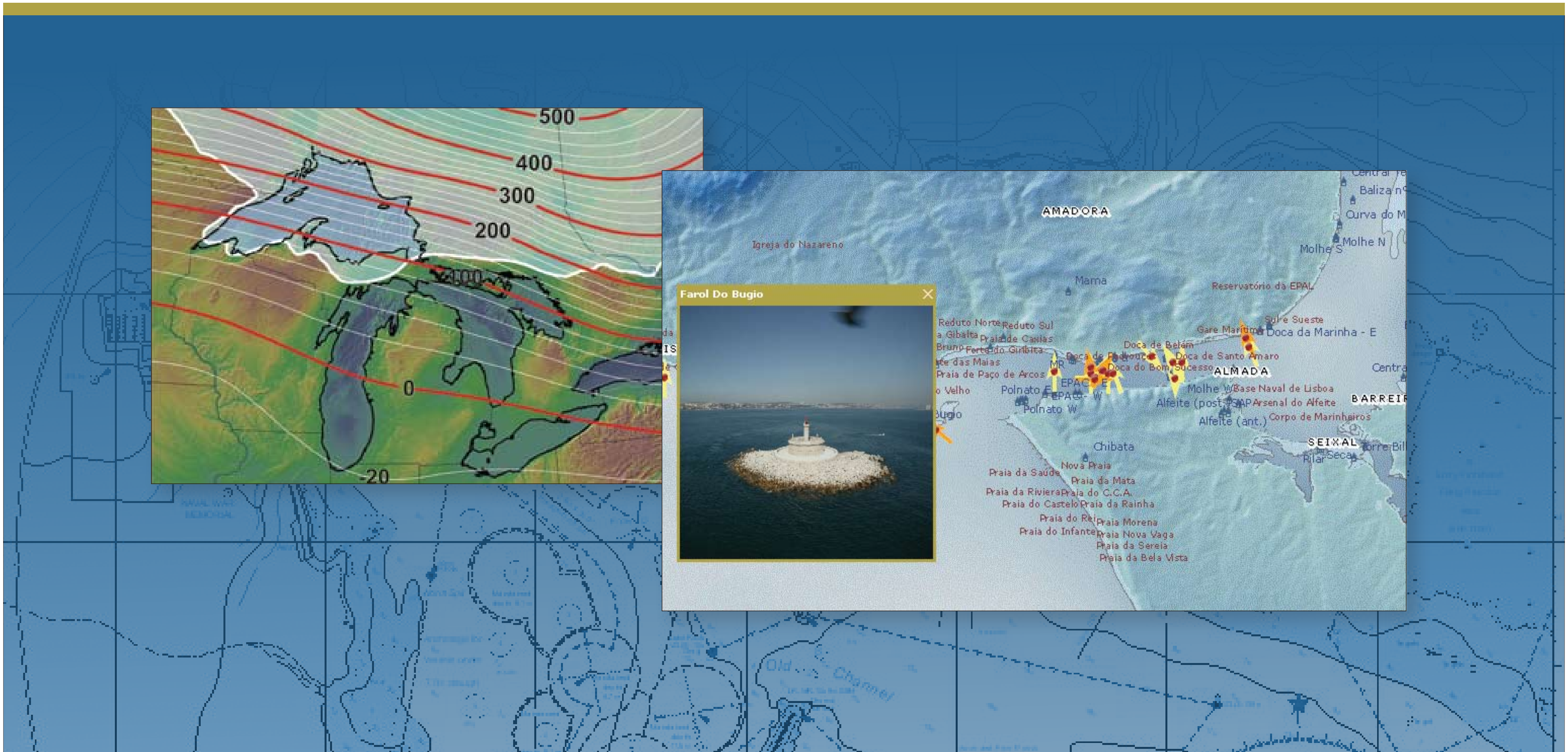
GIS Best Practices

GIS for Nautical Organizations



September 2010

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What Is GIS?

Making decisions based on geography is basic to human thinking. Where shall we go, what will it be like, and what shall we do when we get there are applied to the simple event of going to the store or to the major event of launching a bathysphere into the ocean's depths. By understanding geography and people's relationship to location, we can make informed decisions about the way we live on our planet. A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions.

GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a basemap of real-world locations. For example, a social analyst might use the basemap of Eugene, Oregon, and select datasets from the U.S. Census Bureau to add data layers to a map that shows residents' education levels, ages, and employment status. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for nearly every field of knowledge from archaeology to zoology.

A good GIS program is able to process geographic data from a variety of sources and integrate it into a map project. Many countries have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available. Map file databases often come included with GIS packages; others can be obtained from both commercial vendors and government agencies. Some data is gathered in the field by global positioning units that attach a location coordinate (latitude and longitude) to a feature such as a pump station.

GIS maps are interactive. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as storm drains, gas lines, rare plants, or hospitals. Some GIS programs are designed to perform sophisticated calculations for tracking storms or predicting erosion patterns. GIS applications can be embedded into common activities such as verifying an address.

From routinely performing work-related tasks to scientifically exploring the complexities of our world, GIS gives people the geographic advantage to become more productive, more aware, and more responsive citizens of planet Earth.

