# THE STORAGE, UPDATING AND PRESENTATION OF NAVIGATIONAL INFORMATION

by I.M.J. CLARKE

Marine Systems Engineer, Easams Ltd., Camberley, Surrey, England

## INTRODUCTION

Navigation is an information processing exercise by virtue of the fact that the navigator in unfamiliar waters places great reliance on the information provided by his navigation sensors and instruments and also on the information contained in hydrographic publications.

Since published navigational information is constantly in need of alteration, addition and correction, it can prove very time-consuming to keep up to date a set of publications such as that carried by the average merchant ship. The problem has recently been aggravated by a number of factors, including the shortage of deck officers, the increased volume of traffic in our shipping lanes and the ever dwindling time a ship remains in port. Reports issued by the Chamber of Shipping [1] and the U.S. Oceanographic Office [2] indicate that the failure to correct charts promptly and to make good use of the information contained in publications has been a major contributory factor in many strandings.

The navigator is not alone with his problem of managing information. Data processing has become a significant factor in many organisations but little use has so far been made of data processing techniques at sea. In the following paper, the writer reviews the system by which information reaches the mariner, then sets out what is done to make best use of this information. The writer then considers the developments of information technology and tentatively suggests how these developments may be applied in the maritime field.

## INFORMATION PROCESSING IN THE HYDROGRAPHIC DEPARTMENT

The nature of the sea environment ensures that a country's seaboard is changing constantly. Once detected, these changes must be conveyed

to the mariner and, in the UK, this is done through the Hydrographic Department (Ministry of Defence). The Hydrographic Department was founded in 1795 to supply information to the Navy and has since considerably enlarged its field of operation and responsibility. In the intervening years, requirements placed on hydrographic information have become far more stringent and the consequences of poor information have become very severe. Consequently, the purpose and nature of hydrographic surveys have considerably changed.

In 1969, the then Hydrographer of the Navy [3] referred to the 'Hydrographic Explosion', where the incoming data had increased by about $7\frac{1}{2}\%$ p.a. over the preceding five years. He attributed this increase principally to modern technology, such as the echo sounder and Decca Hi-Fix, which enables more survey work to be carried out in less time than before, and in conditions where surveying would have previously been impractical. In addition, more nations are engaging in survey work and contributing to the growth of data.

Another factor contributing to the increase in hydrographic data is the dramatic increase in ships' draught. The Hydrographic Department changed their limiting depth for dangers to navigation from 20 to 32 m in 1962 [4]. At that time, there were about 4 ships over 70 000 tons, compared with over 930 at present. Of these, some 96 exceed 140 000 tons, with draughts in the region of 24 m [5]. This has necessitated more detailed surveys of very large areas, and resources are stretched to keep up with the number of major chart revisions required.

The Hydrographic Department acts as a central controller of information between its many sources and users and consists of the Professional, the Naval and the Administration and Supply Divisions. Professional Division consists of 10 chart branches, each responsible for maintaining part of the Admiralty series, and also eight Marine Science branches, each concerned with its own specialist field. Naval Division is responsible for survey planning and the structuring of 'Sailing Directions', 'Light Lists' and 'Notices to Mariners'. It also includes sections dealing with Wreck Information, Tidal Predictions, Radio Navigation Warnings and providing Meteorological and Oceanographic services. Finally, the Administration and Supply Division is responsible for the printing of charts and the distribution of all Hydrographic Department publications (NPs).

A nautical chart may contain information from many sources — for instance, one part may be taken from previous editions of charts covering the area, together with fresh information from more recent surveys and reports. Great care is taken to ensure that the data matches up and that the chart is continuous. All new hydrographic data, whether in the form of survey material, new foreign charts or ships' reports, are examined and the appropriate action is taken to correct the Admiralty charts and other publications by 'Notices to Mariners', new charts and new editions. In 1976, 112 new navigational charts, 82 lattice charts and 18 new miscellaneous charts were produced, together with similar numbers of new editions [6].

The Sailing Directions branch of Naval Division is responsible for the upkeep of the 79 volumes in the 'World' Series. In 1976, 20 revisers

produced 9 new editions and 49 supplements to the 'Directions'. In 1968, a committee was set up to review the contents of 'Sailing Directions' and made a number of recommendations which have recently been put into practice [7]. A major problem was that the improved "word picture" created by the professional surveyor made important route information difficult to pick out so, in recent publications, the route information is summarised separately from the bulk of the descriptive text. The Hydrographic Office has recently started to use computer-assisted publishing methods [6], and the potential data bank created in the process could help to solve many of the present problems concerning the updating and presentation of navigational information.

