

DIGITAL UPDATE SERVICE and PRINT-ON-DEMAND

**Thomas J. Loeper
Jason J. Shadid
Marine Chart Division
Office of Coast Survey
National Ocean Service, NOAA
Silver Spring, Maryland 20910**

Select and Correct Charts: . . . obtain all the charts required to cover the entire passage. Verify using the Notice to Mariners that the charts in use have been corrected through the latest change. Make any required changes prior to using the chart. Check the Local Notice to Mariners and the Broadcast Notice to Mariners file to ensure the chart is fully corrected and up to date. Annotate on the chart or a chart correction card all the corrections that have been made; this will make it easier to verify the chart's correction status prior to its next use.

– Bowditch

INTRODUCTION

The nautical chart is the fundamental tool of marine navigation. It depicts information vital to safe navigation such as water depths, obstructions, regulated navigation areas, buoys and landmarks. This information can change daily. Carriage of the official National Oceanic and Atmospheric Administration (NOAA) nautical chart, which is produced by the National Ocean Service (NOS), is mandatory for commercial mariners, the Navy and Coast Guard. NOAA charts are also widely used by recreational boaters and others involved in research and coastal planning.

Today, NOAA maintains a suite of approximately 1,000 paper charts that are printed using traditional lithographic processes. Charts are printed in batches, stored and issued from inventory through a worldwide network of 1,200 authorized agents. As a result, charts can be two or more years out of date when they are purchased and chart agents can have thousands of dollars in capital tied up in stock. Charts are not kept corrected while in stock awaiting sale so the mariner must check all notice to mariners subsequent to the printed edition date and hand annotate all applicable corrections.

In addition to the traditional paper chart, NOAA also supports a digital chart product called the Raster Nautical Chart (RNC). The RNC is a digital version of NOAA's paper chart. RNCs are marketed and distributed through a private-sector partner, Maptech, Inc. NOAA has a Cooperative Research and Development Agreement (CRADA) with Maptech. Such agreements promote cooperative research and development, technology transfer, and allow the commercialization of federally developed technology. Maptech is provided with New Edition raster chart files when paper New Editions are published. Maptech writes the charts to CD-ROM and markets them to the mariner and other Value Added Distributors (VADs) for use in a variety of Raster Chart Display Systems (RCDS). Like the traditional paper chart, today's

RNCs are not kept up to date between New Editions. When purchased, the mariner must update the RCDS by checking all notice to mariners subsequent to the printed edition date and apply all necessary corrections.

In keeping with NOAA's Strategic Goal to "promote safe navigation," NOAA is implementing a new update strategy to provide more timely information to the mariner. This new strategy will result in two new products. The first is a weekly digital update service for RNCs. The second is a new method for production and distribution of up to date paper charts called Print-on-Demand charts (POD).

UPDATE SERVICE PROCESS

The Office of Coast Survey (OCS) of NOS is responsible for producing nautical charts, Coast Pilots, and other publications required for safe and efficient navigation throughout the United States. In January 1996, OCS initiated the update service concept by implementing a new process to evaluate and chart all published notice to mariners chart corrections. In the past, chart corrections from the U.S. Coast Guard Local Notice to Mariners (USCG LNM), the National Imagery and Mapping Agency (NIMA) Notice to Mariners (NM), and the Canadian Coast Guard Notice to Mariners were stored by NOAA, and applied to the chart when a paper New Edition was to be printed. With the new update service, all notice to mariner corrections are applied to NOAA raster chart files immediately upon receipt of the data from primary data suppliers. All notices are applied within one week of receipt from the originator.

The updated raster files are maintained by eight NOS cartographers and five contract cartographers. Each NOS cartographer is assigned one of the nine Coast Guard Districts, with one cartographer handling two districts. Work is performed on networked, desktop Pentium PCs running Windows NT. Digital chart edits are handled by Bentley's Microstation and Intergraph's IrasB software. Data processing and database functions are accomplished using Microsoft Access, dBase III, and a variety of in-house developed Visual Basic applications.

On average, 350 notice to mariners applications are processed each week affecting 91 NOAA charts. The USCG LNM, which accounts for 95% of the data processed, is received by the responsible NOS cartographer as an ASCII delimited file via e-mail, or is downloaded from the Internet as a Microsoft Word or PDF file. This usually occurs 1-3 days after the Coast Guard closes the notice out for the week and sends it for printing. The Canadian NM is downloaded monthly from the Canadian Hydrographic Service web site. NIMA's weekly notice is also available on their web site. Paper copies of all NIMA, USCG, and Canadian notices are received in the office because some graphic inserts and Channel Tabulations are not yet available in digital form.

