

THE DEFENSE MAPPING AGENCY'S NAVIGATION INFORMATION NETWORK

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Abstract

More than a decade ago, the Defense Mapping Agency made a commitment to improve the means of processing, managing, and producing navigation safety publications and information using automation to the fullest extent possible. As the present Automated Notice to Mariners System (ANMS) developed and matured, it became apparent that the future of dissemination of these data lay in telecommunications, thus the creation of the Navigation Information Network (NAVINFONET). This paper will review the history, design, and use of the ANMS and then discuss the present and future utility of the NAVINFONET. As the age of the Electronic Chart Display and Information System (ECDIS) approaches reality, the potential of the NAVINFONET as the only functional existing system to support corrections to ECDIS at sea may well prove its greatest value. In the interim, its worth is proven daily by the myriad of users who seek up-to-date marine safety information to correct their charts and publications far in advance of receipt of the printed word through the mails.

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The Defense Mapping Agency began the design of the Automated Notice to Mariners System (ANMS) in 1975. The intent of this project was to maximize the use of automation to improve the composition, management and distribution of several products which promote navigational safety, primarily the weekly Notice

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to Mariners. In view of the ambitious scope of this project, and keeping in mind the blinding pace at which ADP systems were reaching the market in the last decade, a phased development approach was selected. This allowed DMA to add the latest off-the-shelf hardware and certain pieces of commercial software to the ANMS as the system matured. The initial design concept of this development was to allow communications access to the extensive files to be developed — not in the traditional meaning of a data base but actually as data files. The success of this phased development approach has already been proven even though its full potential has yet to be achieved. Interestingly enough, the communications portion of the system design has been so popular with the user community and so beneficial to the Defense Mapping Agency and the U.S. Coast Guard, among others, that this portion of the workload has now been given its own computer and its own name — the Navigation Information Network or NAVINFONET (see Fig. 1).

The weekly Notice to Mariners is a joint publication of the Defense Mapping Agency (DMA), the National Ocean Service (NOS) and the U.S. Coast Guard (USCG). Its use is intended primarily for the offshore mariner; that is, U.S.

