Web-based Chart Production

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Abstract

Paper charting has been a cartographic craft in the nautical domain for centuries. Like any craft, nautical charting can take advantage of emerging technology to modernize its business operations. This document demonstrates innovations intended to transform paper chart production. With hydrographic offices shifting to an 'ENC-first' based workflow, it illustrates how traditional nautical charts can be automatically generated directly from an ENC. And, while automation cannot replace all of a cartographer's knowledge and expertise, what tradeoffs are reasonable in order to achieve time-savings and cartographic consistency without sacrificing quality. Lastly, the document highlights what hydrographic offices can take away from other mapping industries and organizations that have already undergone this transformation.

1.0 Introduction

Over the past decade, hydrographic offices have been heavily strained by shrinking budgets and reduced resources. Meanwhile, the mandate and workload associated with delivering products to end users with the most up-to-date information that still maintain the same quality and commitment to safety of navigation remains unaltered. At the same time, there has been a shift in the medium used to meet navigational equipment requirements aboard the bridge of a ship, away from traditional paper cartographic products and towards ENCs viewed in an ECDIS with S-52[1].

Despite these trends in policy, there remains an entire maritime community — pilots, navigators, recreational boaters, and even cartographers — who have come to rely on the art and history of the traditional paper nautical chart in equal measure to its original purpose as a tool critical to safe navigation.

The result of these disparate factors means that many chart-producing agencies are seeking new ways to modernize and reduce the time it takes to produce and deliver their suite of paper products. Maintaining the cartographic quality associated with the craft of paper charting while simultaneously delivering the most up-to-date information in an era of depleted assets furthers the resource strains felt by many hydrographic offices.

Fortunately, exciting new technology is emerging, and in fact is already in use in other sectors, like topographic mapping. This technology allows for the complete automation of maps and charts from a web-interface, meaning no map production software needs to exist on the client

machine. You can request and download a raster nautical chart that is generated from the latest ENC-based vector data from your home computer, smartphone, or other mobile device.

This document highlights these new developments in automation technology, which possess the potential to propel nautical chart production into the 21st century, leveraging true cloud-based charting to solve the problems faced today by many hydrographic offices. It will cover existing desktop-based automation, illustrate how that technology is leveraged in the cloud, and demonstrate its actual implementation in another field to make evident its value and potential for nautical chart production.

2.0 Existing Chart Automation in the Desktop

Production systems that use an ENC-first philosophy are capable of using an ENC to generate all navigational products – including paper charts. In the transformation of an ENC into a paper nautical chart, there are many predictable and repeatable processes. Because of this, the transformation is a logical candidate for automation.

The automation of map and chart finishing processes is not a new concept. There are several permutations of automation technology available in a variety of software applications, all aimed at reducing the workload associated with cartographic finishing.

In Esri's ArcGIS for Maritime: Charting solution product, which uses the same data to generate charts and ENCs, the chart automation tool (CAT) executes a series of scripts that are designed to minimize manual cartographic editing and finishing, providing an advanced starting point for the cartographer.

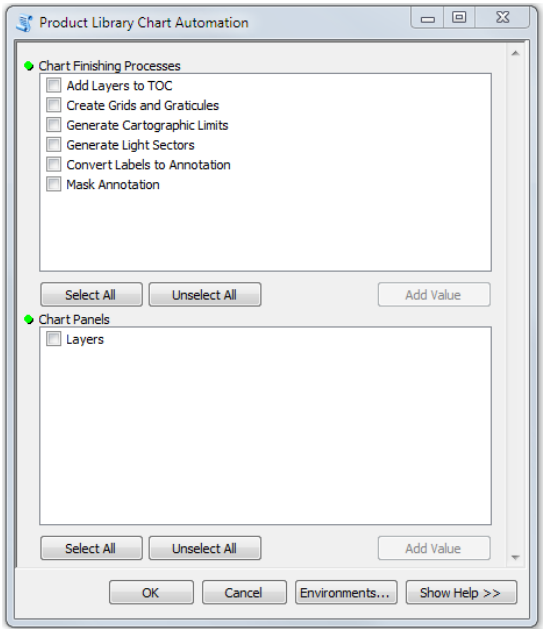


Image of the Chart Automation Tool (CAT)