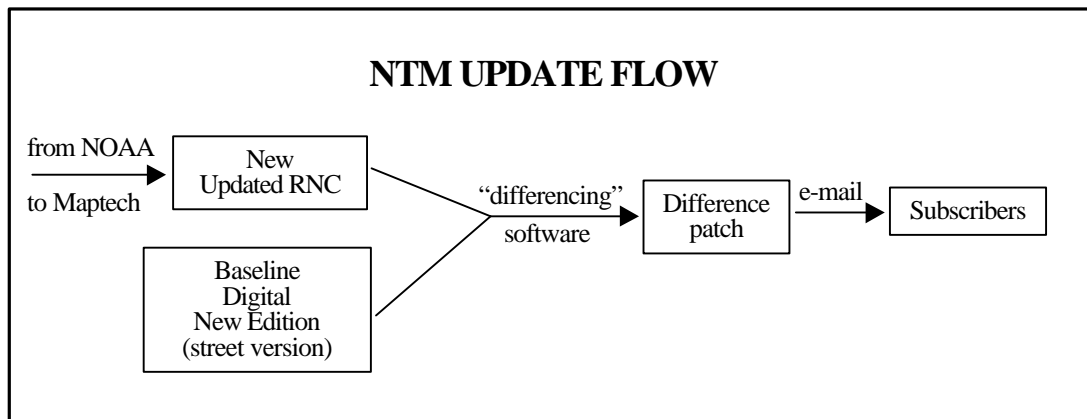
Upon receipt, each notice is evaluated and pertinent charting information is identified. Relevant items are transcribed into a database table by contractors. In-house developed software determines all potentially affected charts. Next, the data entry is reviewed by an NOS cartographer. Each item is then applied to NOAA's raster chart files and certified. The final step in processing a notice is to merge the qualified data into a master database which serves as a record of the revisions made to the charts.

With NOAA's update process in place, the maintained raster files can be utilized to support a weekly digital update service for RNCs, as well as POD.

WEEKLY DIGITAL UPDATE SERVICE

The weekly digital update service is intended as a mechanism to provide updates for the existing NOAA/Maptech RNC product. NOAA has utilized its existing CRADA relationship with Maptech to market and distribute the updates.

The digital update service extends from the basic processing of each notice described above. When all of the items from a notice have been applied and reviewed for a chart, the updated chart is made available to Maptech. NOS generates a 762 dpi composite image file (.CRL) of the revised chart panel (main panel, inset, or extension) and places it on a server accessible by Maptech through a high speed dedicated line. A chart may be updated multiple times during the week as notices are received and processed by NOS. Maptech crops the file to the extent of the chart image, resamples down to 254 dpi, and adds projection and geographic-positioning data needed to produce the NOAA/Maptech RNC product.



The is then **Figure 1.** Update flow from NOAA through Maptech to subscribers. file use pro

duce a cumulative update patch. This is accomplished by comparing the new updated RNC with the previously issued New Edition (street) raster version of the same chart. The New Edition (street) version serves as the baseline for all comparisons. The two files are run through a software routine which identifies areas of pixel variation between the two rasters. The update patch is the “difference” file generated by this comparison. The patch is a relatively small modified .TIF file, typically 1 megabyte or less, containing only the pixels that changed from the baseline New Edition (Fig. 1). Maptech quality checks the patch by applying the difference file to the baseline New Edition and running it through the same software routine used to create the difference file. The baseline New Edition version with the patch applied should match the new updated RNC supplied by NOAA pixel for pixel (Fig. 2). A header is added to the patch for positioning purposes, making the digital update patch ready for distribution.

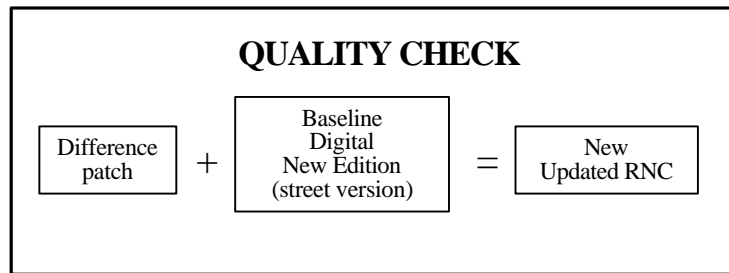


Figure 2. Maptech quality check.