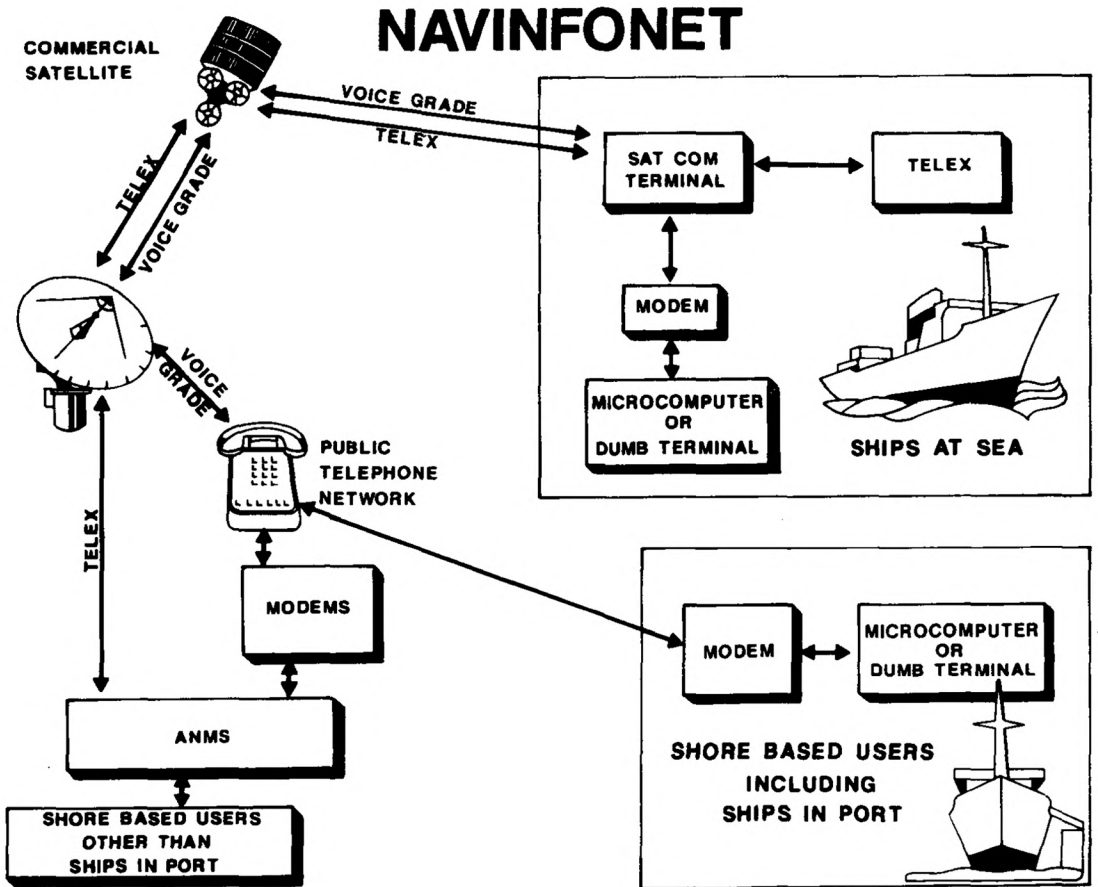


FIG. 1.

Navy units operating worldwide, commercial U.S. vessels operating in international trade or coastal trades and, lastly, the offshore sailor who goes beyond the limits of the USCG local Notice to Mariners. It is a time-dated publication essential to the preservation of the integrity of the nautical products which are necessary for the safety of all shipping, large or small. It is critical to all concerned that the information contained in the Notice be accurate, current and distributed in a timely manner.

When viewed as a battle against time, three separate aspects of the Notice to Mariners process were defined, namely compilation, composition and distribution. Within the compilation phase of a weekly Notice, the first target was chart corrections as the Notice is the legally designated vehicle to correct any or all of the approximately 5,000 charts produced by NOS and DMA. The first thing that had to be done was to break away from the former loosely defined format of a chart correction and create specific guidelines to simplify and standardize information presentation. Suffice it to say that DMA consciously flew in the face of international tradition in designing this new computer compatible format which:

1. Corrects each chart individually;
2. Tracks edition number, date, correction authority and previous correction;
3. Uses a three column format for text that tells action (in five verbs — ADD, DELETE, SUBSTITUTE, RELOCATE, CHANGE), subject (specific standards, minimum of words), position (level of accuracy tailored to specific scale and required action).

By changing to columns, reducing to only the minimum text necessary and custom designing coordinate presentations, data entry for a computer based system became simpler, compiling (and training compilers) became faster and easier, and accounting for various horizontal datums in a common area ceased to be a problem.

Use of the new guidelines, established as the system design proceeded, has allowed the Marine Information Specialist (MIS) compiling a notice to move through his tasks more easily and more accurately than in the past. Data entry to the weekly work file is facilitated by the use of intelligent graphics terminals which will soon be available on each desk. The quality and integrity of chart corrections and, in fact, all sections of the Notice have been maintained throughout the development process.

Automation was used to expedite the compilation of the catalog correction portion of Section I of the weekly Notice to Mariners as well. The DMA indexes its hydrographic products in ten volumes of catalogs. These dynamic publications are corrected weekly. Naturally, if mariners are expected to have the latest available chart on board, there must be a rapid means of notifying them when a chart is ready for purchase. A side benefit of this development was a file of chart titles, scales, coordinates and other attributes for future use. For now, suffice it to say that this change has trimmed compilation time for catalog corrections in half.

Computer assisted compilation of the List of Lights (produced by DMA) and Light Lists (produced by U.S. Coast Guard) has resulted in a measurable decrease in compilation time and a corresponding improvement in product accu-

racy and dependability. In this case, automation was a necessity as well as a desirable improvement because the former method used by DMA and USCG was using totally archaic equipment and technology. Adding the List of Lights and Light Lists to the ANMS provides far more up-to-date information than ever before, due to simplified data entry and storage procedures. The compilation data files for all seven volumes of the DMA List of Lights and six of the seven USCG Light Lists are now mature and strictly maintained on a weekly basis. These latter volumes, although produced by the U.S. Coast Guard, are maintained through the weekly *Notice to Mariners* and compiled and produced using the computerized work files of the ANMS. Unique to these operations is the fact that all the USCG light files (weekly, summary, and annual) are accessed and processed remotely by Coast Guard personnel, thus eliminating their need to be on site at DMA.