Other publications of interest to the navigator include 'Admiralty Notices to Mariners', 'Admiralty Lists of Lights and Fog Signals', 'Admiralty Lists of Radio Signals' (ALRS), climatological data and 'Admiralty Tide Tables'. The Hydrographic Department has thus greatly increased its scope from its initial function of supplying charts to Naval ships. Although much has been done to speed up and improve the flow of information to the chart, the very nature of hydrographic information tends to frustrate any smooth or automatic collecting of data. First, a danger to navigation must be detected, then its position fixed accurately, and even this much is impossible without expending much time, effort and money. Thus, data from numerous sources, of varied reliability, must be presented to a great many users whose requirements vary considerably. With the resources of the Department barely adequate to keep pace with the growth of data, it is not practical to think of them supplying each user with his individual needs under the present structure. The extraction of this specialised information must therefore come at a later stage in the information flow.

## INFORMATION PROCESSING ON
## MERCHANT SHIPS

The process of navigating a ship from one port to the next can be categorised as follows:

a)  Watchkeeping: the dynamic part of navigation where the information received may require immediate action.

b)  Voyage Planning: considering the information presented in charts and publications and deciding on action in the longer term.

c)  Maintenance of Charts and Publications: sorting the information received and presenting it in a usable form to the voyage planner and the watchkeeper.

The ultimate goal of the information system is to provide the watchkeeper with his requirements in a form which can be quickly and easily interpreted and acted upon. Analysis of these processes is thus needed to pinpoint constraints of the system. Fig. 1 depicts this flow of information to the watchkeeper.
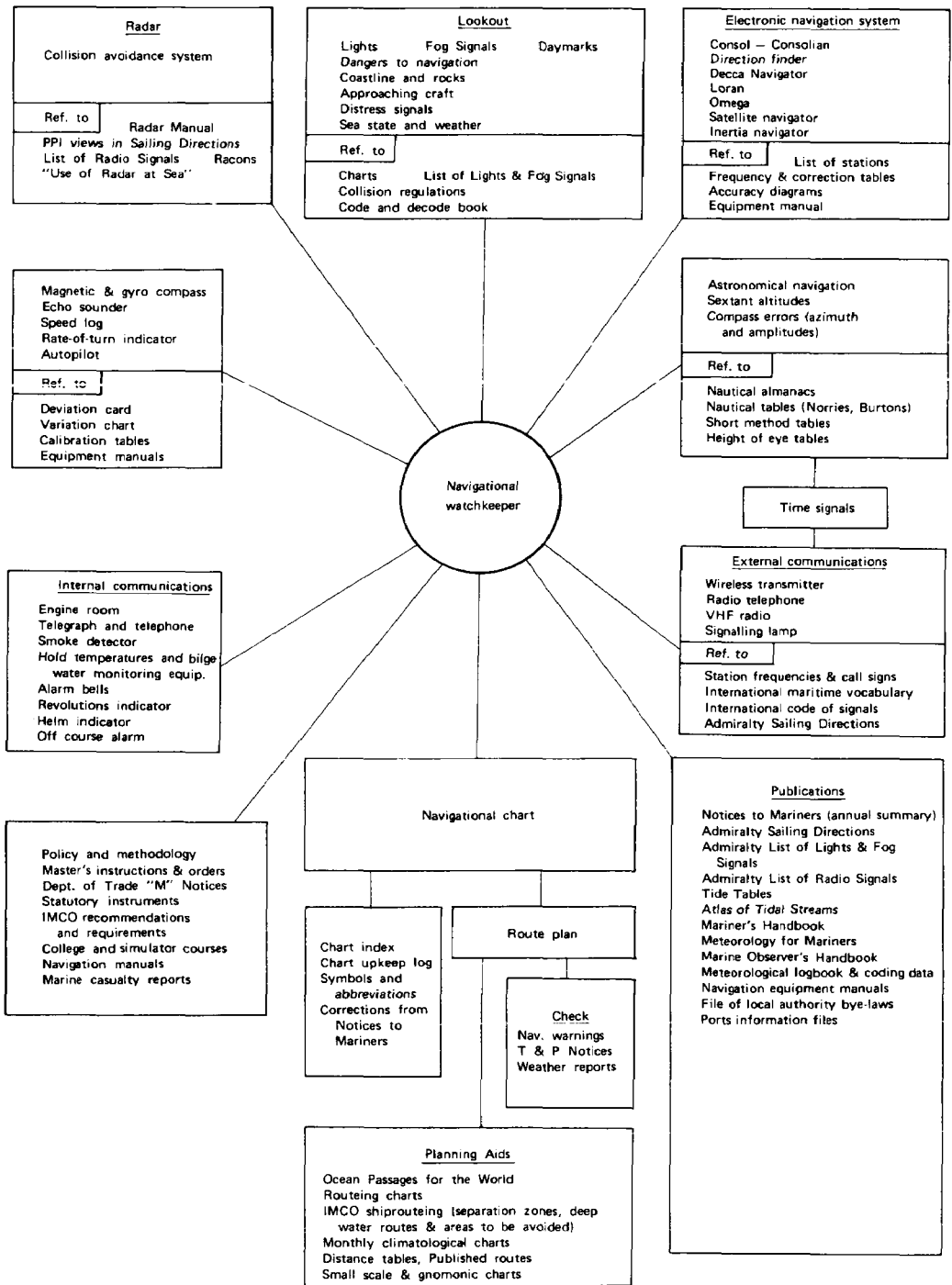
**Radar**