Weekly Digital Update Distribution and Implementation.

Initially, Maptech will distribute the digital updates to individual mariners and other VADs as e-mail attachments. Maptech is evaluating other modes of distribution, focusing specifically on utilizing the Internet. Subscribers to the service will automatically receive the update patch files for the charts in their individualized chart portfolios on a weekly basis. A simple installation procedure using Maptech provided software will update the charts.

Implementation of the service will be carried out in two phases. In Phase 1, digital updates will include only corrections published in USCG, NIMA, or Canadian notice to mariners. Phase 2 will include additional chart corrections from sources other than notices to mariners.

NOAA and Maptech have entered into the beta test stage of the digital update service. The next version of Maptech's chart CD-ROMs (Version III) will support the digital update service. The first CDs available for testing will cover the 1st and 5th Coast Guard Districts (Northeast and Mid-Atlantic). The product should be available to the public by Summer 1999. Full Phase 1 implementation of the service for the remaining districts is expected to be complete by the end of 1999. Individuals or companies interested in becoming beta testers can contact Maptech for details.

Once Phase 1 is achieved, NOAA will begin providing other charting information in addition to notice to mariners corrections. Updates from hydrographic surveys, topographic surveys, Corps of Engineers channel dredging manuscripts, Federal Register, and a plethora of other source documents will be included in the update service product. Chart corrections from these sources that are realized from applications made to the nautical chart suite by NOS cartographers during standard chart maintenance activities will be included on the weekly digital updates. The update service will make these changes available immediately to the public. Currently, such corrections are held until a traditional paper New Edition is printed.

Additional Features of the Weekly Digital Update Service.

NOAA is currently providing Maptech with data to develop a chart note referencing capability. When the user encounters a reference to a note on the chart (e.g., see note D), a simple click on the reference legend will display the note or Channel Tabulation on the screen. Standard chart notes will be handled by a pull down selection menu. Note updates will be included as part of the digital update service. A similar referencing capability is being considered for the U.S. Coast Pilot.

Subscribers are also notified of published USCG, NIMA, and Canadian NM items which may be incorrect. If an NOS cartographer questions the validity of a published notice correction, an attempt is made to confirm the correction with the reporting agency. This process can take anywhere from a day to several weeks. Depending on the nature of the problem, items in question may not appear on the update patch. The raster files are updated through the notice for all qualified items while the disputed item is being resolved. All items in question are forwarded to Maptech in a Microsoft Access file. A utility included with the update service makes the user aware of problem items associated with the raster charts in his portfolio.

PRINT-ON-DEMAND CHARTS

Why move to Print-on-Demand?

Recent user surveys conducted by NOAA indicate that mariners want charts that are current at the time of purchase. The up to date raster files provided by the update service, combined with high speed, large format plotters will enable NOAA to supplement the traditional charts with a better product printed when ordered by the mariner. The main goal of POD charts is to provide the most up to date paper chart to the mariner at the time of purchase.

According to *Chapman Piloting, Seamanship and Small Boat Handling*, only the latest editions of a chart should be used and new editions of charts supersede older editions. Superseded editions of charts held by chart agents are returned to NOAA for a credit on future purchases. Mariners should purchase the new chart editions and destroy the superseded editions. New Editions contain information published in the notice to mariners, and all other corrections from application of hydrographic surveys considered essential for safe navigation but not published in the *Notices*.

To improve this situation, NOAA plans to implement POD to provide mariners with more up to date charts. POD is the use of large format inkjet or electrostatic plotters to print nautical charts. For POD to succeed, raster files updated by the update service must be used to plot the latest chart.

What are the alternatives?

To better serve the mariner with the most current information, NOAA investigated several alternatives to produce and deliver a better paper chart. Currently the best alternative is a combination of large format inkjet and electrostatic plotters.

Shorter print runs. Traditional offset print runs of less than 1,000 impressions or less are not cost effective since prepress work and press makeready charges are factored into every chart. For example, the cost of four-color prepress work including film production, film inspection, and plating is around \$1,000 per chart. Press makeready may be an additional \$800 to \$1,000 per chart. If this \$1,800 to \$2,000 fixed cost is spread over smaller print runs, the per chart fixed cost increases dramatically as print runs decrease. Using the short print run model, NOAA would still be required to store printed charts and destroy obsolete material when superseded. Computer to plate or direct to plate technology is available for short print runs but the fixed costs of prepress (minus film and inspection cost) and press makeready are not eliminated.