Corrective information for certain radio aids to navigation is now compiled on the ANMS either as part of the appropriate List of Lights or as part of Pub. 117, Radio Navigational Aids. Further automated compilation of this latter volume is planned for the near future.

The next compilation task to be addressed as part of ANMS was the Broadcast Warnings portion of the weekly Notice. These warnings are the texts of messages issued by DMA as part of its duties under the Worldwide Navigational Warning Service and include NAVAREA IV and NAVAREA XII warnings; HYDROLANT and HYDROPAC warnings; and Special Warnings. The compilation advantage here was not related as directly to the weekly Notice as it was to the production of the Daily Memorandum and the quarterly summaries of messages in force. None the less, this software package did contribute to the overall usefulness of the ANMS data to mariners via remote communications and to improved efficiency of Notice to Mariners data processing.

Here it is appropriate to mention that, periodically throughout the year, special recaps of information appear in the weekly Notice. Automation of weekly compilation of the Notice allowed automatic updating of numerous summary files for later production; thus, time to compile these listings was eliminated completely. The files referred to here include the monthly mobile oil drill rig update, the quarterly drill rig status list and the quarterly list of charts affected by notices, to name but a few.

In each of the aforementioned cases, the information is processed by a MIS, checked, entered to the work file by an Editorial Assistant working at a terminal, proofed from an output device, checked and revised as necessary and loaded to a weekly work file on the ANMS computer. Although this input procedure represents several new steps in the compilation process, it remains far more efficient than the past manual methods used at DMA. The composition process begins at this point.

At the conclusion of the compilation of the weekly work file, several computer routines are executed by the ANMS. These procedures simultaneously update a number of history files from which various products are composed or queried. In addition, a tape is generated which drives an automated photo typesetter which produces page negatives of chart corrections, List of Light corrections, Light List corrections, Radio Aids to Navigation corrections, catalog corrections, broadcast warning message texts and special cumulative listings — each ready for the press. The reader should contrast the speed of this automated oper-

ation with the old hot lead type operations of the Government Printing Office or even DMA's own Vari-Type List of Lights process where each line of type was manually typed on to one 3" x 10" card that required the operator to change type elements as many as four times per line/card. Computer driven typesetters at DMA can set up to 4,000 characters per minute, a speed which makes even the most proficient manual operator obsolete.

Because this phase of production is controlled by software, it has enabled DMA to upgrade or replace its former typesetting equipment without interfering with the critical schedules of the Notice to Mariners. ANMS software modifications are necessary, of course, but that is far more desirable than complete system redesign. Once again the phased development procedure has proven advantageous.

At the same time that the various summary and history files were created and updated by the weekly work files, an additional compilation/composition benefit was realized. As the master data files reached maturity, it became possible to produce, with vastly improved efficiency, the five volumes of Summary of Chart Corrections twice yearly, seven volumes of List of Lights and six volumes of Light Lists on demand, or on a schedule, simply by generating a print tape to produce page negatives from the same auto photo typesetters previously mentioned. To give an idea of the extent of this improvement, the total summary of corrections file contains every chart correction to every DMA and NOS chart published since mid 1975 or since the latest edition date of the individual chart. In other words, it contains everything the user needs to bring his charts up-to-date to the point where maintenance can be easily assumed by the weekly Notice to Mariners. This represents 40 megabytes of data. The lights data files, on the other hand, contain the current status of over 82,000 aids to navigation worldwide. These files hold 107 megabytes of data. To put this improvement in perspective, composition, negative production and printing of a List of Lights formerly took of the order of 90 days prior to automation. Now it can be accomplished in two weeks, although normally four weeks are allowed. On the other hand, the constant changes representing new data for chart correction summaries were never an easy update process for manual compilation, whereas now the summaries are produced practically at the touch of a button.

