Product on Demand—
Automating Cartographic Production

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Product on Demand—Automating Cartographic Production

An ESRI White Paper

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Introduction

Traditionally, the creation of high-quality, high-volume cartographic products is a hands-on, time-intensive process. The Product on Demand (POD) application brings high-end cartography to the server, introducing on-the-fly map and chart generation over the Web. This white paper will outline benefits, system architecture, and implementation considerations for POD, as well as provide case studies of several POD projects.

Map and chart production organizations face the issue of meeting a high demand for up-to-date products at a reduced cost. Today's proliferation of online mapping services may solve this challenge for readily available city, street, and other common types of map content, but for customers and products demanding higher-end cartography rich with information, these services typically do not meet expectations. POD provides customers with online mapping services they've experienced elsewhere, combined with the high-end quality and detail they've come to expect from cartographic products created using traditional interactive methods. The modern demand for easily accessible, quality products and their customization is the driving factor behind POD technology.

Case Studies

National Geospatial-Intelligence Agency—Enterprise Product on Demand Service

Highlights

- Provided the SS *CURTISS,* a marine aviation maintenance logistics ship, with an updated harbor chart within five days of receiving surveyed data
- Realized 50 percent time savings when creating updated nautical charts necessary for the Georgia-Russia crisis
- Allows NGA to provide the most accurate data possible to support its customers' needs

The National Geospatial-Intelligence Agency (NGA) is a U.S. Department of Defense combat support agency and a member of the national intelligence community. Its primary mission is to provide geospatial intelligence (GEOINT) to U.S. Armed Forces and government agencies in support of U.S. national security, as well as aeronautical and nautical safety of navigation to a variety of users.

To better provide its users with access to timely, accurate, and relevant geospatial intelligence, NGA contracted with ESRI Professional Services in 2004 for a new initiative now known as Enterprise Product on Demand Services (ePODS). One of the main goals of this project was to automate map and chart creation to gain efficiency and reduce errors. In addition, NGA sought to permit access to the most current NGA aeronautical, nautical, and topographic data for selected customers. The ability to design and print custom maps was also high on the list of desired functionality.

A Web portal that gives select users access to the system from specific NGA networks, ePODS is built on service-oriented architecture (SOA) using ESRI's ArcGIS® family of products. ArcGIS Server and ArcIMS® provide geographic information system (GIS) Web services and portal functionality, respectively. Production Line Tool Sets (PLTS™) for ArcGIS provides a robust final touchup or finishing environment for aeronautical, nautical, and topographic maps and charts that NGA chooses to edit prior to publication.

Using the Web interface, users select the data they need; configure it into a map; apply specific cartographic rules; preview the end product; and either print it or download a source package that includes data, instructions, and media to work locally on the maps for further refinement. The ePODS application produces output in several formats including PDF, GeoTIFF, JPEG, CADRG, and geodatabase/ArcMap™ document (MXD) downloads.

Continuing to mature and offer more products to NGA's user community, in April 2007, the ePODS program moved from being a prototype program to an official program of record at NGA. This status provides funding through fiscal year 2015 and the opportunity to become part of NGA's life cycle processes. While ePODS maritime production has been ongoing since 2007, it recently passed NGA's Operational Readiness Review (ORR)/Operational Acceptance Review (OAR). This milestone was the final step in NGA's acceptance process and determined that the maritime service can be officially considered operational by NGA. Future services to undergo an ORR/OAR include Topographic Line Maps (TLM) in summer 2009 and Tactical Pilotage Charts (TPC) and Operational Area (OPAREA) charts in winter 2009. Additional map and chart types will continue to be added through 2011.

The first iteration of the ePODS system went into production in September 2007 and provided immediate benefits. One example involved the SS *CURTISS,* one of the United States' Military Sealift Command's two aviation maintenance logistics ships. While under way to an overseas port, the crew recognized a need for an updated harbor chart for their destination. They notified the Naval Oceanographic Office, which dispatched a survey team to collect new data for the destination port and forwarded that data to NGA. Once received, a combined team from NGA and ESRI accessed the data with ePODS and produced an updated harbor chart in only two days. This updated chart was sent to the SS *CURTISS* within five days of receiving the data and was used by the ship to safely sail into the harbor. Using traditional production methods, this same chart would typically take six to eight weeks to reach operational users.