Direct to paper technology. Digital color presses are based on a "direct to paper" technology by printing directly from digital data. This eliminates the need for films, plates and traditional make-ready time and costs associated with offset printing. Direct to paper systems can produce a small number of copies efficiently in a very short time. There are no systems available for large format charts but there are several systems available for printing the Coast Pilot and small craft charts. Quality is very good and NOAA is continuing to monitor developments in this area.

Large format plotters. Large format plotters that NOAA investigated were inkjet and electrostatic plotters. Both systems produce images directly onto the media from digital data without a press-like imaging machine. Both technologies fit into the NOAA on demand chart production scheme. Inkjet plotters use streams of very fine dyes or pigmented inks that are controlled by digital signals to produce images on plain or coated media. Inkjet plotters are inexpensive, easy to operate, have a wide selection of media, and do not have special environmental requirements. Inkjet plotters are relatively slow (around eight to ten minutes for a 12 square foot chart) but speeds are improving. Electrostatic plotters deposit charges on specially coated media where a color dot is to be formed. The print head consists of tiny wire "nibs" that contact the media and places a charge on it. The media with the charged image is passed through one of four color (CMYK) toners. The charging and toning process continues until all four colors are fixed on the media. Electrostatic plotters are fast and can handle high volume production but the toners are petroleum-based and require special handling. Electrostats require strict environmental control and the initial cost is several times more than inkjet plotters.

Experience of NOAA and other Federal agencies.

NOAA investigations have included operating an inkjet prototype POD site in Silver Spring, Maryland; having the Maritime Exchange for the Delaware River and Bay operate a distributed printing site in Philadelphia, Pennsylvania; and utilizing the experiences of NIMA and U.S. Geological Survey who have operated or experimented with the same technology. The investigations have shown the following:

- ! The technology is adequate to produce a usable, up to date chart from both centralized or distributed sites.
- ! Professional mariners thought the product was acceptable and that the up to date information would be valuable if priced reasonably.
- ! Inkjet technology is low-cost, relatively slow and more difficult to operate than an office copier. Inkjet technology is the most likely candidate for distributed print sites.
- ! Electrostatic plotters can handle large throughput and continuous operations but require trained operators and strict environmental conditions. Electrostatic technology is the most likely candidate for centralized printing.

Technology is a driving force.

NOAA goals of promoting safe navigation and getting the most updated information into the hands of the mariner are being made possible by technological advances. During the last three to five years, dramatic advances have occurred in large format plotters. The introduction of low cost, high resolution inkjet plotters, inexpensive, high-powered workstations and PC's as well as more robust graphics software is enabling the concept of charts printed on-demand. The subtle and incremental changes that have advanced the printing industry and more specifically NOAA chart production for years are giving way to a wave of change driven by short run digital printing and Internet solutions.

Traditional offset print runs of one thousand charts or less are not cost effective so NOAA is forced to print more copies than can be sold in a given edition cycle to reduce the per chart cost. Excess charts must be shipped, warehoused, shelved, inventoried, and eventually destroyed adding to the operating costs of NOAA. The ongoing expenses of materials, prepress and printing costs, high returns from chart agents and the need to deliver more up to date information to the mariner are forcing NOAA to look to technology-based solutions for relief. (Xerox)

Producing plotter files.

Plotter files are generated using the most recent high resolution raster files with all the latest notice to mariners corrections incorporated by the update service. The 762 dpi composite images generated by NOS must be resampled down to a useable resolution for various output devices – in general, 300 dpi resolution for inkjet plotters and 400 dpi resolution for electrostatic plotters. In-house developers at NOS are also working on an algorithm to “intelligently upsample” from the 254 dpi files produced by Maptech. Use of the 254 dpi files would reduce storage space, file transfer time and simplify file flow since all the files would be served from the same source. Next, insets must be correctly positioned into the main panel using a batch process and a raster editor. Chart specific crop limits and raster merge coordinates are called by the batch file which automatically initiates the raster editor and positions the insets using the merge coordinates. The raster editor also assigns the proper chart colors using a lookup table mapped to specific plotters. Finally the file is converted to a .TIF format and sent to the Raster Image Processor (RIP). The files are RIPed once and saved separately as the input file for a given plotter.

Currently, NOS is investigating two specific POD strategies as an alternative to traditional offset printing – centralized printing and distributed printing. Both strategies will use the most recent high resolution raster files with all the latest notice to mariners corrections incorporated by the update service.