The CAT can perform the following steps without input from the user:

- **Adds and organizes chart data in a map document**
  This process adds all necessary nautical data. It prioritizes the data in the correct draw order. It turns on all the text with the appropriate font, font size, and font color. And, it positions the text relative to the object being labeled.
- **Creates INT2 grids**
  Since the tool is aware of the chart scale, it is capable of choosing the appropriate INT2 grid. This process also sets the projection of the map document.
- **Resolves conflicts between area limit features and the coastline**
  Since most area limit features in S-57 are captured as area objects and an ENC is being used as the data source to create the chart, there can be symbology conflicts between these limit features and other objects. For example, prohibited anchorage area limits can conflict with the symbology of the coastline where the two features are coincident. This part of the process converts those area objects to lines and eliminates the portion that is coincident with the coastline, removing symbology conflicts automatically without the need for masking.
- **Generates light sectors**
  The generate light sectors portion of the CAT uses information in NAVAID points to create light sector symbols.
- **Creates feature-linked annotation**
  Feature-linked annotation is text that is linked to objects so that as an object's attributes change, the linked text updates automatically as well.
- **Generates text masks**
  CAT determines where certain types of text intersect other features and creates a mask at the intersection. For example, masks will be created at the intersection of sounding text and latitude/longitude graticule lines.

All of the logic that defines the individual processes — for example, which INT2 grid is used based on the chart scale, or which text should be masked against which features — is configured in a script. This script is completely open and accessible to the user. And, because it is written in a common scripting language (Python), it can be easily customized to meet an agency's unique cartographic rules. Moreover, any number of Esri geoprocessing tools or additional Python scripts can be added to the list of processes that are executed by the CAT, if desired.

Although the tool does not require input from the user, many aspects of the tool can be exposed as user-defined parameters to be filled out by the cartographer before the tool is executed. For example, the tool automatically determines the standard parallel for the projection based on the chart extent. However, if you do not want the tool to determine the standard parallel for you, the standard parallel can be exposed as a parameter in the user interface that a cartographer would define before running the tool.

3.0 Charting in the Cloud

Although the current purpose and scope of CAT is to provide a good starting point in the production of a traditional paper chart from an ENC in the existing ArcGIS Desktop application, ArcMap, it was developed with a web-based product-on-demand (PoD) application in mind.

Web-GIS applications provide the capability to completely automate the production of charts from ENCs using a web-browser as the interface – meaning no desktop technology needs to exist on the client machine making the chart request, thus lowering software acquisition costs.

This technology can be leveraged in a web-based environment in a variety of ways. It can be implemented as a complete PoD application, as a hybrid where any amount of automated cartographic finishing is performed on the server delivering a map package to the cartographer for some manual finishing, or it can be leveraged as a tool for simply sharing static maps and charts, regardless of the technology used to generate them.

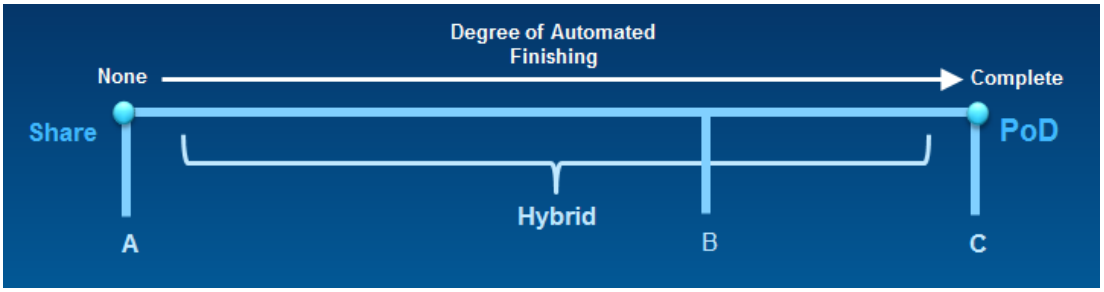


Diagram of spectrum of options available, from simple Static Chart Download to complete Product-on-Demand, and everything in between

