations.

(*b*) Immediate access to individual line files, with no wait for data cartridge tapes to be read.

(*c*) The ability to recompute navigational data using different parameters.

(*d*) Semi-automatic depth processing and sounding selection, with interactive editing;

(*e*) The use of co-tidal models for automatic adjustment of the height of tide from tide gauge to position of sounding.

(*f*) Database generation, including the digitization of analogue records and plots.

(*g*) Plotting of survey information as working or fair sheets, with colour banding, weeding of overlapping soundings, crossline comparison, digital elevation model, survey comparison and 3-D views available.

The first SIPS-H was installed in HMS *Bulldog* in October 1989, completed acceptance trials in harbour in November 1989 and at sea in June 1990, the sea

trials having been postponed due to delays with the completion of the refit. The second SIPS-H was installed in HMS *Beagle* in April 1990, with sea acceptance trials undertaken in July 1990. The final system was installed in HMS *Fawn* in October 1990, trials being completed in November 1990.

SIPS-T

The training system at the Royal Naval Hydrographic School was installed in September 1989. It is a reduced SIPS-H system, scaled down by the exclusion of the second plotter, the second printer and one DPS workstation. The instructor uses an external simulator to provide the input data through the various interfaces to the DLS side of SIPS-T, and smaller surveys from SIPS-based systems for DPS training. Training in the use of SIPS-based systems has been included in career courses since January 1990.

A smaller boat's system, based on a TRAC HL, was supplied to the school in March 1991 to enable students to gain experience in the collection of digital data in the field as well as the processing of the data on SIPS-T.

SIPS-HD

SIPS-HD comprises the DPS side of a system, together with extra software yet to be installed for translation of SIPS 1 data into SIPS 2 format, thereby allowing it to handle all SIPS-related systems' data. It was installed at the Hydrographic Department in early December 1989. The main uses for the system are envisaged as:

(*a*) The checking, cataloguing and archiving of data.

(*b*) The recomputation of survey positioning data in the event of the discovery of major problems in the rendered products.

(*c*) The production of reduced-scale plots to assist chart compilation.

(*d*) The development in-house of further processing and databasing facilities.

S4

S4 comprises a separate DLS and DPS, using data cartridge tapes for transfer of logged data to the DPS as in the original SIPS 1. The DLS and DPS are both based on Qubit TRAC V hardware, with the addition of cartridge tape drives. With the exception of a digitizing table, its configuration is very similar to SIPS 1 as can be seen in its diagrammatic representation in FIG. 3. The system is reasonably transportable and compact, an important consideration for the Naval Parties as they need their systems ashore for processing each winter. This is also important for *Gleaner* as she has limited space onboard, and has to set up her DPS ashore in the vicinity of her survey area.

Performance

In S4, the initial software contained many faults, due partly to the very limited time available between the award of contract and the start of the surveying season of the Naval Parties. However with much perseverance on the side of both the naval personnel and Qubit, together with close monitoring of defects, the major problems were soon rectified, and S4 has developed into a reliable system which has been used by Naval Parties 1008 and 1016 for all their surveys since April 1988, and by *Gleaner* since August 1988. Whilst the processing speed of S4 has been adequate for the timely progressing of surveying data, NP 1008, which operates 24 hours a day, thirteen days out of fourteen for six to seven months each year, found that there was insufficient time available to produce the fair records of previous surveys as well as processing current survey data. To rectify this problem, a second DPS, including a second drum plotter, was supplied for the 1989 season.