The final time-oriented design element that was chosen was information distribution. This was a tough problem because broadcast warnings are transmitted by Morse telegraphy radio, the Notice to Mariners is sent by first class mail, and the remainder utilize various rapid automatic distribution methods to reach the user. So, where did we go from here? After all, already we had cut compilation and composition time down by a factor of 50%, that is, from 42 days to the user under former methods to 21 days for the printed paper copy with the computer assisting with compilation and composition. Enter the Navigation Information Network (NAVINFONET) which, for our primary target of chart and light corrections, reduced another eight days off the user access time.

NAVINFONET, like the ANMS, is centered around a second Prime 2550 super mini computer. In point of fact, they are very close to being totally redundant systems. This is necessary to ensure dependability, data integrity and uninterrupted service to the user. Each time the ANMS data files are updated, a similar update is performed on the master disk of the NAVINFONET. Thus, its data

files are up-to-date making the latest information available for remote query. The NAVINFONET computer is a multipurpose computer which simultaneously supports new system development, broadcast warning processing, manages the query system and stands ready to take over from the ANMS, if necessary.

NAVINFONET's primary function is to bring the user closer to the data needed while at the same time providing selective query options to minimize the connect time and associated costs involved with interactive data exchange over commercial communications circuits. As the potential user community was examined, it was obvious that the versatility of the worldwide voice grade telephone system presented the most efficient and accessible circuitry readily available to NAVINFONET. Not so simple to access, or as versatile, but universally accepted, was TELEX. Even though it is slow and somewhat unfriendly in a conversational mode, it also was selected because all ships equipped with an INMARSAT ship earth station have TELEX and the ship driver is considered a main target. Up until early 1987, NAVINFONET was also accessible by TWX; however, it proved to be of little use, so the line was converted to a TELEX rotary circuit.

As of today, NAVINFONET is accessible over voice grade telephones (including INMARSAT voice circuits) on: the U.S. telephone systems, by five 300 baud lines, five 1200 baud lines, and two lines at 1200/2400 bauds; the European standard CCITT V.21, by two lines at 300 baud; and one dual TELEX line compatible with any International Record Carrier. This equates to 16 lines plus several hard-wired access ports.

At the time this paper was prepared, there were over 1,600 individual user identification codes on issue that permit access to the NAVINFONET system. Of this number, about half have used the NAVINFONET and made an average of 1,000 queries to the system each month. These figures do not reflect special query options used by DMA, the Federal Republic of Germany, Lykes Brothers Steamship Company, or selected other customers with whom DMA collaborates on special projects. Current usage is at about 16% of capacity which leaves much room for expanding the customer base as well as improving DMA's available services.

A pioneer in managing the development of the ANMS and NAVINFONET, Mr. Glenn R. DeYOUNG, a former head of the Notice to Mariners, was adamant about the fact that the system must be user friendly. His position was (and DMA's still is) that the system is for the end user, the navigator and cartographer; therefore, it must operate in plain language, not in code. With this guideline in mind, nine separate modules were developed within NAVINFONET, each with appropriate sub-elements. As with most things, an advantage can become a disadvantage at times. Whilst working in plain language was advantageous overall, it had the effect of slowing the user's response time by requiring numerous prompts and replies. This became just another on-going challenge for DMA to design an optimum compromise position and DMA is still striving for that plateau.

No matter whether the user selects 'good old' 50 baud TELEX or the more efficient 2400 baud voice-grade circuit, a conversational series of prompts will lead the user step by step to the needed data. Preformatting a request can be very helpful to the user unless he is just experimenting with the system. It must be emphasized again that although the data are free, the connect cost is paid by the

user. To receive a user ID, one need only convey the request to: Director, DMA Hydrographic/Topographic Center, ATTN: MCN, Washington, D.C. 20315-0030, USA, and an identification code will be assigned and a user manual supplied by return mail. Nearly any data terminal with an internal MODEM or acoustic MODEM or a micro computer with a communications software package may be used. NAVINFONET is configured to operate full duplex, parity off, 8 data bits, 1 stop bit. The 300 baud modems are compatible with the Bell 103 standard while the 1200 baud equipment corresponds to the Bell 212 or Racal-Vadic 3400 standards. The 2400 baud circuits are compatible with Bell 201 modulation standards and, of course, there are two 300 baud modems conforming to CCITT V.21 standards for our overseas user community.