In summer 2008, NGA was faced with another operational challenge—how to rapidly produce up-to-date nautical charts for the U.S. Navy and Coast Guard to use while supporting the Georgia-Russia crisis. Once again, NGA turned to ePODS and was able to produce six nautical charts of varying scales and rapidly disseminate them to operational users at sea. In the end, NGA realized an approximate 50 percent time savings over legacy production methods during this crisis.

The ePODS system will continue to allow NGA to change its focus from producing cartographic products to providing the most accurate data possible to support its customers' needs. With the help of ePODS, NGA has significantly reduced the time required to produce maps and charts. For some maps and charts, production time has dropped from hundreds of hours to less than one.

NGA further increased its efficiency by using ePODS to determine on a case-by-case basis how much production time to spend on a product based on the intended use of the product, eliminating the need to spend hundreds of hours finishing a one-off product that will only be used for quick analysis.

The system allows NGA to focus more of its resources on data quality, integrity, and currency rather than cartographic product generation. With ePODS, NGA is able to provide its customers with timely access to relevant and accurate GEOINT data. Safety of navigation is also significantly improved for both military personnel and civilians with the improvements in accuracy and timeliness of aeronautical and nautical charts.

USDA Forest Service—FSTopo

The United States Department of Agriculture (USDA) Forest Service (USFS) is responsible for managing all national forests owned by the federal government. One of its responsibilities is to supply agency resource managers and the public with basemapping products over the USFS' area of interest. These cartographic products include the 1:24,000 and 1:63,360 (in Alaska) topographic maps. USFS shares this duty of mapping the country with the United States Geologic Survey (USGS). USFS' portfolio consists of approximately 10,600 of these 7.5-minute quadrangles (the extent varies in Alaska) over the national forests. Like many federal mapping agencies, USFS wanted to improve map revision and production efficiency. ESRI, based on its success with helping NGA implement the ePODS system, worked closely with USFS to implement a similar system—FSTopo—tailored to its large-scale products and associated workflows.

Previously, basemap cartographic data was managed in ArcSDE® (where edits were performed in checked-out ArcInfo® coverages. To take full advantage of ArcGIS server abilities, a project was implemented to enable editing in a seamless enterprise geodatabase. The new geodatabase model would ensure that data could be maintained more effectively while enabling required production capability. The model was constructed as a cartographic database, meaning it would be used directly to make high-end cartographic products with limited processing on the server. However, before the maps were made directly from the geodatabase, cartographic editing would ensure that required cartographic standards were upheld. This included topologically correct data from vectors originally collected on a CAD system. Data topology enabled symbolization and automated product generation. The legacy coverage annotation was translated into geodatabase annotation to meet product specifications involving text placement. Due to the relatively large scale of the maps, the contour data was quite extensive. To ensure that performance was maximized, ArcSDE best practices regarding spatial indexing were implemented.

Once the database model was populated with the required data, a map template document was constructed. The document comprised both static and dynamic surround elements. Two custom dynamic elements were created: the declination diagram and the adjoining sheet diagram. Due to the new ability for users via POD to create custom maps that cross traditional boundaries, the adjoining sheet diagram was required to show the extent of the current map as it related to existing map sheets. The declination diagram, which shows the relationship between magnetic and true north, was programmed to be sure it would update based on any location across the United States chosen by a user. Both these elements were developed to allow deployment on ArcGIS Server or ArcGIS Desktop, enabling USFS to use the elements in either environment.

Once the data and map templates were configured, the project switched its focus to the server architecture and deployment. The site is hosted externally via a third-party commercial company to ensure around-the-clock support, maintenance, and performance. FSTopo's system architecture consists of four physical servers and three virtual servers. One of the physical servers is the data server, running ArcSDE® and Oracle. The three remaining servers house the three virtual servers, which are used to load balance the map requests. The virtual servers provide an ArcIMS front end that receives the map request from the client, depending on which server is free. The request is then passed to one of the remaining three physical servers, which are running ArcGIS Server. Again, to ensure maximized load balancing, the request is passed to the server not currently being used. This is where the map is created with the most current data, exported to PDF format, and sent back to the client.

