

Print on Demand for Nautical Charting Products

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Introduction

Print on Demand is the use of large format plotters and digital files to print nautical charts when they are ordered. The technology is capable of far more than simply replacing lithographic printing, but using its full potential adds substantially to the complexity.

The National Oceanic and Atmospheric Administration (NOAA) began selling Print on Demand nautical charts as an official product in 2000. NOAA's Print on Demand charts are made under a public/private partnership with OceanGrafix, LLC, a private company in St. Paul, Minnesota. This paper will discuss the uses of Print on Demand for nautical charting, the technology, NOAA's experience, recent enhancements, and mariner reactions to the results.

Uses of Print on Demand in Nautical Charting

At the simplest level, Print on Demand technology can be used as a replacement for traditional lithographic printing. In this mode, it can:

- reduce or eliminate chart inventory and warehousing costs;
- insure that copies are always available;
- efficiently manage the production of charts that only sell small quantities;
- eliminate the wasteful destruction of obsolete charts when a new edition is issued;
- permit the use of different papers;
- avoid a reprint when inventory is low but when a new edition is imminent;
and
- permit point-of-purchase printing.

With attention to quality control, it would be possible for governments to stop printing charts themselves by letting retailers print the charts in their stores.

At a more advanced level, the process can be augmented with computer-assisted cartography, near real-time chart maintenance, the dynamic assembly of chart files, and electronic ordering to produce additional benefits such as:

- making nautical charts that are up-to-date at the moment they are printed;

- allowing charts to be customized for different user groups;
- supporting different versions of the same chart, such as with and without LORAN; and
- providing a subscription service to deliver professionally updated charts whenever there is a Notice to Mariners correction.

The benefits of reduced or eliminated inventory and warehousing costs are still achieved if these advanced benefits are targeted.

Print on Demand Technology

Supporting Technology – No special computer technology is needed to use Print on Demand as an alternate printing method. Chart files can be prepared in advance and stored on a hard drive or network. Orders for copies are then sent to a plotting facility rather than a warehouse. Software to plot copies of a chart is simple to operate. The only real requirement is for digital files. A file resolution of 300 dots per inch is adequate, although bar codes may not be readable. File resolutions greater than 600 dots per inch do not appear to provide any further improvement in readability for a standard nautical chart.

Printing Technology – Ink jet plotters are the most commonly used plotters for Print on Demand nautical charts because of their low initial cost, ease of use, variety of paper and inks, and acceptable image quality. Large format, full color plotters are made by many different manufactures, and range in price from a few thousand to several hundred thousand USD per plotter. They offer a range of dots-per-inch (dpi) resolutions with the mid-range (600 dpi) being acceptable for nautical charts. They also offer good color control. Inexpensive personal computers and commercially available software are all that is needed to operate and manage these plotters. Brand name plotters are proving to be reliable as a production tool.

Ink jet plotters, however, have some shortcomings. It usually takes several minutes to plot a chart-sized image, and the image quality is not as good as lithographically printed charts. A perfect color match to printed charts is not easy if that is one's goal. The ink is not as durable as lithographic printing, and may smear when wet, or may partially erase when course lines are erased. However, the careful selection of materials is providing a satisfactory product.

Suitable plotters are available worldwide. NOAA and OceanGrafix selected one based on price, reliability, plot speed, paper width, available papers, and brand reputation. Additional plotters are being added as the number of charts being sold increases. The changed image quality was handled by changing the chart colors to a brighter set, thus changing the user's expectations – a tactic that worked effectively.

Materials – Papers for ink jet plotters are available with a wide variety of characteristics and prices. Coated papers made for ink jet plotters give the best image quality results. An appropriate combination of paper tear strength, water and

ultraviolet resistance, available width, and cost is needed. In field trials, mariners were sensitive to their ability to write and erase on the material, and the ability to fold it repeatedly. Paper that felt too thin received negative comments. However, several papers can be offered to mariners with the mariner's choice being used at plot time.