Collision avoidance system

Ref. to
Radar Manual
PPI views in Sailing Directions
List of Radio Signals Racons
"Use of Radar at Sea"

**Lookout**

Lights  Fog Signals  Daymarks
Dangers to navigation
Coastline and rocks
Approaching craft
Distress signals
Sea state and weather

Ref. to

Charts  List of Lights & Fog Signals
Collision regulations
Code and decode book

**Electronic navigation system**

Consol — Consolian
Direction finder
Decca Navigator
Loran
Omega
Satellite navigator
Inertia navigator

Ref. to  List of stations
Frequency & correction tables
Accuracy diagrams
Equipment manual

Magnetic & gyro compass
Echo sounder
Speed log
Rate-of-turn indicator
Autopilot

Ref. to

Deviation card
Variation chart
Calibration tables
Equipment manuals

Astronomical navigation
Sextant altitudes
Compass errors (azimuth
and amplitudes)

Ref. to

Nautical almanacs
Nautical tables (Norries, Burtons)
Short method tables
Height of eye tables

Navigational
watchkeeper

Time signals

**Internal communications**

Engine room
Telegraph and telephone
Smoke detector
Hold temperatures and bilge
water monitoring equip.
Alarm bells
Revolutions indicator
Helm indicator
Off course alarm

**External communications**

Wireless transmitter
Radio telephone
VHF radio
Signalling lamp

Ref. to

Station frequencies & call signs
International maritime vocabulary
International code of signals
Admiralty Sailing Directions

Policy and methodology
Master's instructions & orders
Dept. of Trade "M" Notices
Statutory instruments
IMCO recommendations
and requirements
College and simulator courses
Navigation manuals
Marine casualty reports

Navigational chart

Chart index
Chart upkeep log
Symbols and
abbreviations
Corrections from
Notices to
Mariners

Route plan

Check

Nav. warnings
T & P Notices
Weather reports

**Publications**

Notices to Mariners (annual summary)
Admiralty Sailing Directions
Admiralty List of Lights & Fog
Signals
Admiralty List of Radio Signals
Tide Tables
Atlas of Tidal Streams
Mariner's Handbook
Meteorology for Mariners
Marine Observer's Handbook
Meteorological logbook & coding data
Navigation equipment manuals
File of local authority bye-laws
Ports information files

**Planning Aids**

Ocean Passages for the World
Routeing charts
IMCO shiprouteing (separation zones, deep
water routes & areas to be avoided)
Monthly climatological charts
Distance tables, Published routes
Small scale & gnomonic charts

FIG. 1. — Flow of information to the watchkeeper.

**Watchkeeping**

The amount of information the watchkeeper deals with varies considerably with the stage of the voyage. During the oceanic stages, there is normally little incoming data and plenty of time to process it. The coastal waters situation proves quite different, however, and the load of incoming data from radar, lookout and other navigational sensors may occupy the navigator's full attention, leaving little time for looking up and interpreting the information contained in various publications. Here, pre-planning and the extraction of required information beforehand are essential.

Making optimum use of all this information calls for considerable skill and familiarity with what is available. For example, on a ship making a landfall and then proceeding along the coast towards a harbour, information from several books will be required in a short space of time. Thus, if fixing by DF, Vol. 2 of 'Radio Signals' will be required, light characteristics should be checked with the 'Light Lists', relevant Sailing Directions should be scanned for cautions and general approach advice while they remain also the prime authority for buoyage systems. If using Decca, reference will be made to the accuracy diagrams presented in the manual and to the tables of fixed and variable errors. When in radio contact with the pilot and immigration officials, Vol. 6 'Radio Signals' will be referred to. Meanwhile, tide tables, the atlas of tidal streams, routeing charts and various other books may be consulted.

The above information must be found and utilised while still maintaining a safe navigational watch, and avoiding traffic and adjusting the ship's course, and possibly in reduced visibility. However, much can be anticipated at the planning stage and the watchkeeper's job will be considerably lightened if the correct volumes are at hand and marked or made reference to on the chart. It can alternatively be made more difficult, or even impossible, if the charts and publications are out of date or uncorrected. It follows that good planning and careful correction are the keys to the safe and speedy execution of the voyage.

**Voyage planning**

Subject to certain restrictions in charter parties, Articles of the crew, company rules and government regulations, the Master has final authority in selecting the route. The job is usually left to the second mate and checked by the Master which, besides allowing the junior officer to play a responsible role in the running of the ship, allows the work to be monitored. Thoroughness is important at this stage, and insufficient planning has been stated as a prime cause of many accidents.