FSTopo has improved map production efficiency. The cost and overhead of film-based map production has been eliminated. The site produces approximately 30 maps a day, with access limited to USFS only; however, public access is planned. Other plans include extending the delivery formats to include GeoTIFFs, vectors, and text.

Government of the Hong Kong Special Administrative Region, Lands Department—Geographic Information Retrieval System 2

The Lands Department is the government department responsible for the administration of all land within the Hong Kong Special Administrative Region. Some of its main functions include land disposal for development purposes, valuation of land, acquisition of private land for public projects, land lease control and enforcement, maintenance of the geodetic control network, land boundary surveys, aerial surveys, and map production. The Lands Department comprises a number of district offices throughout Hong Kong. It is vital to have a simple-to-use system that allows all staff to access the topographic maps and land record information via a thin Internet client. The Geographic Information Retrieval System 2 (GIRS2) is the next-generation application designed to allow Lands Department staff to continue to easily access the information and produce standard maps and other types of reports for land administration purposes using POD technology.

The system is required to be flexible and configurable to support the functions and responsibilities of the different offices within Lands Department; however, constraints and standards must also be enforced. These constraints and standards relate not only to the maps and plans themselves but also users' access to the different datasets for display within the maps. The initial rollout of the map production portion of the GIRS2 application will consist of seven unique plan types—within a single plan type, the styles vary greatly. The plans and styles change with respect to page size, scale, geographic extent, data content, and marginal and note information. Authorized Lands Department staff are provided with access to change any or all of these parameters on each type of plan. Configuring the map templates for such a dynamic system involves a significant amount of planning intelligence from the system.

GIRS2, once completed, will leverage the latest Web-based server technologies, providing a modern user experience customized using Adobe's Flex technology. ESRI's ArcGIS Server technology allows the deployment of a Web-based GIS solution to a workforce of approximately 500 users and provides map content over the Web.

Key Benefits of POD

POD allows an agency to streamline and automate its production workflows, allowing quickly produced, cartographically refined products using the most up-to-date data from the available data stores. Reducing the time needed to create cartographic products allows analysts to focus more on updating and performing quality control on the data. When a data change is made in the central database, any chart downloaded from the POD system will reflect that change. The up-to-date information is made immediately available to any user that connects to the system.

The POD service is a Web service, so anyone connected to the network can access POD by using a Web browser. If published to the World Wide Web, the POD service is available to anyone with an Internet connection. The Web site interface is customizable based on need and purpose, and downloadable formats can include (but are not limited to) JPEG, TIFF, and PDF. Unlike with traditional paper maps, users are not limited to only predefined extents—custom extents and scale can be made available, allowing custom map products that meet the direct needs of each specific user.

In addition to map generation, POD users also have the ability to export the data to a finishing package. The finishing package is a ZIP file containing a geodatabase, related data, a map document, and any other relevant documents; the contents of the finishing package are customizable by the organization publishing the service. The user can import this information into ArcGIS Desktop and perform additional cartographic finishing operations such as adding more data sources for custom charts; performing analysis; or building finished products for traditional, color-separated, printed maps.

Workflows for interacting with the POD service are dependent on the needs of the organization, and the variety of output options already available through POD offers flexibility. The POD service can be used solely as an internal tool for an organization to keep up with the demands of the customer. This means that internal analysts will receive customer requests, generate the product internally, fine-tune the cartography (using the finishing package option, if it is needed), and send the final product to the customer either digitally or as a printed output. Another approach is to allow external customers to connect to the POD service directly and download their desired product on the fly. In this workflow, depending on what makes sense to the publishing organization, customers may have the ability to choose their own area of interest, as well as define the page size, select the specific information they want to see, and select the output type they want. Once all their options are defined, they just need to click the download button, and a new chart is created specifically for them.

POD was developed to

- Provide users with quality cartographic products via a Web portal.
- Generate maps on the fly from the latest data.
- Offer an alternative to outdated products.
- Provide users with rapid access to custom centered maps.
- Accelerate map creation efforts by automating the generation of the base cartographic products.

- Enable the generation of current maps based on demand.
- Improve and expand functional capabilities in map creation and dissemination.
- Remove or eliminate the need for highly labor-intensive methods of producing specification maps and products.
- Reduce or eliminate the need for manual updates on products.