Inks for ink jet plotters are also available with a wide variety of characteristics and prices. Water-fastness, ultraviolet resistance, and price are factors to consider in selecting inks. Some inks are solvent-based rather than water-based, and emit noxious fumes. Most plotters allow a wide range of colors to be simulated. Hydrographic offices should select a color set by trial and error that is appropriate for the plotter/paper/ink combination they are using.

The materials used for Print on Demand are significantly more expensive than those used for lithographic printing. If Print on Demand is being used to avoid inventory and warehouse costs, or to avoid printing costs for low volume charts, one can determine the cost for Print on Demand using equipment, paper, and inks available in the local market, and then calculate the breakeven number of copies at which Print on Demand is less expensive than the alternatives.

The NOAA charts are offered on two papers. One is a water-resistant paper, and the other is laminated. The water-resistant paper is less expensive, but lacks tear strength. The laminated paper has been criticized because it does not fold as flat as paper, and the chart may slip off the chart table in heavy weather. Both products, however, are fully suitable.

Advanced Computer Requirements – Substantial computerization is necessary to achieve the advanced benefits of Print on Demand such as making up-to-date charts and customization. Computerized cartography is needed to keep the digital charts updated. At NOAA, the charts are maintained as raster images that are updated weekly for all Notices to Mariners. Custom data is maintained as digital overlays, or as additional files to be plotted outside the chart neat line.

A suitable file management system is needed to keep track of the asynchronously changing files that make up a Print on Demand chart. NOAA has 3 different groups of people that may be changing the 20 files making up a Print on Demand chart. File naming conventions, file management software, and work flow management all help to see that the right files are combined automatically when a chart is ordered to be printed.

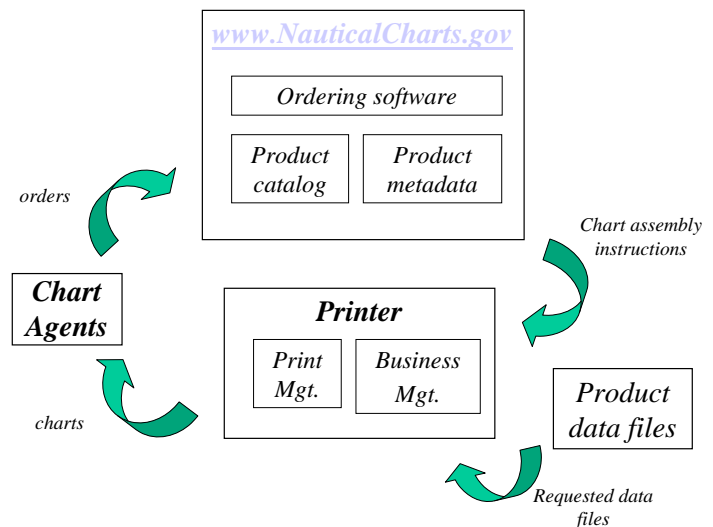


Figure 1 -NOAA Print on Demand Block Diagram

NOAA developed an electronic commerce system to support Print on Demand. This system (www.NauticalCharts.gov) is the way chart agents place their orders. It is also part of the chart production software. It writes an electronic message containing assembly instruction for each chart in an order. OceanGrafix' software follows the instructions in the order to assemble, print, and ship the charts. A diagram of the e-Commerce system is shown in Figure 1.

NOAA's Experience with Print on Demand – NOAA and OceanGrafix began selling Print on Demand nautical charts in September, 2000, in a test mode. This test was to determine:

- product acceptability;
- retail price acceptability;
- production costs and times; and
- the reliability of the production system.

The test ran for 16 months and grew to 268 charts and 19 chart sales agents. Over 10,000 charts were sold. The laminated product was offered in 2 versions, one for commercial mariners and one for recreational mariners. The commercial version had extra information printed outside the chart neat line such as bridge clearances, tide correctors, radio frequencies, phone numbers, and text from NOAA's Coast Pilot (Figure 2). The recreational version had extra information dealing with safety and boating. The electronic commerce system was used for chart ordering.