In planning the passage, the navigator must call on the experience of his early watchkeeping days, together with the rather 'general' advice given in the navigational manuals. Publications which may help him include the 'Distance Tables', 'Ocean Passages for the World', 'Sailing Directions'

and current and climatological charts. The route planner has to consider a number of factors associated with safety and the economic success of the voyage. The various stages of the voyage require different considerations and methods of presentation. In pilotage waters, the appropriate river and harbour plans should be presented together with any relevant information from local 'Notices' or bye-laws. The initial course should take account of incoming traffic and small craft while allowing the watchkeeper sufficient time to check compasses and ensure that the ship is secure for the passage.

While still in shoal waters, attention must be paid to charted depths and heights of tides. Weather conditions must be borne in mind and alternative fixing methods and alternative routes evaluated at an early stage. The route should comply with the IMCO Traffic Separation Zones, and account must be taken of fix accuracy and tidal streams which may add to the ship's positional uncertainty.

When selecting the ocean route, an attempt should be made to minimise the time on passage. Considerations include the choice of Rhumb Line or Great Circle sailing, ocean currents, winds, swell and the possibility of fog. Studies at Liverpool Polytechnic indicated that, on Atlantic passages, optimising for currents can make from 0.1 to 2% difference in passage time, while wind and swell considerations made around 5 % difference. Other factors which must be considered include position fixing system accuracies, the possibility of encountering fishing fleets, and that the freeboard complies with the Seasonal Zones as per the 1968 Load Line Rules [8].

Comparing the current Department of Trade (UK) syllabus for the examination of Masters and Mates with the syllabus for the Flight Navigator's Licence [9], it is apparent that the airman's training places a greater emphasis on flight planning than the seaman's training places on voyage planning. Relevant topics include the Preparation of Flight Plans, Choice of Routes, Flight Progress Charts and 'Modifications of Flight Plan Necessitated by Conditions Experienced in Flight'. The air navigator is also furnished with a wider field of literature on the subject than the mariner and, while being subject to more rigid control, has comprehensive back-up facilities in the form of pre-planned routes and flight folders containing complete information over the selected route.

**Maintenance of charts and publications**

The number of charts and publications carried on board a merchant ship depends on the class of ship, the extent of her trading limits and the management policy of the company. For instance, a medium-sized foreign-going ship may carry around 1 000 charts and 120 books. Most of these publications contain information liable to be changed, updated or deleted with time.

New information is received in the form of 'Notices to Mariners', radio messages, 'Pilot Supplements' and, occasionally, letters from agents or port

authorities. Various systems are used for processing this information depending on the number of publications being maintained, the length of the voyage, the frequency of receiving information, the folio system used and the personal preference and experience of the officer. The structure of 'Notices' has changed little over the years, which is advantageous in that familiarity with the layout speeds up the job of locating relevant information.

Various arrangements have been developed by ship managers, chart agencies and officers to rationalise the correcting procedure. Revised folio systems have emerged whereby the charts covering the ships' trading limits can be located more efficiently, while indexes of consecutive and chart numbers against folio number allow a chart to be identified with a single entry. Chart log books enable the navigator to apply all the corrections to any chart at a single session and are useful on long voyages where 'Notices' may be received at infrequent intervals, or where information must be taken from foreign sources.

Whichever system is used, the extraction of information and the correction of appropriate charts or books remains a repetitive and time-consuming task. This alone sheds doubt on the reliability of the final product. When other factors such as ship motion, vibration and adverse climatic conditions, which tend to frustrate the smooth flow of information from Notice to chart are taken into account, it follows that any reasonable techniques which could improve on the present system should be considered in the interests of safety.

## INFORMATION SYSTEMS IN GENERAL

In recent years, a new discipline has developed in an attempt to handle the vast stores of information contained in libraries, archives and filing cabinets. S. ARTANDI [10] defines Information Science as the 'Group of techniques necessary for the ordered presentation, organisation and communication of recorded (specialised) knowledge in order to give maximum accessibility and utility to the information contained'. The basis of the study is that information is regarded as a 'resource' rather than some intangible entity conjured up by intellectuals and prophets. Like any other resource, its exploitation depends on the ability to isolate it from its environment and present it, in a usable form, to the consumer.

The changes which have made this concept a practical proposition are developments in computer science, discoveries in other disciplines, and the emergence of quantitative measures for evaluating retrieval performance. Computers are becoming more reliable and available to the average organisation while the trend towards miniaturisation means less bulky equipment at relatively lower cost. The interdisciplinary nature of information science facilitates the adoption of the latest developments in a variety of fields: for instance, advances in linguistic research have assisted developments in automatic translation. However, quantitative measures

for evaluating retrieval performance still present problems : for example, in considering the Recall and Precision Ratios where :

$$\text{Recall Ratio} = \frac{\text{Number of Relevant Documents Retrieved}}{\text{Number of Relevant Documents in the System}}$$

$$\text{Precision Ratio} = \frac{\text{Number of Relevant Documents Retrieved}}{\text{Total Number of Documents Retrieved}}$$

When dealing with a large system, the total number of relevant documents will not be known and, in most systems, there is a trade-off between the two ratios. The imprecise knowledge of the quantitative measures can be a great drawback when choosing a system, and more easily quantified criteria such as cost, speed, response time, coverage and physical characteristics are resorted to.