Module 1 is the ANMS MAILBOX/Utilities group. There are only two sub-elements to this section at the present time. Program 10 is the ANMS MAILBOX. This allows the user to send a message to DMA from his location and to get a copy of exactly what he sends to DMA. This is a supplementary, one way communications program. That is, it is not intended to compete with commercial electronic mail systems or bulletin boards, but merely provides a narrow set of users with an alternative method of communicating information to DMA for immediate consideration for action. In point of fact, an incoming MAILBOX message prints out at the Worldwide Navigational Warning Service watch desk which is operated 365 days per year. Most of our oil drill rig movement data comes in over our MAILBOX as do many requests for information from companies under contract to DMA. Occasionally, DMA will promulgate outgoing information on the MAILBOX; however, in order to receive these messages, the user must call into the system. As can be seen, that is not particularly dependable or efficient in the outgoing mode.

The second option under this module is the NAVINFONET User's Manual. As the Manual is composed on the ANMS, this option was added to allow changes to the system to be made available to users without continually reprinting the instruction booklet. This option is preceded by some very interesting numbers concerning the down load times to transfer the Manual from its file to the user. Quite simply, it states 'This selection prints out the 1987 Edition of the NAVINFONET User's Manual. This takes 4 minutes at 2400 baud, 8 minutes at 1200 baud and 32 minutes at 300 baud. TELEX users should not exercise this selection'. These statements illustrate quite graphically the advantages of voice grade use over TELEX. Although voice grade may cost more per minute, ultimately its efficiency and speed override the lower per minute TELEX rates.

The second module, subsystems 20, 21 and 22, deals with chart corrections for NOS and DMA nautical charts. Program 20 is the most active query program on the system. It gives the user access to all corrections to selected charts or corrections from the current notice, back to a user selected notice number for selected charts. The most common and efficient use of this program is as a last minute update before making port or as a supplement to the printed Summary of Corrections and weekly Notice when a change of orders is received to divert to a port or area where the chart portfolio may not have been maintained previously.

Option 21 was created to save the user from having to enter a long series of chart numbers. It is called 'Query by Port'. By entering his choice of all

Notices or Notices back to a certain point following the two digit figure which corresponds to one of 92 ports or regions, the user avoids typing a long list of chart numbers. A word of caution is necessary here. The charts selected for each port may not be suitable for each individual user. It is up to the user to make that decision and supplement the data received as he feels necessary.

Lastly in this section is program 22 which DMA informally calls the automated chart card. By entering a chart number, the user obtains a printout of the Notice week numbers in which that chart was corrected beginning with its announcement as available from a distributor. This program is used extensively by U.S. Navy units and others who track the number of Notices charged against a chart.

Module 3 is concerned with the text of various radio broadcast warnings. This particular group is valuable to retrieve previously transmitted radio messages which were missed for whatever reason. This is the only program on the system that gives information after it was promulgated by another means; however, it provides a highly valuable means of restoring radio warning continuity after a break in reception. Selections are based on all warnings or warnings since a specific date. Further decisions are made using the DMA subregion system to narrow the affected area or else NAVAREA/HYDROLANT-HYDROPAC designations can be used. Special Warnings may be queried by date or by number as can MARAD Advisories. The intent of this module was to provide the user with sufficient parameters to narrow his search for these vital data as much as possible. Last, but not least, with this in mind, option 32 prints a list by number only of all effective warnings in a chosen warning series so that the user can check his inventory and request *only* the missing items.