A. With a static chart download PoD implementation, traditional paper chart workflows can still be performed in any desktop software application. The purpose of the server component in this architecture is purely limited to the dissemination of the finished raster nautical chart. The Adobe Portable Document Format (PDF) files, or other raster formats, are simply stored on the server. When a request for a product is made through the web-interface, the raster file is delivered to the client device making the map request.

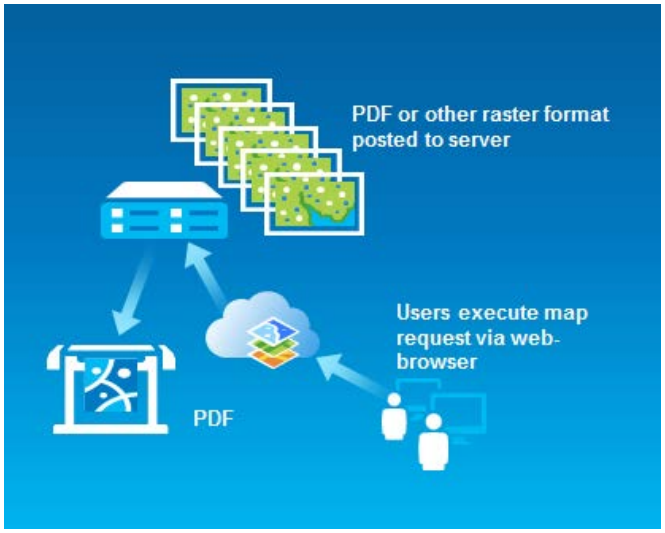


Diagram of a 'Static Chart Download' PoD System

B. Using a hybrid, or partially automated, approach, some degree of finishing is automated while some, hand-placed text for example, is performed manually by a cartographer. When complete, the cartographer then posts the cartographically finished vector data to a cartographic database. When the end-user requests a chart via the web-application, the latest cartographically finished data is pulled from the cartographic database, the marginalia is generated on-the-fly, and a resulting raster nautical chart is delivered to the person making the map request. One of the main advantages of a hybrid approach is that it supports the concept of a dynamic extent. Chart requests are no longer constrained by the boundaries of existing chart products, and users are free to define their own custom chart extent.

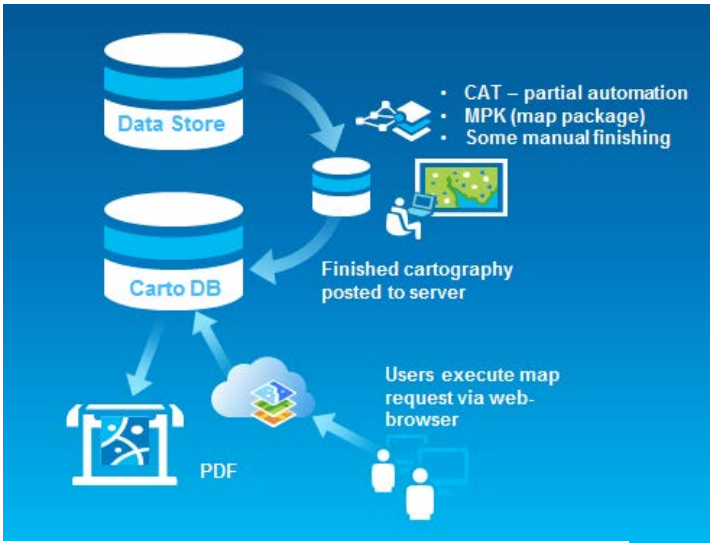


Diagram of a 'Hybrid', or partially automated, PoD system

C. In a complete PoD implementation, all of the finishing is processed automatically and on demand on the server at the time the map request is made. The output is then delivered directly to the end-user in the raster format of their choosing. In addition to supporting dynamic chart extents, similar to the hybrid approach, a completely automated PoD eliminates manual cartographic work entirely, leading to significant savings in costs while simultaneously improving the currency of product information.