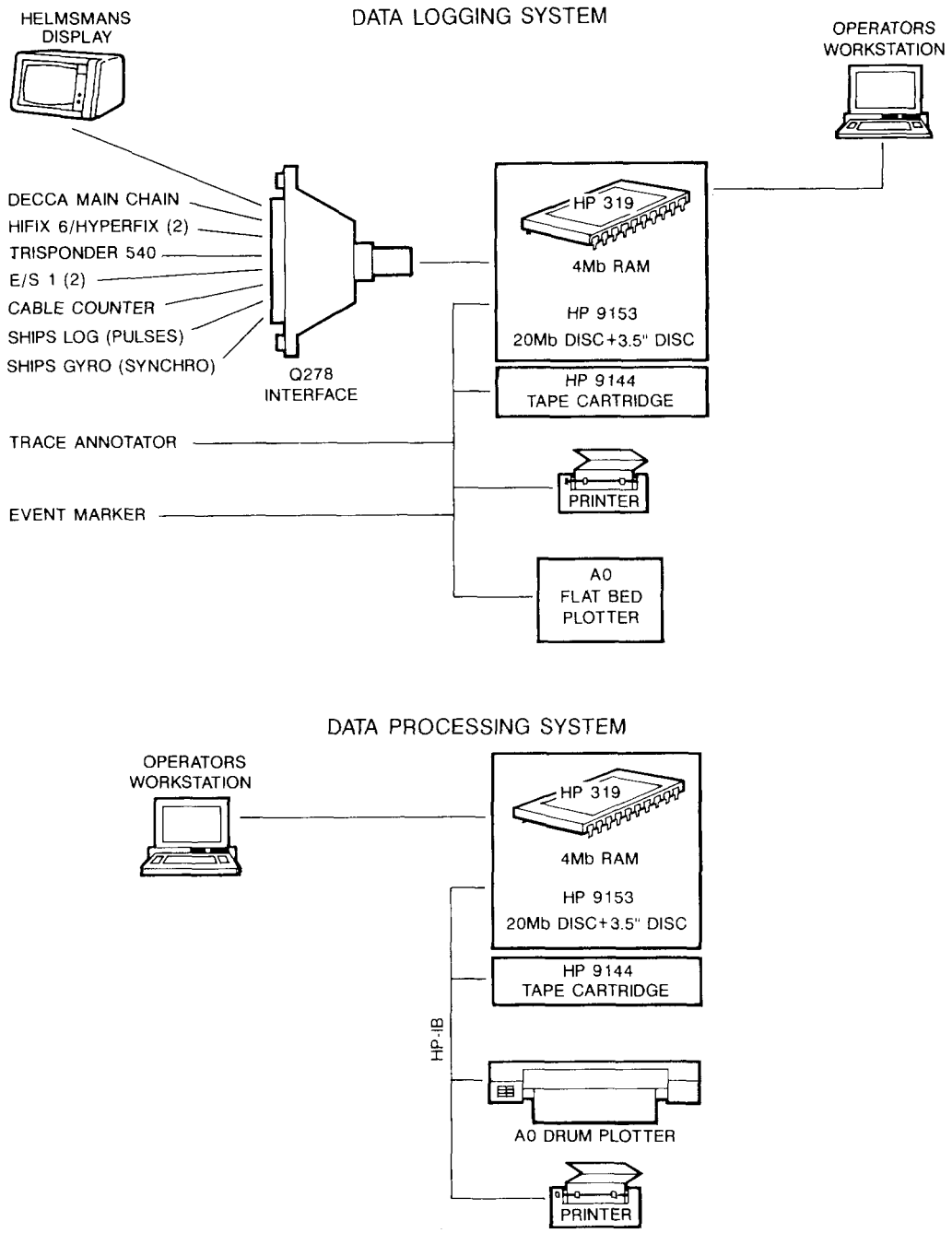

FIG. 3—THE S4 SYSTEM

During the winter of 1989/1990 S4 was upgraded by the installation of single user versions of SIPS 2 software, TRAC V and CHART V(S). This solved the problem of S4 software and data files not being compatible with those of SIPS 2, as had been the original intention. This new software also added extra facilities into S4, which was renamed SIPS-S, but at the start of the 1990 season in March it still contained several known defects which had to be worked around. However these were cleared in May by Qubit with version 2·0, and after some patient fault-finding by the users whilst busy surveying, version 2·02, issued in June 1990, resulted in a reliable system which was used for the remainder of the year. In early 1991 the software was updated to the latest versions, and some of the hard disc drives were upgraded to 40 megabytes to facilitate data processing of larger survey areas.

In order to assess the performance of SIPS 2 time elapsed meters have been fitted to all SIPS-H systems for use in conjunction with ARM log books, as was done with SIPS 1. However prolonged trials have not been used to test all the functions of the systems. Instead, sea trials have involved the use of each system to undertake a small survey, the successful completion of which resulted in the issue of a certificate of clearance for use.