Mariners overwhelmingly described the physical characteristics and utility for navigation of the Print on Demand chart as excellent or good. The most desirable feature was that they were up-to-date with all critical safety information. One hundred percent of responding professional mariners

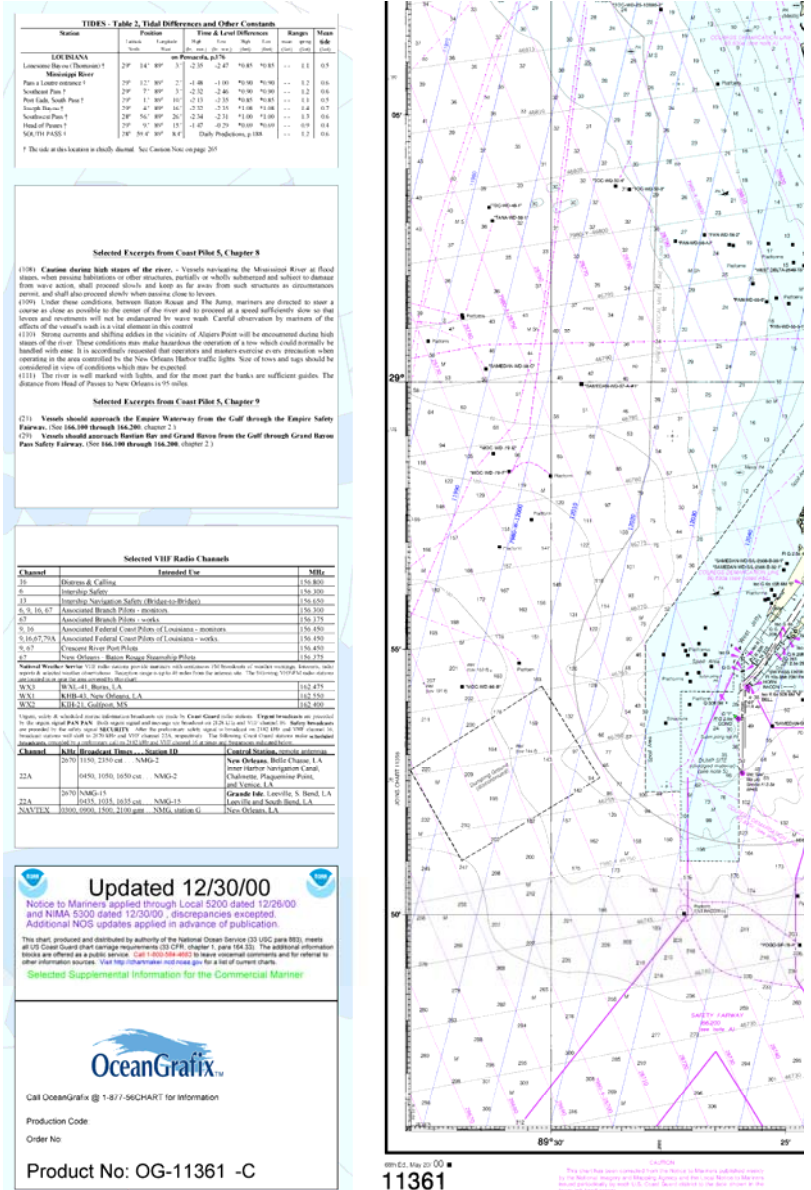


Figure 2 - Extra Information Added Outside the Chart Neat Line

thought the up-to-date feature was extremely important. Mariners liked the durable, water resistant nature of the chart, and the chart's new colors, contrast, and readability. The extra information in the margin of the chart was also rated as important. The Tide Tables were considered important by 72 percent; 89 percent said that bridge clearances were important; 41 percent said phone numbers and Internet addresses were important; 71 percent said excerpts from the Coast Pilot were important; and 95 percent said VHF radio frequencies were important.