There are a variety of systems available for information retrieval ranging from the completely manual, such as edge-notched cards, and semi-automated, many of which make use of optical coincidence techniques, to the completely automatic information retrieval system based on the digital computer. The main task of each system is to speed up the location of information, and the efficiency with which this is accomplished depends largely on the user. Studies indicate that most users are not 'information-conscious' and often prefer to find out for themselves rather than make better use of available data. It is therefore necessary to aim for a system that the user can put his faith in, which indicates that it should be reliable and not too complicated.

Both the manual and semi-automatic systems have their limitations regarding flexibility and rely heavily on the user, especially at the input and update stages. Computer systems overcome many of these disadvantages, and the ultimate dream of many computer scientists is to put the vast collections of data stored in the archives and research establishments of the world at the fingertips of users everywhere. This dream has so far been frustrated, not so much by technology as in our lack of understanding of the way in which the human mind works in making associations and value judgments. There is, however, great scope for providing a trained user, whose requirements can be anticipated, with speedy access to limited and carefully defined stores of data. Information required by the navigator could be made to fall into this category.

All computer systems use the following basic pattern. A source of data is presented at the input terminal and converted to a machine-readable form. The data is stored in the memory, processed or updated according to the control program, and presented to the user at the output terminal. To access the data in store, there must be some means of identifying what is required, then the information must be analysed and marked for retrieval. The simplest method is the 'single access index' where one word or concept is searched for at a time, as in a book. A more comprehensive system is co-ordinate indexing where information is entered under all relevant headings, making use of the computer's ability to handle many dimensions. This requires a structured look-up vocabulary which can prove time-consuming and expensive at the input stage.

This has led in turn to the development of automatic indexing methods, the earliest in general use being the KWICK Index (Key Word in Context) where a block of data was filed under each word it contained with the exception of non-informative words such as 'and', 'but', 'almost' etc. More sophisticated methods use a statistical approach where the most repeated words in the text form the keys to the index. The resulting gain in precision ratio may, however, be accompanied by a fall in the recall ratio.

A promising approach in computer retrieval-systems is the development of a small manipulatable model which, in construction, resembles the body of information under consideration. For navigational information, a workable model could be initiated by looking at a restricted zone and classifying all the data necessary for a safe passage to be made across it, and then manipulating this data into a presentable form to satisfy a number of forseeable situations. The full-scale counterpart can be developed by feeding in the raw data from all areas being considered.

An effective information system cannot exist without a complementary communications system. Traditional communications links have become overcrowded, and satellite links such as Skynet and Marisat have been developed which enable high-quality data transmission anywhere in the world. Other improvements include Error Detection and Correction equipment, the use of time diversity to increase the probability of avoiding bursts of interference, and message switching computers which enhance the likelihood of the message getting through. Such equipment allows techniques for receiving an acceptable quality of data for computer use or reproduction on a page printer on board ship. Further developments along these lines could revolutionise the handling of navigational information.

## RECENT MODIFICATIONS AND DEVELOPMENTS

Although the Hydrographic Department has brought about many improvements in the presentation of information, there still remains much work to be done by the navigator in order to keep the publications up to date. Many shipping companies make use of the chart correcting services offered by most of the major British chart agencies, though this service is only of value to ships calling regularly to a port where the facilities exist. These agencies have used BNITA (*) tracings for the past 40 years and it has been estimated that correction using tracings is up to 85 % faster and possibly more accurate than corrections straight from the text of a Notice. In the past few years, the tracings have become available through chart agents for use on ships.

Further afield, the American company Lykes Bros. of New Orleans have operated their 'Chart Folder Correction System' since 1967 [11]. In this system, a Central Office on shore carries out the 'book keeping' associated with chart correcting for their entire fleet. The object of the system

(*) British Nautical Instrument Trade Association.

is to make the navigator of each ship aware of all relevant chart corrections for an impending voyage, together with the issue of new charts and new editions and also any changes or additions to other related nautical publications. The relevant information is supplied in 'Working Folders' to each ship thus relieving the navigating officer from the task of sorting through hundreds of Notices.

Each folder relates to a group of charts pre-selected to cover a standard route and contains :

a)   A Numerical, Geographical and Alphabetic Index of Corrections.
b)   A Summary by Notice to Mariners' numbers.
c)   All corrections from a selected date in chronological order for each chart.

The navigator is thus supplied with all the corrections for the charts relevant to his route (and only for those charts) and, after correcting each chart, can mark off the appropriate page in the folder which now becomes a permanent record of the chart's completeness. It has been estimated that this system can halve the time required to keep a set of charts up to date. By eliminating much duplication of work, together with other associated advantages, the system appears successful and may be worthy of consideration by other shipowners.