The benefits of POD include the following:

- The ability to focus maintenance efforts on database(s) and still provide products without expending additional resources
- The ability to update older products, making them more timely and accurate
- Customer access to the latest high-quality data available
- Wider variety of customization and delivery options available to the customer

System Architecture

POD is built using ESRI's three-tiered architecture, which is a service-oriented architecture designed to support enterprise-level implementations. The three tiers of this architecture are the authoring tier, the serving or publishing tier, and the use or consumption tier (see figure 1). For the POD-specific application of this architecture, the authoring tier contains the database-driven cartographic rules, label content, and label placement. Product logic, permissions, and a connection to the database and product templates are all established at the server tier. The use tier can include thick-client software such as ArcGIS Desktop, thin-client software such as a Web browser, or direct connections such as those from a mobile device.

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Figure 1
Three-Tiered Architecture

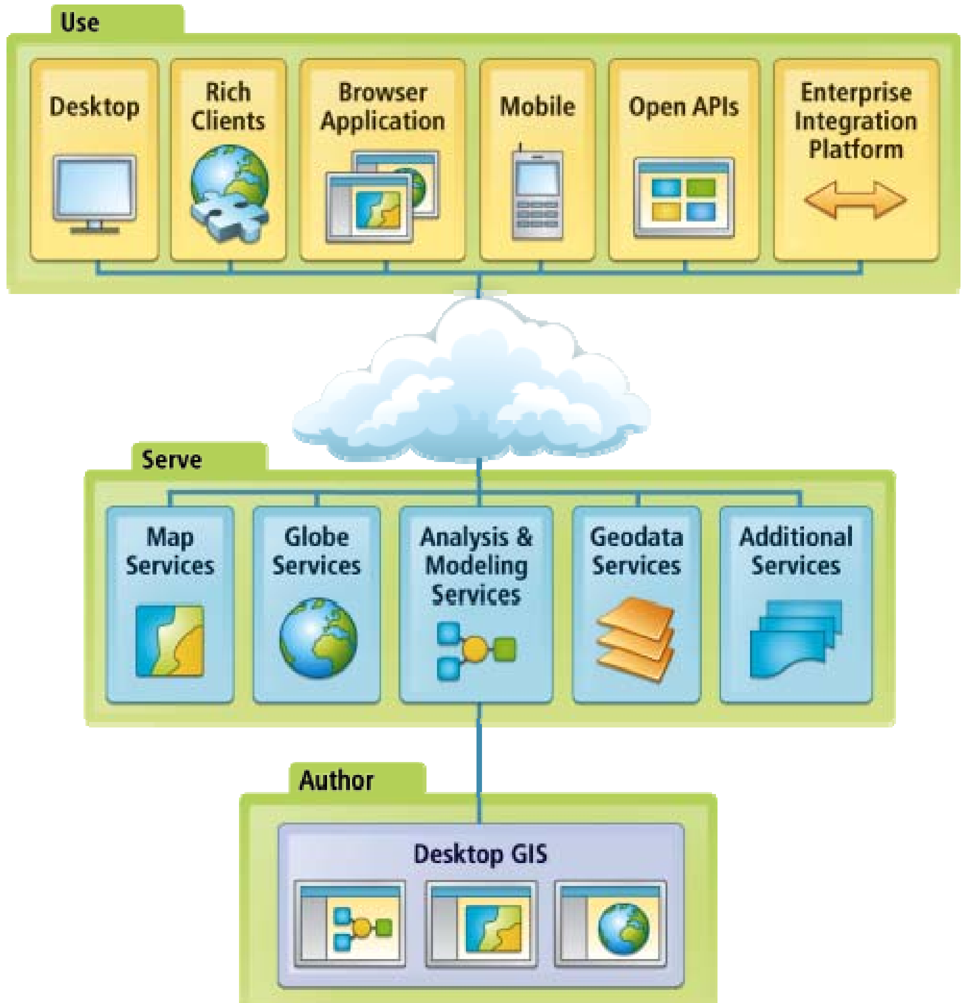

Figure 2 outlines the POD architecture in more detail and shows the relationship between POD and ArcGIS Server. The yellow boxes represent POD components, and the white boxes represent unique components to be developed for each POD implementation. The POD framework is composed of two components that sit on top of ArcGIS Server—the POD interface and the POD server. POD uses a Simple Object Access Protocol (SOAP) Web service end point that can be called through other applications. The POD server contains all the business logic needed for the particular products. The requests from the POD interface are processed by ArcGIS Server, which calls the project's specific data and map templates.