The overall size of the chart was criticized – a situation made worse by the extra 6 inches added for the information in the margin. The laminated chart folds less well than paper, and there were 2 or 3 laminate failures. The water resistant paper was not as good for writing and erasing as lithographic charts.

Costs were found to be slightly higher than anticipated before the test began. Paper and ink costs were part of the reason because product acceptability was given a higher priority than retail cost. In addition, order-handling costs had not been accurately estimated.

Production times were better than expected. The original goal was to provide a corrected chart before mariners would receive the Notice to Mariners in the mail. This was achieved. Three activities take place to do this. First, NOAA must update all charts, every week, for all Notice to Mariner (NTM) items. NOAA is applying all NTM items within the 5-day advanced receipt window it has for the Notices. The e-commerce site automatically updates itself for these changes every 30 minutes. As a result, chart changes made by NOAA are effective within 30 minutes. Orders received in that 30-minute window are automatically held by the system and released for fulfillment only after the new data is on-line.

The final purpose of the test was to exercise a full, production system in a pilot mode. This was successfully accomplished during the 16-month test.

Present Status – All of NOAA's 1,000 charts are available as Print on Demand charts. They are up-to-date with all Notice to Mariners and other critical information when they are printed. Orders received by 11:30 a.m. are shipped by the next business day. Two versions of the charts are available: commercial¹ and recreational, and either version may be ordered on laminated or water-resistant paper.

All Print on Demand charts are ordered using the e-commerce site which also takes agent orders for the traditional lithographic charts. Six hundred of NOAA's 1,300 agents have logged on to the site, and 450 have placed orders using it. At present, 33 agents are carrying Print on Demand charts.

¹ Note: Not all NOAA charts will be produced in the commercial version. Only those covering locations and scales that support commercial navigation will be offered as such – about 45% of NOAA chart suite. All charts are offered in the recreational version.

Remote printing has been added at seven sites around the nation. These are chart agent's stores in which a plotter and appropriate software have been deployed and the agents trained to operate the system. More agents are in the process of signing remote printer agreements, and leasing the necessary equipment from OceanGrafix.

Remote printing uses a hybrid ordering/processing/data delivery approach. Orders are still entered via the e-commerce system by an agent equipped for remote printing. The Order.XML assembly instructions are still sent to OceanGrafix for preprocessing of the order files. The files are then transmitted via .ftp to the remote agent for final assemble and printing. The agents are proving to be more than capable at operating the equipment, and their agreement with OceanGrafix provides them with technical support when it is needed. 10-15 remote sites are planned in 2004, with the expansion to international printing shortly thereafter.

Two-sided printing began in January 2004. While the equipment being used does not support automatic two-sided printing, OceanGrafix has perfected image registration control sufficiently to print a string of charts, turn the roll of paper over, and print side two on the back in the correct, aligned location. The results are then accordion-folded for distribution. This version, appropriately named "MapFold," has proven to be most beneficial to vessels that have limited bridge space, as well as accommodating those that may have tighter quarters, allowing for convenient storage.

Extension of the Concept – An underlying strength of NOAA's Print on Demand technology is its database-driven design.

The database contains the file names and attributes for all the pieces needed to assemble a chart: the main panel, insets, overlays, blocks of information to print outside the neat line, crop windows, page numbers (for multi-page charts), reduction factors, last NTM update, etc. It also contains insertion points for the individual files. Therefore, to create a new product it is only necessary to properly describe it in the database. From that database, the Order.XML assembly instruction is automatically written and then executed to make a plot file for a particular product. This gives the opportunity to make a broad range of products.