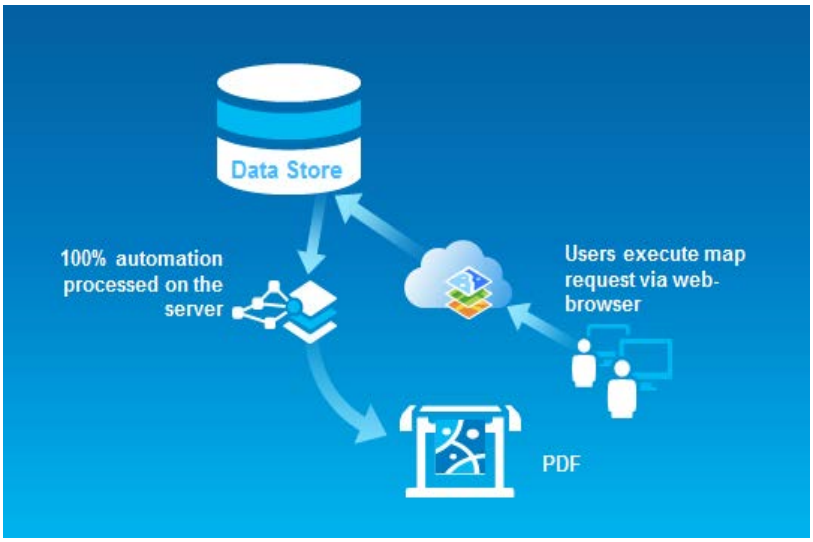


Diagram of a Complete PoD system

4.0 Web-based Map Automation in Action

Outside of the maritime domain, PoD Web-GIS has already been implemented by major mapping agencies. One example is the United States Forest Service, which manages over

17,000 maps in their PoD application, producing approximately 750 maps per month from this service.

(Access to a sample application that illustrates the capabilities of PoD technology is available upon request by contacting the authors of this document.)

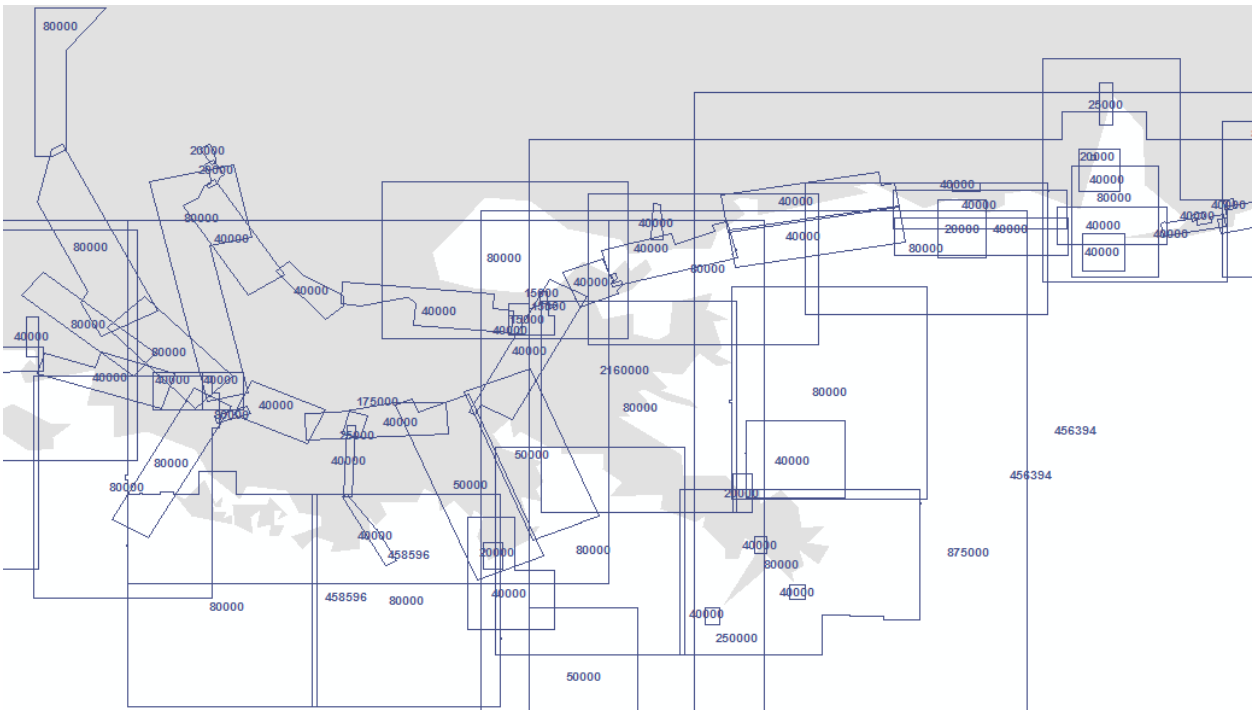
There are many options related to the types of products and output formats available from the web-application. Provided a product over an area containing supporting data is chosen, the output will be in the form of a completed quad map. In addition to returning an easily transferrable map in a variety of widely supported raster formats, vector-based map packages can also be downloaded. A map package delivers the data necessary to perform further cartographic finishing in the ArcGIS for Desktop application, ArcMap.