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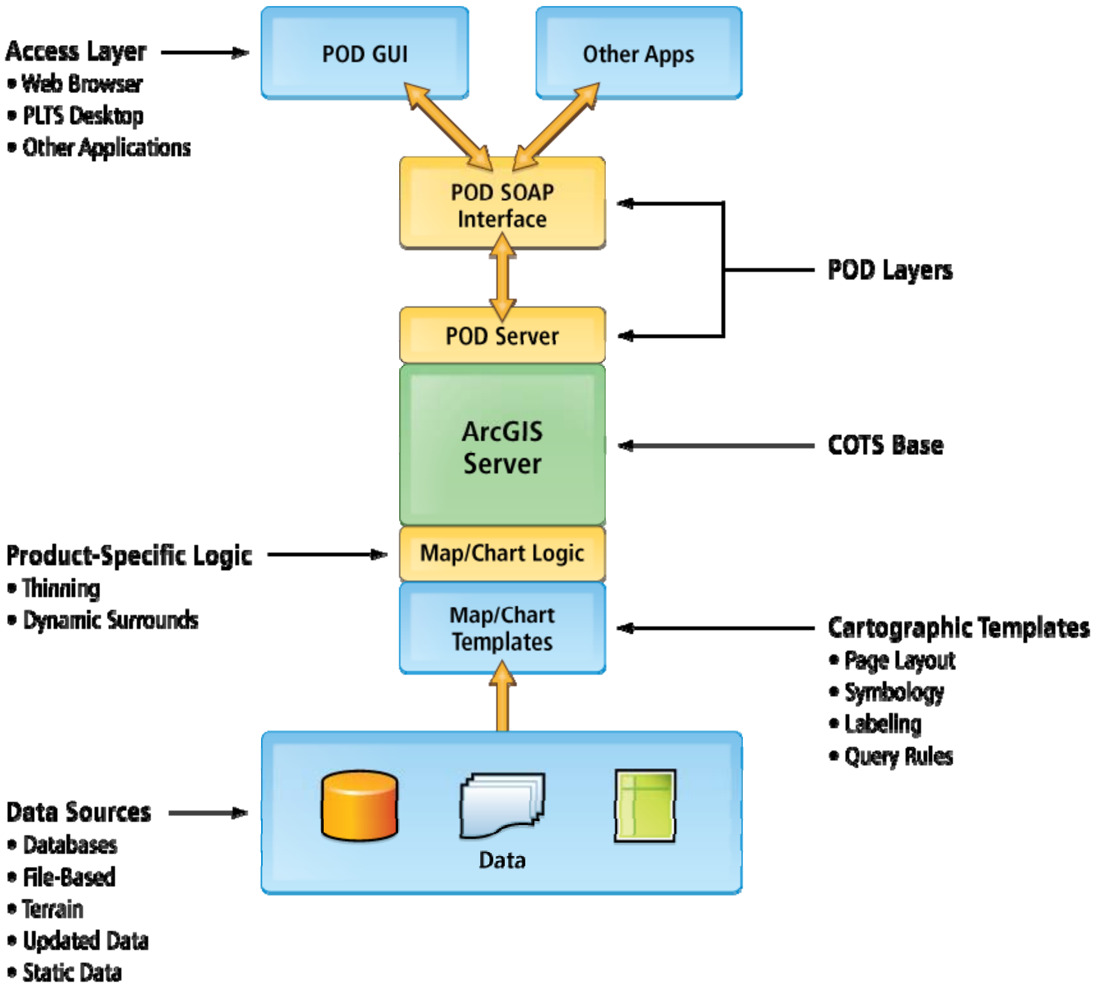
Figure 2
Layered Components of POD



Web Components

- Web server accepts the request from the user.
- The request is passed on to the Internet map server.
  - The map server finds the requested area of interest (AOI).
    - The data on the map server viewer is not the same data that will be exported on the chart.
  - The map server takes all the users' inputs and queries and passes them along to ArcGIS Server to do the heavy lifting.