Near-term goal – centralized printing.

The near-term goal of NOAA is to jointly develop a reliable, low cost print to order capability with a private sector partner to print charts from a central location. Since printing is not an

inherently governmental function, NOAA is negotiating with a business partner (CRADA partner) to print charts when ordered by customers. This business relationship will leverage expertise in the fields of imaging technology, color and file management, e-commerce and distribution. This public/private partnership was selected as the method which offers the greatest flexibility to respond to rapidly evolving needs at the lowest risk and cost to the taxpayer. More fundamentally, it was chosen because collaborative government/private research and development work was required to fully develop the POD product and service concept. Contracting was not selected as the method to provide POD charts since it would require public funding of all subsequent research and it would also require the government to set the direction for product evolution rather than the market. (Enabnit)

Current projections indicate the central plotting facility will need to produce an about of 2,000 charts per day (based on a five-day work week and public sales of 500,000 charts per year). Electrostatic plotters are best suited for this type of scenario since they are built for heavy-duty operation and they are capable of high-volume production.

The centralized printing strategy also incorporates commerce over the Internet to form an end-to-end production system. Chart agents will be able to access a web site, enter a virtual chart store, view summaries of notice to mariners changes, order a chart or charts of their choice, select handling and shipping options, as well as track production and shipping progress.

Orders would also be received by traditional means from chart agents by telephone, fax and mail then entered into the chart production system by a customer service representative. However, chart agents would be encouraged to enter orders via the Internet using a commercial e-commerce solution to automatically generate a work order to produce and ship the requested products. The e-commerce site would also help agents better manage their chart stock, customer accounts, as well as order, track and review account history 24 hours a day.

The plotting equipment, file management and transfer systems, toners and media, and e-commerce systems are all currently available on the commercial market today. Minor adjustments to the chart colors, media type and coatings are being tested with commercial mariners to determine the final POD product specifications. The ultimate goal is to have POD charts supplementing traditional chart sales in selected regions around the country by the end of this calendar year.

Long-term goal – distributed printing.

The long-term goal of NOAA is to develop a reliable, low cost, true Print-on-Demand capability at the point of sale. A customer would be able to place an order with a chart agent, and have the charts printed on site with the most up to date information available. Small orders could be printed while the customer waits but larger ones would need to be placed with some advance notice. An inkjet plotter connected to a PC with a high speed modem is the most likely equipment configuration for the distributed printing strategy. Plot files would be served and maintained from a central location to chart agents around the world, 24 hours a day, 365 days

each year.

The impediments for a successful point of sale system include large file size, slow inkjet plotter speed, and relatively high system and media costs. Current technology requires an investment of \$12,000 to \$15,000 for the ability to produce a twelve square foot chart in eight to ten minutes. Compressed 300 dpi raster files are several megabytes making them impractical to transmit using current modem technology and difficult to manage, process and store in bulk since they expand to around 100 megabyte plot files. Chart agent training and help desk staffing would be time-consuming and an added personnel cost to NOS or the business partner. File security and configuration control are also complex issues that need to be resolved before a viable point of sale system could be developed for agent use in a store setting.

CONCLUSIONS

Over the past several years, NOAA has undertaken a massive modernization effort to improve its nautical chart suite. Emphasis has been placed on increased accuracy, enhanced visual quality, and product timeliness. The implementation of the weekly digital update service and Print-On-Demand charts continues this trend.

Continuous application of notice to mariners corrections on NOAA raster nautical charts allows NOAA to provide the mariner with an up to date graphic representation of USCG, NIMA, and Canadian critical chart corrections. Charts depicting the most current information available can be delivered to the mariner in digital and paper form. Utilizing on-demand technology, NOAA can improve safety of navigation by putting the most current information into the hands of the mariner and test the market with customized chart products. In addition, producing smaller numbers of up to date paper charts for immediate use rather than printing and storing large batches will help NOAA reduce warehouse and inventory costs and reduce returns by the chart agents.

Our nation's waterways are a treasured natural resource and an essential element of our economy. Be it for the recreational boater or the commercial shipper, NOAA will continue its effort to produce and distribute products that keep pace with advances in marine technology and promote safe marine navigation.