Not only can users of this technology request a map from an existing product extent, custom products by can be defined by dynamically drawing a box, or by choosing a page size and then letting the application define the extent that will fit within that page size. Lines can even be drawn in the web-interface, for example, along a planned navigational route, which will generate a series of charts at a given scale that intersect the route.

When a map is requested through the web-application, a process is executed on the server that creates the product, on-the-fly. It is possible that if a map is requested of the same area at a later date, the content could be different, as the most up-to-date data is constantly being posted to the database that resides on the server.

5.0 Full Automation vs. Tradition

The obstacles to implementing fully automated paper nautical chart production are not driven by technological limitations, but instead rest within a few key areas of legacy paper charting traditions. A couple of examples of the change necessary to implement full automation include conflating myriad scales available in a typical raster chart portfolio down to a few key product scales, as well as re-scheming the traditionally irregular paper chart layouts to a more consistent grid.



The range of scales available in the portfolio of paper nautical charts is irregular, overlapping and wildly diverse.

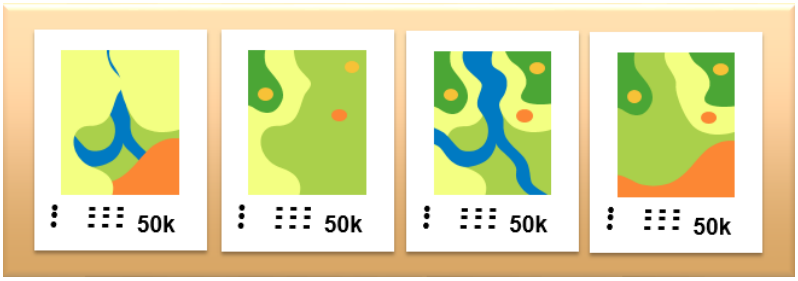
The more unique the portfolio, the more difficult it becomes to maintain and automate. Some agencies support well over 100 unique scales in their portfolio of paper chart products. Most marginalia is placed inside the chart plan, or kapp, meaning it is placed inside the map area. Titles, scale bars, projection information and other key map elements are carefully placed inside the map face to avoid conflict with features important to the map reader, depending on which corner of the chart has enough inconspicuous land to support their placement. Because of this, it is not a stretch to say that each chart possesses its own unique layout.

Meanwhile, the topographic domain enjoys a perfectly gridded and evenly sized and distributed collection of product extents at only a handful pre-defined of scales (e.g., 1:25k, 1:50k, 1:100k).

Topographic map layouts are perfectly gridded over a common scale.