Over the past few years, much has been done to improve the presentation of information derived from electronic sensors. One example of this is the Decca Marine Automatic Plotter which presents the Decca output in a form which enables almost instantaneous interpretation. Another development of interest within the context of this paper is the facility included in Sperry's NAVMARK to present selected chart data on the radar PPI. Besides facilitating the identification of radar-visible objects, this enables 'non-visible' marks such as routeing zones and danger clearing lines to be displayed. The information is digitised and stored on tape to be accessed by the computer as required, in accordance with a continuously updated estimated position.

Other dynamic map techniques such as those used in aircraft are either too expensive or degrade the data too much to be applicable on merchant ships. Part of this lack of success may be attributed to the requirement for co-operation amongst the various parties involved in the information flow, and it may be useful at this stage to disregard such exogenous difficulties and outline what would be required of a completely automatic Navigational Information System.


## A COMPUTERISED NAVIGATIONAL INFORMATION SYSTEM


With present-day requirements for speed and accuracy, and considering the growing demand for automation on merchant ships, a completely automatic computer-based information system may prove to be the only viable long-term proposition. There are basically two broad concepts of how the system may be applied in the shipping industry, the first being

built around a central computer on shore and the second using a computer on board ship.

A shore-based system would enable highly sophisticated equipment to be used and operated by skilled computer staff but would be remote from the user and place a great reliance on the shore-operator. A shipboard system would give priority to the vessel's most immediate problems and allow closer involvement with ship's staff but would call for robust and expensive equipment with a necessity for high-level or interactive operation.

A combination of the two systems would not only resolve these problems but would also enable greater use to be made of the service. Three levels of shipboard requirements could result : ships with on-board computers could be supplied with data files, ships with teletype terminals could interrogate the central computer, and ships with no such equipment could be given correction sheets tailored for the voyage and also watch-keeping and voyage planning data sheets.

The ideal system would process data from all the defined sources and present it to the navigator both automatically and on request. It remains to consider each of the three stages of the navigation process in order to determine how much can be automated, and whether this would be an improvement.

### Data updating

At present, the major part of this task involves correcting charts, and more than half of this correcting time is spent in looking up and documenting corrections. On a particular route, only a small proportion of the total information contained in the Notice is of any value to the navigator. The process of presenting the relevant corrections in a convenient order lends itself quite readily to automation, provided that the areas to be covered are adequately described.

The automatic correction of charts, while being technologically possible, would require very complex equipment which would, at present, be too costly for the benefits attainable. The requirement for constant atmospheric conditions, and the wear and tear a normal chart receives during its working life, tend to make the concept impractical.

### Computer-aided voyage planning

The factors to be taken into account when planning a voyage are too subjective to allow consideration of completely automatic planning at this stage. However, the machine retrieval of the information to be considered and the computer optimisation of alternatives fed in by the navigator may be of great value in making voyages safer and more efficient. The type of information which the computer could supply would include identification of the charts required, the availability and suitability of Nav-Aids, distances and ETAs, relevant Navigation Warnings and Cautions

together with such details as the areas to be traversed in darkness, the likely set and the probable effects of winds and swell.

One of the advantages to be gained from computer-aided voyage planning would be the evolution and standardisation of an efficient approach. Familiarity of all officers, and not only those involved in developing the plan, would lead to a better understanding of what was required of them. The evaluation of back-up aids and alternative plans would become routine practice rather than an added chore to be undertaken only when time permitted and would mean less likelihood of the wrong emergency action being taken.

Computer-aided voyage planning would not relieve the navigator from his duties of observing and anticipating dangers, but would make more certain that the obvious is noticed and that important information is not overlooked. Unforseeable situations can still arise, and it is in the handling of such cases that the skill of a competent navigator is called for.

**Watchkeeping data sheets**

As stated earlier, the purpose of data updating and voyage planning is to provide the watchkeeper with the necessary information on which to base his judgement when he comes to execute the voyage plan. The information on the chart can be best supplemented by the provision of a single 'watchkeeping data sheet' covering all information he would normally obtain by reference to other publications. The content of the sheet would vary according to circumstances and the type of voyage, and it would be necessary to compile lists of terms which must be 'searched for', based on what the navigator considers important, and supplemented from sources such as the General Council of British Shipping 'Marine Casualty Reports' [1].

The provision of such specific information on a data sheet would be more effective than storing it in a book of 'M' Notices (*) or within a detailed description of a coastline in the 'Sailing Directions'. The improved safety aspect of this alone would make it worthwhile considering.

The changeover to computer publishing by the Hydrographic Office means that all navigational information must be stored in a machine-readable form. The access of such data would greatly facilitate the initiation of a completely automatic computer-based information system. Fig. 2 illustrates the process which may be necessary to extract the required information.