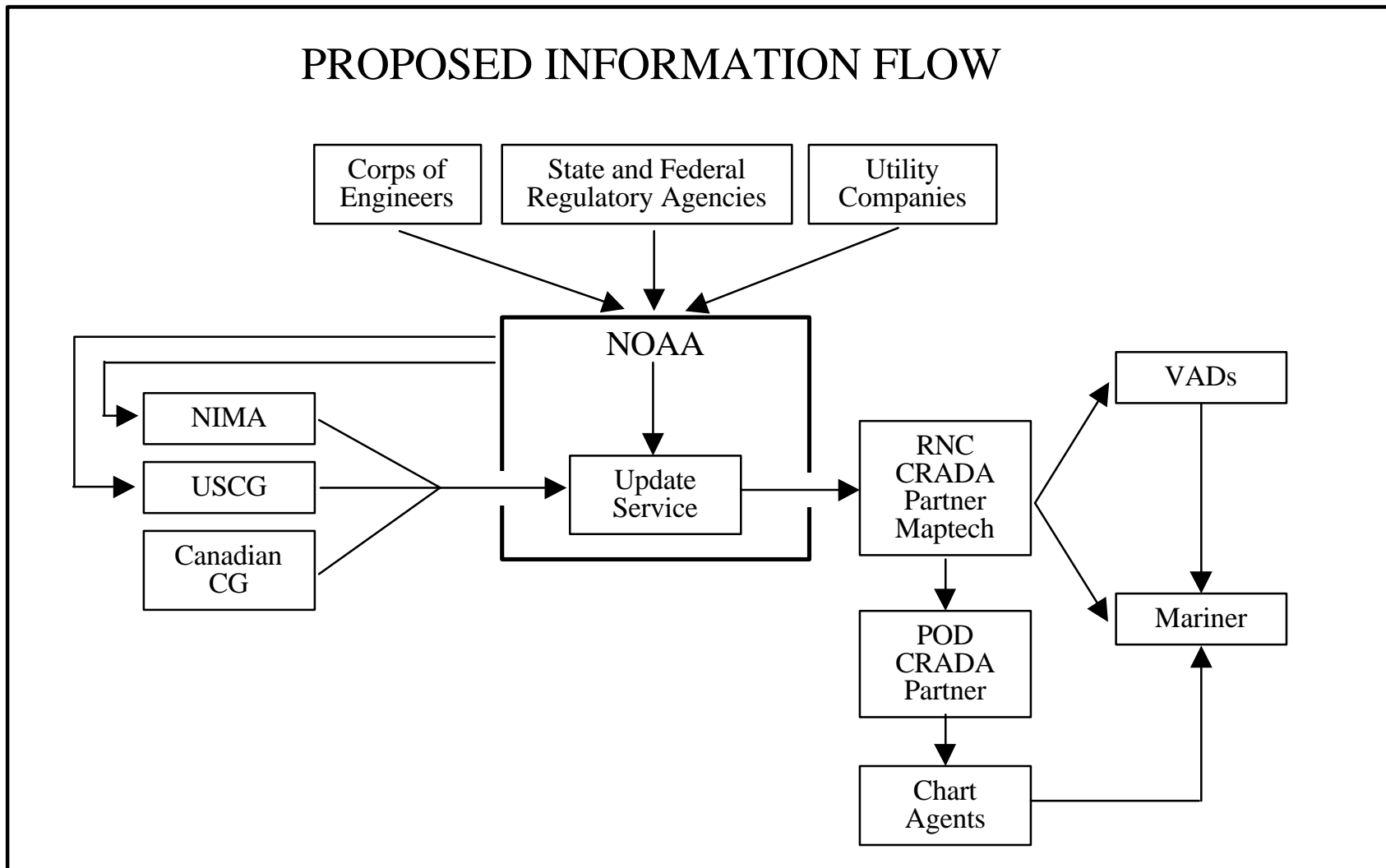


Figure 3. Proposed information flow from outside sources through update service to POD and Maptech.

For more information on the update service contact:

Kirby Gean
1315 East-West Hwy - Rm 6359
Silver Spring, MD 20910

Tel (301) 713-1205
Fax (301) 713-0377
email: kirby.gean@noaa.gov

For more information on Print-on-Demand contact:

Richard Sillcox
1315 East-West Hwy - Rm 7359
N/CSx9
Silver Spring, MD 20910

Tel (301) 713-2737 x 112
Fax (301) 713-4516
email: richard.sillcox@noaa.gov

For more information raster charts and other Maptech products contact:

Maptech, Inc.
6 State St, Suite 206
Bangor, ME 04401

Tel (207) 990 3446
Fax (207) 990-349
email: mj@agate.net

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