ArcGIS Server

- ArcGIS Server handles business logic for a particular product.
  - Dynamic surround element updates based on data content
  - Projection information updates based on centerpoint of an AOI
  - Addition of output formats (e.g., GeoTIFF & CADRG)

- Determination of constraints for page size and scale of products
- Back-end processing of data for enhanced cartographic display
- On-the-fly data conversion and loading
- Thinning of hydrographic and transportation network features

ArcSDE

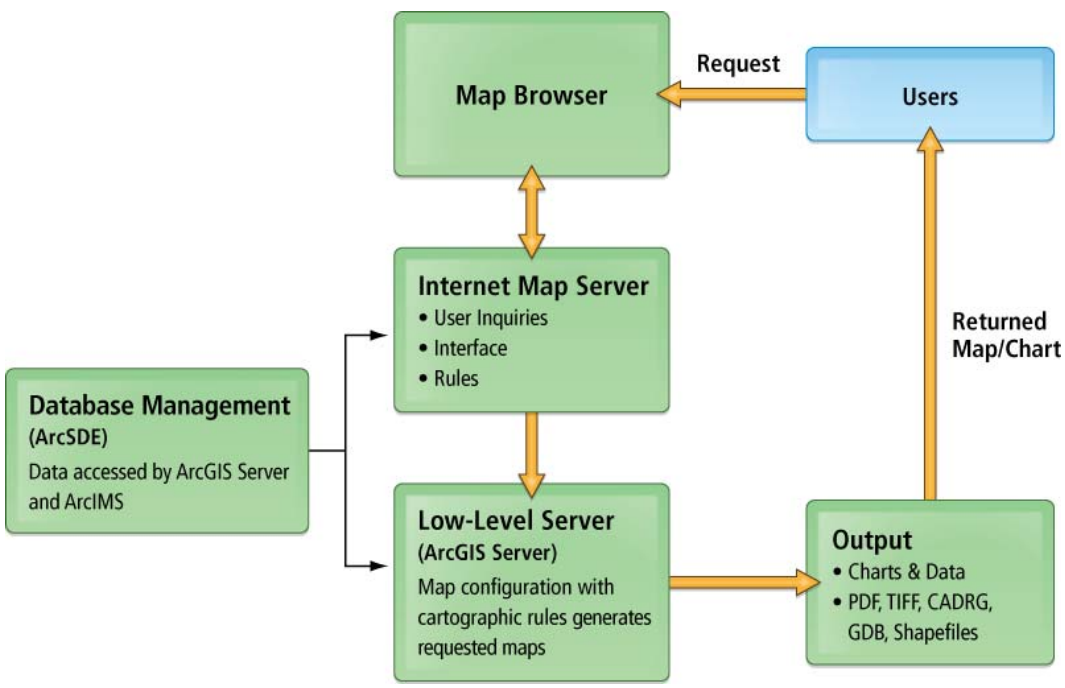
- ArcSDE is the database access engine to spatial data and its associated attributes.
  - Requires a relational database management system (RDBMS)—in this case, Oracle 10*g*

Specific Technologies Used for NGA ePODS

There are a variety of ways that POD can be configured. It is primarily composed of COTS ESRI software and third-party software. COTS ArcGIS Server is available in two base languages—.NET and Java. Either one can be used to create a POD site; the decision depends on which existing technologies the system may want to leverage and on the language with which the system needs to be built.

The ePODS application uses a combination of third-party software and COTS ESRI software. The relationship of these various technologies is illustrated in figure 3.

Figure 3
The ePODS Architecture



Technologies used in ePODS include

- Third-party software
  - BEA JRockit
  - Apache Web Server
  - Apache Tomcat Servlet Container

- Oracle 10*g*
- Internet Explorer

- COTS ESRI® software
  - ArcGIS Desktop
  - ArcGIS Server
  - ArcIMS

- ePODS specific files
  - The ePODS software components are the PodServer, POD Service, and ePODS Web application.