An example of this flexibility is shown in Figures 3, 4, and 5. The figures show a chart that has been customized for the Coast Guard by overlaying routes and operational areas specified by them. The capability of replacing the information plotted outside the chart neat line with a customer's information has also been

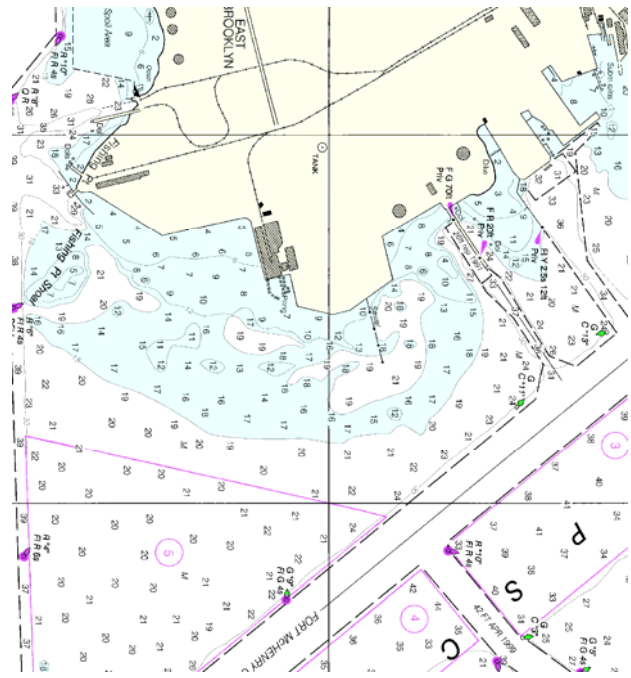


Figure 3 - Chart Segment Without Custom Overlay

demonstrated. This is being used, for example, to add a selling agent's business card to charts. The capability has been used to make charts with or without LORAN lines. LORAN lines are an awkward issue for NOAA with advocates on both sides. However, for Print on Demand charts, an agent can indicate LORAN as an option when placing an electronic order, and the appropriate files will automatically be called for in the assembly instructions used to print the chart.

Another use of the advanced Print on Demand technology is the production of a reduced scale "Pocket Chart™" for beginning boaters (Figure 6). These boaters are characterized as having open boats, 18 to 22 feet in length, and who presently use no navigation products. A small, inexpensive, PocketChart™ was designed for them to use as a "locator." Boating safety information has been printed on the back to help NOAA further its safety mission.

The Pocket Chart™ is 19" x 13." The chart image has thus been reduced to approximately one-third of its original scale. The process to make this PocketChart™ is the same as before – a database description of the files and their attributes is used to generate an Order.XML assembly instruction from which the Pocket Charts™ are printed. They are printed on water-tolerant paper using a Hewlett Packard CP1700 duplexing inkjet plotter. The desktop printer costs \$600 USD, and is suitable for use in a chart agent's store.

NOAA released the Pocket Chart™ in August 2003. In May 2004, comprehensive coverage exists from Boston, Massachusetts, to New Orleans, Louisiana. Coverage is expanding weekly and a Pocket Chart™ version of each NOAA chart will eventually be available.