Modules 4 and 8 are practically identical. The major difference is that 4 deals with the DMA Lists of Lights for foreign waters and 8 deals with the USCG Light Lists for U.S. waters. The user first selects the volume number he wishes to query. Thereafter, he may select individual lights by number or groups of lights consecutively listed or even all lights between two selected light numbers. This last option will allow a user to print an entire volume if he so chooses. All these option selections print the light data, including any corrections processed, against the selected lights since the latest printing of that particular volume. On the other side of the coin, an option is offered that allows the selection of just the lights that have changed since the last edition date of the publication. These programs are designed to facilitate updating small portions of a List of Lights or Light List until the hard copy Notice is received through the mails. This will allow the corrected volume to be used safely as a supplement to the appropriate up-to-date nautical charts.

The last unique user selection in the lights program allows the navigator to select only those lights exceeding a certain range of visibility. This option may be useful when coasting in order to see at a glance the specifications of all lights visible at 12 miles or more. Other uses are as a voyage planning tool for the navigator and for the cartographer. It simplifies lighted aid selection for certain smaller scale charts which show only the more powerful navigation lights.

Module 5 does not really 'correct' anything, but it contains information that could help save a ship and crew. It is called the Anti-Shipping Activity Message (ASAM) subsystem. This file was developed at the request of the U.S. Interagency

Working Group on Piracy and Maritime Terrorism. It contains random reports of various forms of aggression against shipping around the world. Events are categorized by date and by geographic area based on the DMA subregion system. ASAM reports can be filed with DMA using option 50 which is the first subroutine of the module. Step by step prompts help the user enter full particulars of the incident to be reported and then automatically transmit the message to DMA over the ANMS MAILBOX subsystem. Upon receipt at DMA, the text is reviewed, evaluated for further action or disseminated, edited, and filed in the ASAM data file for use by all system users when needed. This is an immature file as of this writing. It is expected to gain favor as a voyage planning tool in the future by providing cautionary information to owners and masters concerning security conditions in and near ports and narrow channels around the world. Examples of data in this file include the *Achille Lauro* incident, robberies of ships transiting the Malacca Straits, attacks on fishing boats and merchant ships coasting off Western Sahara, and certain events occurring in and around the Persian Gulf over the last few years.

As the world need for petroleum increases, more and more offshore oil exploration has become necessary. Despite the present slackening of interest, a point had been reached a few years ago when there were so many mobile oil drill rigs and drill ships plying the seas that it became extremely awkward to trace their whereabouts. Thus, module 6 'Oil Drill Rig Locations' (ODR) was created. This subsystem is used to track nearly 1,000 of these very fluid exploration vessels. The ODR file makes an ideal supplement to the weekly radio broadcast warning messages which update the movement status of the rigs. The user may use this file in several ways. If he knows the name of a particular unit, entering the correct spelling will produce the current location, assuming the information has been accurately reported to DMA, of course. Secondly, the user may query an area by subregion, which corresponds to the first two digits of a DMA or NOS chart number. Thirdly, he may query by broadcast warning area; that is, HYDROLANT, HYDROPAC, NAVAREA IV or XII. The last subroutine in this file allows the user to enter a rectangular area of operation by coordinates and the NAVINFONET will search for and print the names and locations of all oil exploration units within the designated area. This file is updated daily from a variety of sources, many reports of which come to DMA over the MAILBOX subsystem.

Module 7 was designed to give the user convenient access to DMA Hydrographic Products catalog corrections. Sales agents, shipchandlers, and navigators reviewing portfolios for chart replacement can make use of this group of subroutines to stay on top of what is new in the world of charts and publications. Selections are made first by catalog volume number. The numbers one through nine correspond to the 9 DMA catalog regions. Selections may be further defined by subregion using two digits. The exception to this rule is Volume 10, Miscellaneous Charts and Publications, which can be searched only by volume number. In any case, the user may make all corrections to the volume or subregion or all corrections since a certain notice. Further, within the subregion query group is the option to query a specific notice number alone.

Programs 97, 98, and 99 are operational in nature in that the first two supply a short or long menu for reference purposes and the last selection actually terminates the system access.