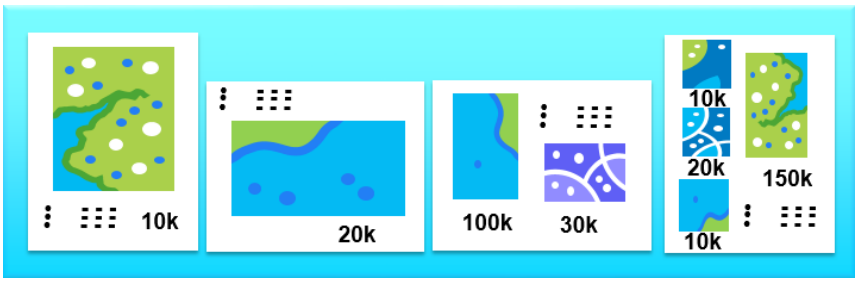
Although it is not feasible to have a continuous coverage of nautical chart products at 1:25k, since large scale coverage is not necessary in all navigable areas, nicely gridded layouts over focused areas are certainly achievable.

In the topographic mapping domain, the use of a consistently gridded product portfolio means that the map page, its layout, marginalia and other surround information, can be automated and maintained much more efficiently and consistently. The layout is the same on every product, while only the geographic area of the map content changes and no elements are placed inside the map area.



Consistency in layout and scale are critical aspects to fully achieving automated map production.

Conversely, traditional paper chart layouts are like snowflakes in that no two are precisely the same. This results in obstacles to complete automation, especially as the layout is concerned, which are not experienced with topographic mapping products.



Typical nautical chart layouts – inconsistency in layout and scale hinders fully automated production.

Paper nautical chart producers should not look at the effort associated with re-scheming and re-scaling their product portfolios as a significant technical hurdle. With a completely automated PoD approach, the cartography is all done on-the-fly, so re-scheming could conceivably be done at will with no impact on the time it takes to generate new products from the new scheme. Today, it is the bindings of tradition that prohibit producers of paper nautical charts from the agility required to keep pace with the benefits created by rapidly changing technology.

6.0 Summary

The introduction of Product-on-Demand technology allows for dramatic changes in the way hydrographic offices have traditionally created and maintained their products.

This innovation asks several challenging questions of chart producing agencies: is there still a need for traditional cartographic products? Is there still a need for raster updates when the continually-maintained ENC data can be automatically converted into a finished chart in a matter of minutes? Can traditions be sacrificed in favor of cost, currency of information, simplicity, and alacrity?

The ultimate success of full automation, or near-full automation, lies less within the technical capabilities of modern software, and more within the willingness of hydrographic offices to part with legacy paper charting traditions that are based on workflows that can be overcome by technology. Regardless of the software provider, there is little doubt that modern technology can come quite close to producing a cartographically finished nautical chart with very little intervention from the cartographer.

It may be an internal political challenge for hydrographic offices to implement the changes required to best support full paper chart automation, such as re-scheming their raster chart portfolios to topographic-style layouts. However, if the goal of an agency is to gain maximum efficiency and cost benefits, while still supporting their main initiatives, including safety of navigation, the technology exists to support these goals. With the production and use of paper nautical charts expected to continue well beyond 2015, producing authorities have access to technological alternatives to improve the value and return on investment of these information products for both mariners and other users of nautical data, while simultaneously addressing strain on budgets and resources.

About the author

Craig T. Greene is the Product Owner of the Esri Desktop Solution Product, ArcGIS for Maritime: Charting. Craig joined Esri's Maritime Team as a cartographer in 2006. Throughout his cartographic career, Craig has worked on a diverse collection mapping projects, including city mapping for the Oregon Department of Transportation, as a cartographer on the Atlas of Oregon, as the lead designer of Esri's Ocean Basemap, and on the Thailand Topographic Mapping project. Craig also supported the IHO's paper chart working group, CSPCWG, as an industry liaise from 2009-2012. Craig holds a Bachelor of Science in Geography of from the University of Oregon, with special emphasis in Cartography and GIS.

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