Using Print on Demand gives a low cost way to test new products like the

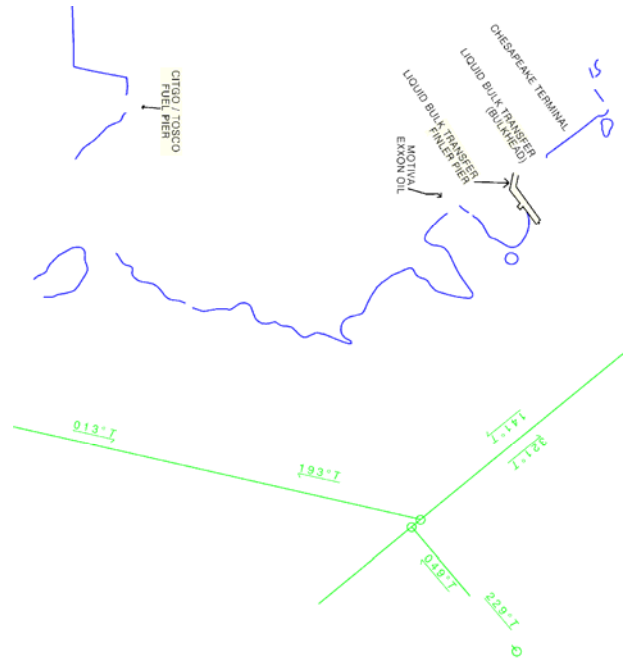


Figure 4 - Custom Chart Overlay

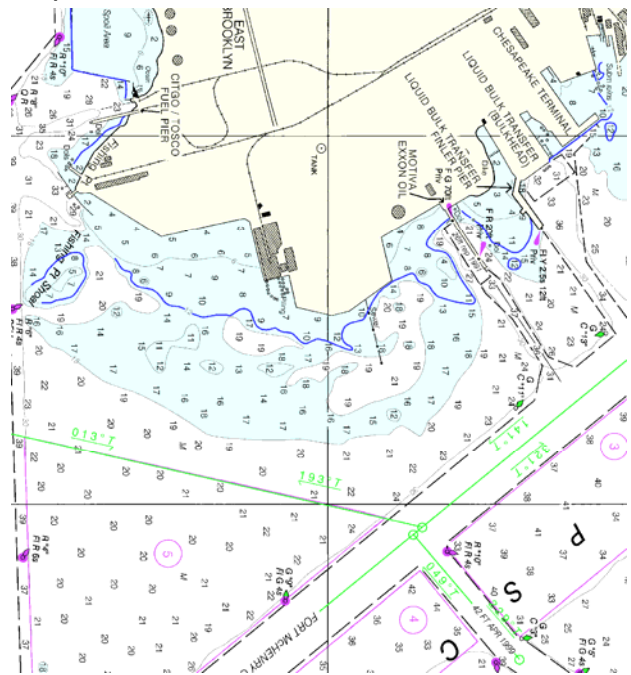


Figure 5 - Chart With Custom Overlay

PocketChart™, and to change them rapidly as feedback is received from boaters and retailers. Another such new product concept is undergoing development using Print on Demand. That is the BookletChart™. Whereas the PocketChart™ is targeted for the beginning boater, the BookletChart™ is intended for the novice boater.

The BookletChart™ being prototyped is printed on two sides of 11"x17" paper, folded once in the middle and saddle stitched with 3 staples. Pages contain systematically arranged sections of a chart, much like road atlases are arranged. Other information is included appropriate for the intended user. Again, the product is defined in the database, and assembled automatically. Presently, they are being printed on a Xerox 7700 laser printer. Samples will be made this year for a market survey and public evaluation.



Figure 6 - PocketChart™

Conclusions – Print on demand is ready for use by hydrographic offices. It can be used as a replacement printing process to reduce inventory and warehouse costs, and to avoid out-of-stock conditions. Print on Demand also offers the opportunity to make an improved nautical chart. It can make charts that are always up-to-date, charts that have been customized for market segments or individuals, and charts with special physical characteristics. Electronic commerce is proving to be a natural “front end” for Print on Demand. The database-driven approach is an excellent way to specify a dynamic product like the charts that are constantly being updated. It is also an excellent approach to provide additional products.

Together, these can be transformational technologies that permit a hydrographic office to improve and expand its products. As more offices begin to update charts every week, it would be an easy step to share digital files so that one hydrographic office could print up-to-date charts on behalf of another hydrographic office at any location in the world.

AUTHORS



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Mr. Loeper is an engineer working on the Print on Demand project. He has worked on NOAA's Fleet Replacement and Modernization Project and is a former submarine officer in the U. S. Navy. He has a BS in Biology and a BS in Mechanical Engineering and a Masters Degree in Engineering Management.