GIS for Nautical Organizations

National hydrographic organizations, commercial data/chart producers, oceanographic institutes, and naval commands can benefit greatly by leveraging a database-centric approach to the production, maintenance, and dissemination of authoritative data in a modern service-oriented architecture (SOA).

With ArcGIS, nautical organizations can

- Utilize a complete solution for managing high-volume, database-driven data production for navigational products.
- Bring real-time tracking, tasking, and geofencing analysis capabilities into their organizations.
- Avoid duplicating geospatial resources and the effort to create them via a marine spatial data infrastructure.

Organizations can now implement real-time information from not only global sensor networks but also field crews and staff. New nautical capabilities that are being implemented in organizations are used for alerting, mapping real-time information for analysis, and generating reports. Applying real-time technology allows organizations to handle the problems of shrinking resources and increased demand to support broader roles such as global disasters where nautical base data is required.

National nautical entities can also eliminate redundancy of efforts and missions by collaborating with others in support of national spatial data infrastructures. Sharing marine data within this enterprise approach pushes forward the use of authoritative data in all aspects of government and makes data accessible for projects dealing with larger issues, such as climate change, sea level rise, and the security and defense of national borders.

To find out more about products and best practices, please visit www.esri.com/nautical.

NOAA Modernizes Nautical Chart Production

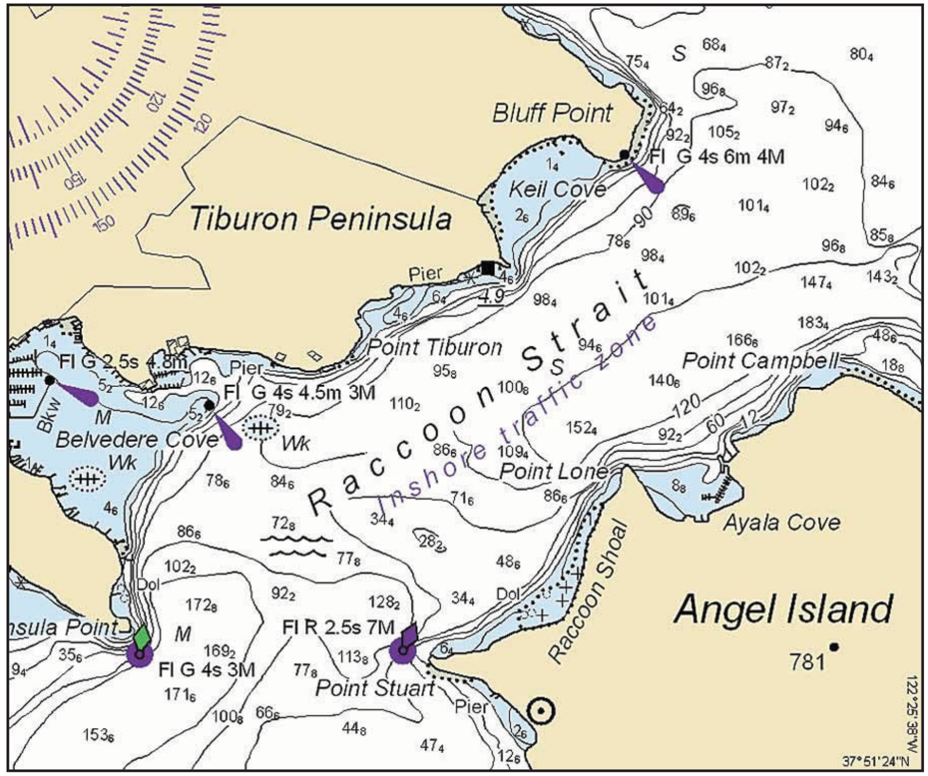
Implementing Next-Generation Charting System with Esri Nautical Solution

Highlights

- GIS will be used to manage production of nautical charts.
- Data is obtained from more than 50 entities.
- Project aims for gains in productivity and flexibility.

The Marine Chart Division (MCD) at the National Oceanic and Atmospheric Administration (NOAA) has embarked on an ambitious new deployment of GIS technology in the management of hydrographic information and the production of digital and hard-copy nautical charts. The result will be the next generation of the Nautical Chart System (NCS II).

MCD is a division in the Office of Coast Survey (OCS), which is part of the National Ocean Service (NOS), one of five NOAA line offices. NOS works to observe, understand, and manage U.S. coastal and marine resources, including navigation safety. OCS specifically oversees the Marine Transportation System.