Steps for Implementation

The two major steps in implementing a POD system are customization and deployment. As mentioned above, there are project-specific components that are unique for each implementation of POD. The development of these components makes up the customization step for POD and is the most time-consuming piece to set up. The customized components fall into three groups: product-specific map templates and business logic, project-specific datasets, and an entry point such as a Web page.

Customization

Map Templates and Business Logic

For each kind of product that needs to be produced using POD, a template map (or chart) document is created. This document stores the unique details about the map such as symbolization, surround elements, specific data layers, and spatial information. Symbolization within the map document defines when to use fonts, shapes, points, lines, and polygons to represent particular kinds of information displayed within the map itself. The graphics around the map, or the surround elements, can include things like legends, scale bars, and north arrows. Surround elements can be set up to be dynamic, meaning that they can change depending on the part of the world over which the chart is generated. The layers of data needed for each type of chart are also defined in the template chart document, as well as spatial information such as scale and projection. Setting up and refining the template are key to a cartographically mature output.

Sometimes products need special processes to happen on the fly that cannot be set up in the map document. An example of this is hydro thinning. When NGA's ePODS was set up, the hydro data, or the records of rivers and streams, was too dense when placed directly on the chart. The information was not very useful because there were too many small streams showing up on the page; the output looked like a blue blob rather than lines representing rivers. The hydro-thinning back-end process introduced a logic that dynamically thinned out all the smaller streams, leaving just the main bodies of water to populate on the chart. This allowed NGA to keep its data as it originally existed and helped produce a cleaner output. Back-end processes like this can support needed business logic and can extend beyond just data processing.

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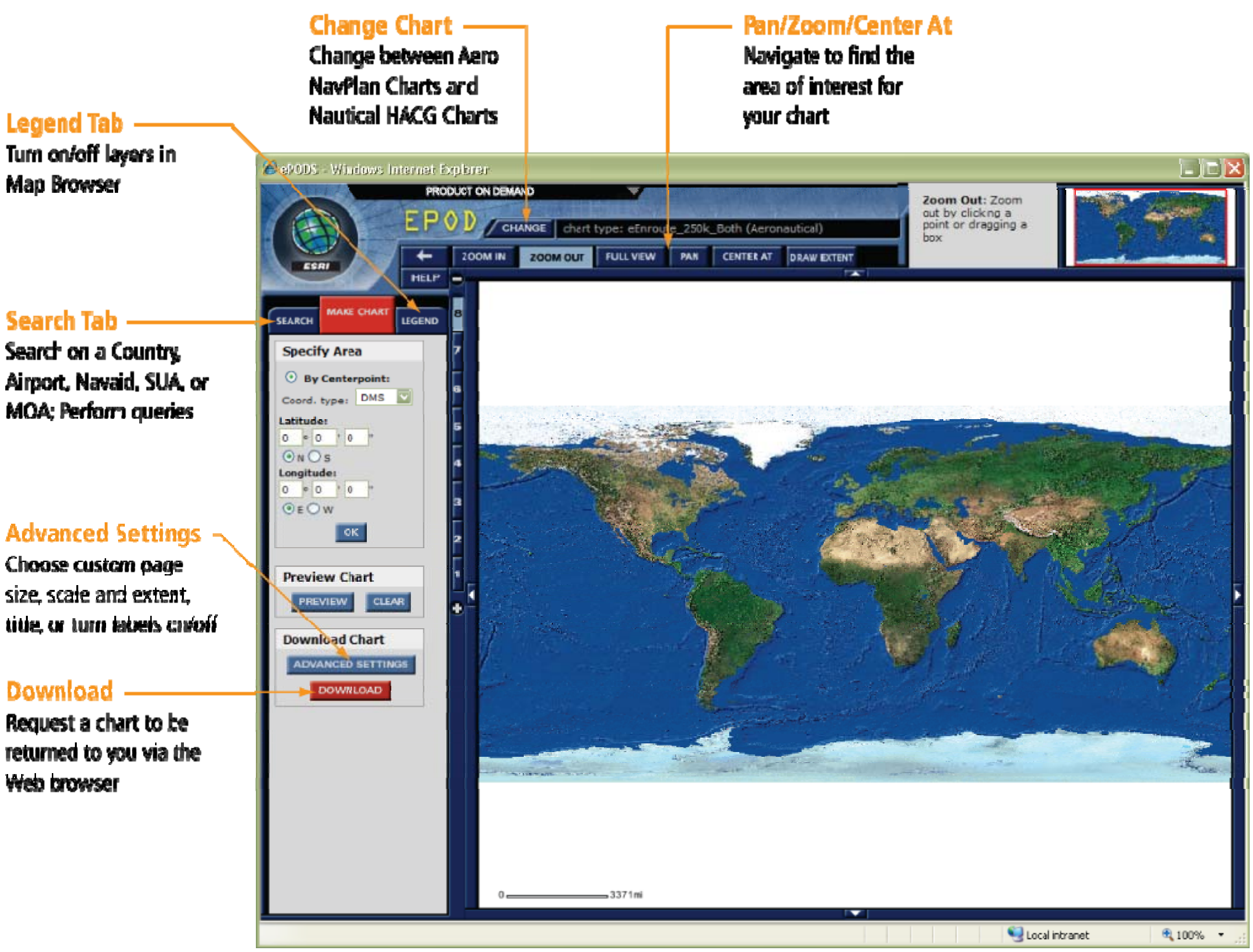
Connecting to the Datasets