By way of recap, there is here, readily available at one's finger tips, a full file of corrections tied to individual charts by edition date and number, broadcast warnings with worldwide application, List of Lights, and Light List data for the world, anti-shiping intelligence information, mobile drill rig/ship location data, and chart catalog updates. Each program was designed to be a functional tool for the user — the mariner at sea or the planner in port. Of course, the cartographers within DMA and NOS received great consideration when the system was designed, expanded and modified. In fact, DMA remains the highest volume remote user of the system. Several instances have occurred wherein a user requested a specific program and DMA was able to accommodate the request, such as the Automated Chart Card and the Query By Port file. It is in DMA's interest to continue responding to such requests whenever possible, not only to create new options, but also to discontinue unused selections now that sufficient user statistics are available to make competent decisions.

What does the future hold for ANMS/NAVINFONET? Technology is moving ahead so rapidly that it is almost futile to look too far into the future, but plan one must in order to be a part of the future rather than an afterthought of history. The primary goal of automating the Notice to Mariners and associated information was to be able to produce that weekly periodical, cover-to-cover, by digital means. It is about 60% complete. Still to be completed are all of the free text sections, chartlets (or small paste-on sections of charts), depth tabulations, weekly Sailing Directions corrections and miscellaneous graphics. Automation of full Sailing Directions will be accomplished in the near future using the DMA Consolidated Navigation System and the Navigation Graphics Workstation. The major benefit of these improvements in relation to NAVINFONET will be the remote access availability of the weekly Sailing Directions and Coast Pilot corrections and, ultimately, remote receipt of chartlets, depth tabulations and graphics.

A project of major concern at this time is, of course, the development of the Electronic Chart Display and Information System (ECDIS). It would seem only a halfway job if a functional ECDIS were created to meet international standards without a means of providing corrections to the ECDIS data while at sea. Should the United States endorse the ECDIS concept and even produce an ECDIS, it will, no doubt, be incumbent upon the Defense Mapping Agency to provide the means to keep it corrected. The ANMS/NAVINFONET is available for that purpose when the time comes.

Once more, it should be emphasized that the data is already in the files of the ANMS, although the format will surely need some revision. The communications system is there in the form of NAVINFONET waiting for a heavier workload.

The Federal Republic of Germany has attempted to study the magnitude of chart correction under ECDIS conditions and has generally arrived at a figure of 60 kbyte to correct a 100 chart portfolio. A use of the NAVINFONET not previously discussed is to electronically transfer chart corrections contained in each weekly Notice to Mariners digitally from Washington, D.C. to New Orleans, Louisiana. This process is done over a 1200 baud voice grade line using an error checking protocol and takes about 20 to 30 minutes to complete an error free transfer. Coincidentally, the size of this transfer, when converted to the 10 bit German byte is 57.7 kbytes! One item that remains to be resolved is how to

transfer these data to the user. INMARSAT Standard C may be a viable candidate system, but at a speed of 600 bits per second in simplex mode, its low cost may not sufficiently offset higher costs associated with duplex operation of voice (up to 2400 baud) or data speeds. This will bear further investigation, especially since someone will have to absorb the cost for the data.

In this paper the author has given some background on the development of the Automated Notice to Mariners System, discussed the content of the various files accessible using the Navigation Information Network, and presented a few ideas and potential avenues to pursue in the future. Existing systems consist of dual PRIME 2550 super mini computers with a full range of peripheral devices. Each is equipped with one 600 megabyte disk drive and two 80 megabyte disk drives. DMA has designed room for expansion and can support future uses as well as new users of its systems.

The NAVINFONET was designed for flexible external access to these vital data. The mission of the Navigational Aids Division which controls the ANMS/ NAVINFONET is to promote safety of life at sea through up-to-date, accurate and inexpensive nautical charts and publications. Today most of the in-house processing is accomplished paper to paper or digits to paper. Tomorrow, it will be done digits to digits. Satellite communications using Standard A, Standard B, or Standard C, or land based radio using VHF or high frequency narrow band direct printing, or conventional distribution of unconventional products such as mailing floppy disks or larger printouts are potential avenues worth investigating. The list for tomorrow is endless. DMA will be part of tomorrow with the Navigation Information Network.