The principal characteristics of the system are the maximisation of throughput, with 'rejection routines' to eliminate blocks of irrelevant data. A large secondary memory is required, probably in the form of disk storage. Software requirements are for automatic indexing, file creation and searching on a numerical and 'index term' basis. The calculation of bearings and distances is also essential in order to define the relative positions of the ship and the dangers.
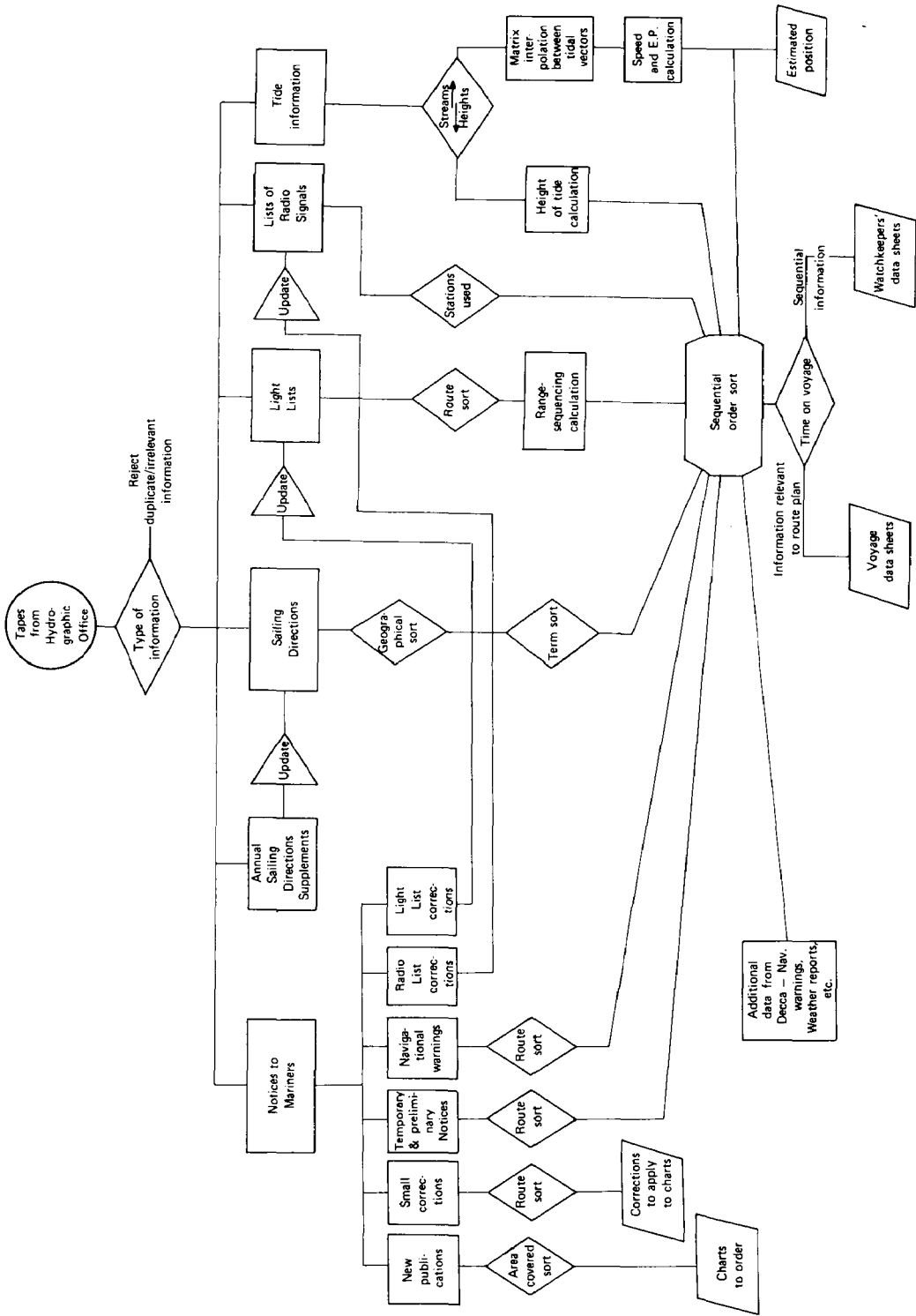
(*) Merchant Shipping Notices (UK).

Fig. 2. — Elements of an automatic navigational information system.

The technology for implementing the system exists. The equipment necessary for the various processes, although expensive, can be obtained, while software methods used elsewhere can be adapted for our purposes. What may be lacking at present is a complete understanding of the navigator's requirements. This includes a thorough knowledge of shipping routes and the relative importance of various environmental conditions, together with a comprehension of the way in which the navigator makes associations and value judgments regarding the information with which he is presented.

## CONCLUSIONS

This paper investigates methods of presenting the navigator with information in order to determine how maximum utility can be achieved. The information he requires suffers a lack of utility from being presented amongst other data and, under present-day conditions, insufficient time is available to make optimum use of it.