The map template documents are created using the ArcGIS Desktop ArcMap application. Within ArcMap, data is added to the document in layers. Each layer represents a particular data file, such as a feature class, a shapefile, or a raster file. As layers of data are added in the MXD, the location of the data is stored within that layer. When a new product is requested from the server, the data is retrieved using this stored location.

Setting Up a Web Page

The POD user interface (usually a Web page) can be set up in any way that best suits the end user. The options are open ended. In the simplest case, the front end can be a direct connection from another application designed to ingest the available POD products. In another simple case, the front-end Web application can allow the user only the choice of AOI and product type. The NGA ePODS Web application is the most robust front end developed yet for POD, so it's a nice example to illustrate all the possible options for the Web application. Options for a POD front end are not limited to the ePODS list of functionality.

Figure 4
The ePODS Web Application



A summary of options in the ePODS front end are outlined in figure 4. This Web page provides the user with a variety of options for product search and download. The user has the ability to search by tile number, coordinate entry, country, and industry-specific codes such as special use airspaces (SUAs). Product options are many as well, including the ability to define any reasonable page size, on/off check boxes for each of the information (or data) layers, customized title, and the option to not include the surround elements such as the legend and scale bar. File format for product download is another option available to the user. The generic formats include JPEG, TIFF, PDF, and EPS. Industry-specific formats include georeferenced PDF, Spot EPS, CADRG, and ECRG. The finishing package is another option for file type and, as noted earlier in this paper, is a ZIP file containing the map document and/or associated data.

Deployment

Once the system is functioning as expected and is sufficiently debugged, the next step is to go live. This may be as simple as sending a Web address to key users but can be as complex as completely changing internal workflows. If the organization publishing the POD system plans to use it internally to create products for formal publishing, then the cartographers working on the products will need a workflow that describes how to take the POD output and turn it into a publication. If the organization requires some data adjustment before it is made available via POD, then the data analyst will need a workflow outlining those new procedures. The impact that a POD implementation has on an organization can be significant, depending on the project requirements. The efficiency gains and added advantages from easy access to up-to-date data will likely have an even greater impact on production processes and user satisfaction.

About ESRI

For four decades, ESRI has been helping people make better decisions through management and analysis of geographic information. Our culturally diverse staff work with our business partners and hundreds of thousands of people who use GIS to make a difference in our world.

A full-service GIS company, ESRI offers support for implementing GIS technology from the desktop to enterprise-wide servers, online services, and mobile devices. GIS solutions are flexible and customizable to meet the needs of all our users.

Our Focus

At ESRI, we focus on promoting the value of GIS and its applications throughout the world and pay close attention to our users' needs. Our software development and services respond to our customers with products that are easy to use, flexible, and integrated. Our technology is multidisciplinary, productive, and valuable to our users.

We have a strong commitment to educating our customers through ESRI's various training programs. ESRI is a socially conscious business and invests heavily in issues regarding education, conservation, sustainable development, and humanitarian affairs.

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