The SIPS 2 software was initially tested on SIPS-T during the autumn of 1989, when all avenues through the system were explored by staff at the Hydrographic School who had used SIPS 1. Where problems were experienced or shortcomings found defect reports were raised on specially designed forms which include a severity grading. These forms are used by all SIPS-fitted units and are forwarded to the Hydrographic Office where they are collated and assessed prior to forwarding to Qubit. The whole process is monitored with the help of a control list where one line is devoted to each defect report, and the list is subdivided into a number of categories according to the action taken[4].

During the winter of 1989/1990 further experience was gained on both SIPS-T and SIPS-HD. Most of the earlier reported defects in the DPS CHART V software were corrected by July 1990, and the DLS TRAC V software had already developed into a reliable system through use in SIPS-S. However the number of defect reports increased rapidly as systems became operational and were used for surveying. In September it was decided that all high severity software defects and 90% of the remaining defects at that time had to be cleared before further progress could be made towards Fleet Weapon Acceptance of SIPS 2. A vital, but rather painful, software development and testing phase, through which with considerable perseverance the ships adhered to their survey programme, continued for the next six months. In March 1991 this stage was reached with issue of TRAC V software version 2·09c and CHART V software version 1·14. The progress of this software development is portrayed in FIG. 4.

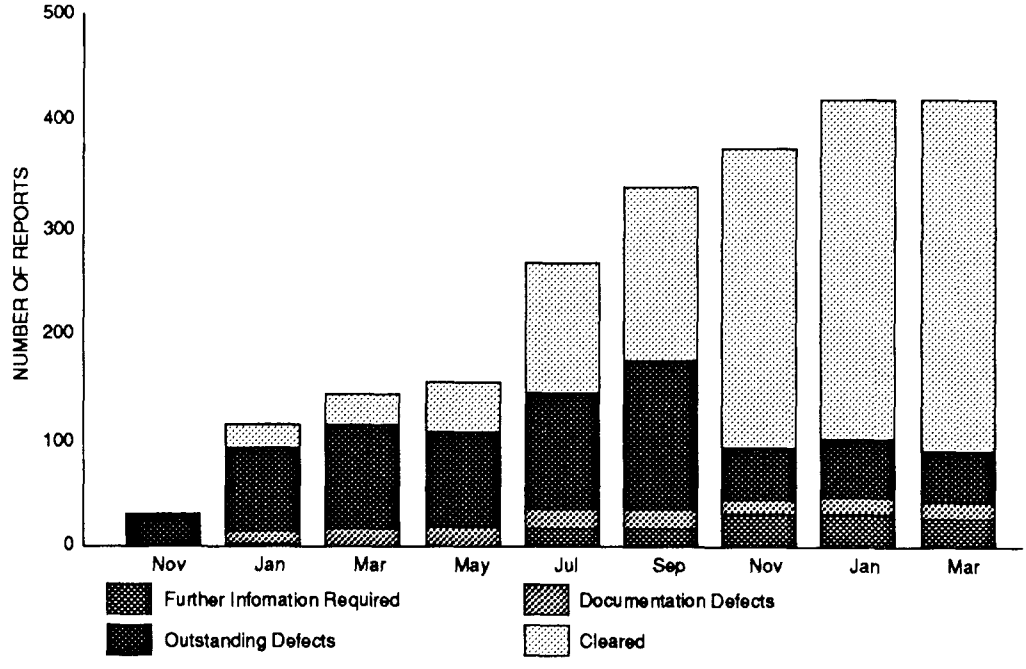

FIG. 4—SIPS 2 SOFTWARE, DEFECT REPORT HISTORY NOVEMBER 1989 TO MARCH 1991

Fleet acceptance trials of SIPS 2 used this version of software in June 1991, and the same versions of software have been used for six months in order to collect ARM data. A new issue of software is due shortly which should clear the majority of outstanding defects.

Other Systems

In 1989 three TRAC V systems were purchased for use in the 9-metre survey motor boats carried by the coastal survey vessels. The systems (designated SIPS-B) are similar to those being supplied to the Royal Australian Navy for use in their boats as part of the HYDLAPS project. Each has an A3 plotter to display the track, a liquid crystal helmsman's display to provide track guidance, and a touch sensitive plasma display which replaces the monitor and keyboard for overall control of the system. It is contained in a rugged transit case to permit easy shipment, and is presently provided with interfaces for Trisponder and echo sounder digitisation. The data is logged onto a fixed disc and can be transferred to 3·5 inch floppy discs for subsequent processing in SIPS-H.