The main points which arise from the preceding sections are :

a)   The Hydrographic Department is continually making an effort to present the navigator with clear and readily accessed information. The necessity to process an ever-growing quantity of data with limited resources is their main drawback, and with current rates of information growth it is likely that the system could break down in the future.

b)   The extraction and use of information in the various stages of navigation is not sufficiently covered in nautical literature or in the professional examinations. Expertise in this area is left to chance.

c)   Methods of presenting and extracting navigational information have changed little over the years, little use having been made of advances in information technology.

d)   Considering the application of information technology, manual and semi-automatic systems do not appear compatible with marine requirements. Computer techniques appear more suitable but further research of the navigator-information relationship will be necessary for their application.

e)   The development of such a system would resolve basic storage and retrieval problems. The professional staff necessary for its implementation could help fill the void in nautical literature on the subject, together with being accessible to the navigator to assist him with information-related problems.

Technically, the work necessary for sorting and retrieving information is done most efficiently by the computer. From the social point of view, however, it can be argued that an automatic system would take away much of the navigator's job satisfaction. My own point of view is that it would be beneficial in eliminating much of the routine side of the job and

encouraging greater attention to forward planning and the evaluation of alternative routes.

The development of an automatic Navigational Information System would involve a considerable financial outlay. At first, this may appear to be an expensive solution, while the benefits in the way of safer and more economical passages may appear to be marginal. On the other hand, merchant ships are becoming progressively more capital-intensive, and technology is supplying the means of making more effective use of resources. The storage, updating and presentation of navigational information is an aspect which should not be overtaken by other advances in ship operation. The expertise and abilities necessary for such development are available and, once set up, the system could prove to be a marketable commodity stimulating a worldwide demand.

## ACKNOWLEDGEMENTS

## REFERENCES

[1] Chamber of Shipping Marine Casualty Report Scheme; analysis No. 2. Sept. 1972. (Now the General Council of British Shipping, London).

[2] FRICKER, F.W. and Anon. : *Groundings.* Printed on reverse side of U.S. Pilot charts, Nov. 1971 and Dec. 1973. USN Oceanographic Office, Washington.

[3] RITCHIE, G.S. : The Admiralty Chart. *J. Navig.,* 22 (4), Oct. 1969, p. 420. Royal Institute of Navigation, London.

[4] Report of the Hydrographic Study Group 1974-1975, Appendix 4. Ministry of Defence, London, March 1975.

[5] *Lloyd's Statistical Tables,* 1976. Lloyd's Register of Shipping, London, Nov. 1976.

[6] *Report by the Hydrographer of the Navy, 1976.* Taunton, April 1977.

[7] MOITORET, V.A. : U.K. Hydrographic Office conducts searching review of Sailing Directions. *Int. Hydrog. Review,* XLVII (1), Jan. 1970, pp. 143-153. Monaco.

[8] Statutory Instrument (1968) No. 1053 — The Merchant Shipping (Load Line) Rules (1968). HMSO, London.

[9] The Flight Navigator's Licence. Ministry of Civil Aviation, 1971, HMSO.

[10] ARTANDI, S. : *An introduction to computers in information science.* Scarecrow Press Inc., Metuchen, NJ, U.S.A., 1972.

[11] SAWYER, E.P. : A practical approach to modern-day chart maintenance. *Navigation*, 16 (2), Summer 1969, pp. 129-132. Institute of Navigation, Washington.

## BIBLIOGRAPHY AND FURTHER REFERENCES

DAY, Sir Archibald (1967) : *The Admiralty Hydrographic Service (1795-1919)*, HMSO.

MAY, W.E. (1973) : *A history of marine navigation*, Hopkins.

*The Mariner's Handbook*, The Hydrographer of the Navy (4th edition), Taunton, 1973.

CHRISS, M. & G. HAYES (1964) : *An introduction to charts and their use* (3rd edition). Brown, Son & Ferguson.

FRANKLIN, B.E. & E.B. BROWN (Spring 1972) : Navigational planning and the use of special techniques, *Navigation*, 19 (1), pp. 1-6, Washington.

WORTHINGTON, G.D.P. (1962) : *Flight planning*, Pitman.

BENNETT, D.C.T. (1967) : *The complete air navigator*, Pitman.

DOUDRICKOFF, B. (1973) : *Information retrieval*, Anarbach.

LUCAS, H.C. Jr. (1973) : Computer based information systems in organisations, Science Research Associates Inc.

BAYNHAM, B.H.G.M. (Capt.) (Oct. 1974) : What the shipowner needs, *Journal of the British Interplanetary Society*, Vol. 27.

PHILLIPS, H. & A. WHITWELL (1969) : Computers in the shipping industry, International Maritime Shipping Conference, London, Section 7, p. 30.

GREY, M. (5th Aug. 1976) : A "simple" approach to sophisticated radar equipment, *Fairplay International Shipping Weekly*.