A CHART V system was also purchased in 1989 for use by the Survey Analysis section at the Hydrographic Office. As well as the standard DPS software, this outfit also includes a volumetric package which permits the monitoring of dredging projects and the study of sediment transportation in sandwave areas. It takes its data either from a BBC microcomputer running a software package used by some Port Authorities or from standard SIPS 2 and S4 cartridge tapes.

Further TRAC V and CHART V systems, configured as S4 systems but without the tape cartridge drives, were purchased in 1990 for fitting in the ocean survey ships HMS *Hecla* and HMS *Herald* for use in their MCM support role where they need similar capabilities to the coastal survey vessels. These systems are also called SIPS-S.

Maintenance

All systems are supported by maintenance contracts with Qubit which cover both equipment repair and engineer support. Apart from the spares for SIPS 1 held on board HMS *Roebuck*, the reversionary mode of operation provides a short-term fallback position until an engineer is available. SIPS 2 is also supported by Naval Stores, with all items of equipment NATO codified. On board spares for SIPS-H are held at a 20% stock-out risk level, with some items already rack-mounted. Depot spares allow for a 5% stock-out risk, with a complete set held by Qubit for use as a reference system, for software development and emergency support. Limited reference systems have also been provided for SIPS 1 and S4 support and these are also held by Qubit.

Future Enhancements

The hardware of SIPS 1 in HMS *Roebuck* dates back to 1983, and has started to provide problems with support. It uses a different, real-time operating system, with different code and languages, and any new facilities, even those available on other SIPS systems, require dedicated software to be written. For example SIPS 1 cannot handle Latitude and Longitude as a positional input (as from a GPS receiver). However HMS *Fawn* payed off during the autumn of 1990, and the opportunity has been taken to remove her SIPS 2 hardware prior to her disposal, for subsequent installation in HMS *Roebuck*.

Better handling of GPS data and a hyperbolic navaid calibration program have been specified for development for SIPS 2 when Continuing Design Support funding is available. Also to be included are a host of minor items outside the original contract specifications which have been revealed among the software defect reports. Once proven these enhancements will be incorporated into SIPS-S software, as has happened with some extra facilities already developed for SIPS 2. The Hydrographic School has also requested two more workstations for SIPS-T.

Enhancements already under way for the SIPS-S systems of the Naval Parties are the replacement of the four year old HP319 processors with newer, far faster HP382 versions, running the latest TRAC V and CHART V(S) software. Rewritable optical disc drives are also being incorporated into their systems which will significantly reduce the time taken to transfer data from DLS to DPS and also provide far greater data storage capacity on the data processing side. These upgrades should speed up the processing of their surveys, and add to the reliability of these hard worked systems.

Other Developments

The CHART V(M) software used in the DPS side of SIPS 2 is written in the C language and it has already been adapted by Qubit to run under X-Windows on Intergraph workstations in Hong Kong, and on an Ethernet LAN and X-Windows in a new Venezuelan survey vessel recently built in Spain. Qubit is also investigating the incorporation of a contouring facility, and the ability to handle swathe data so that it can be checked against conventional echo sounder data and adjusted through the survey and crossline comparison routines.

Trials of the system's ability to produce reduced-scale plots for chart compilation are taking place on SIPS-HD. These have so far indicated that the system selects depths, the quality of which has yet to be fully assessed, at a fairly even horizontal density. Qubit is believed to be investigating the use of bottom roughness as a means of varying this density more to cartographic requirements.

Conclusions

SIPS 1 and SIPS-S have been successfully used for almost four years, producing accurate records within weeks of completion of surveys, thereby meeting Hydrographer's main requirements of the systems. SIPS 2 has been used to undertake programmed surveys since July 1990. The surveys have been processed all the way through to fair records and rendered to the Hydrographic Office.

The use of special software defect report forms and control lists has facilitated the rectification of shortcomings in the systems.

All the systems have been obtained from the same supplier, thereby providing benefits in compatibility and software development. The use of an experienced contractor has proved to be advantageous.

With the enhancements under consideration and investigation above, the systems are well placed to meet the requirements of the surveying flotilla during the next decade.

References

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