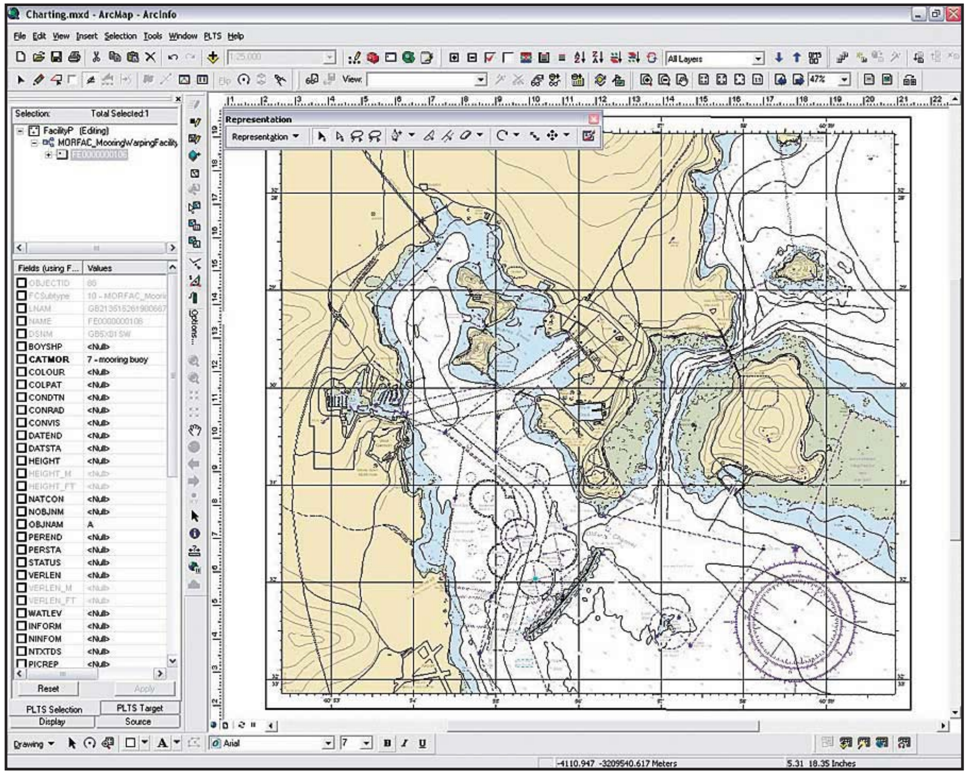
The NCS II system uses Esri Nautical Solution to create, manage, and publish hydrographic information in paper and ENC formats.

NCS II will help MCD meet its critical challenge of providing navigation products that cover approximately 11 million square kilometers of coastal waters, including the Great Lakes (areas collectively called the United States Exclusive Economic Zone). Ninety-five percent of U.S. commerce, by weight, travels through these waters alongside 110,000 commercial and recreational fishing vessels.

A nautical chart is a graphic portrayal of the hydrographic navigation environment, showing the nature and form of the coast; the general configuration of the sea bottom, including water depths; locations of dangers to navigation; locations and characteristics of man-made aids to navigation; and other features useful to the mariner. In conjunction with supplemental navigational aids, the nautical chart is used by the mariner to lay out courses and navigate ships by the shortest and most economical safe routes.

To produce these complex products, MCD uses source data including hydrographic survey data, hazard updates, and navigation aid information. From this data, MCD maintains a suite of more than 1,000 paper nautical charts and is in the process of providing complete coverage in Electronic Navigational Chart (ENC) format based on the International Hydrographic Organization S-57 transfer standard. Data is obtained from more than 50 entities, including the Army Corps of Engineers, NOAA survey ships, and the U.S. Coast Guard.

In the current system, critical updates for paper and electronic charts are published weekly. However, the noncritical update cycle for paper charts ranges from every 6 months for areas of high commercial traffic to as infrequently as 12 years for remote areas. The average revision interval per nautical chart is about 2 years. Data must be applied multiple times, stored in multiple applications, and processed through several production lines to either an ENC or a paper chart, which is a major factor in the amount of time, effort, and quality control needed for updates.



The Nautical Chart System will help the Marine Chart Division meet its critical challenge of providing navigation products that cover approximately 11 million square kilometers of coastal waters.

MCD has used GIS for many years to improve workflows and data management but wanted a COTS-based enterprise-wide system for NCS II to gain efficiencies and streamline data management and product generation. NOAA MCD contracted with McDonald Bradley, Inc., an information technology solutions provider, to integrate, operate, and maintain NCS II. After a rigorous selection process, McDonald Bradley selected Esri as a subcontractor on the project due to Esri's expertise and experience working on GIS projects. In particular, the team wanted to leverage Esri Nautical Solution, which provides production-oriented applications and end-to-end workflows tailored specifically to the needs of hydrographic offices.

With the implementation of NCS II, McDonald Bradley is creating a system that compiles source data from the myriad of providers, stores the information in a single database, and is able to extract information to produce various paper and electronic charts.

MCD expects NCS II to decrease production time for charts significantly, allowing more frequent updates. The streamlined workflows and improved data management will increase the agency's ability to respond to coast-altering events, as well as improve the accuracy of charts and ensure greater navigational safety and better coastal management. Because MCD will manage data centrally, integration with ancillary legacy systems will be centralized and optimized. Furthermore, MCD will have the capability to offer new products and Web services within NOAA or to end users of the data.

The NCS II project is in the integrate and test phase, with initial system capability acceptance planned for mid-2008. Following system acceptance, MCD will conduct an extensive operational test and a multiyear transition plan based on charting priorities. With NCS II, MCD expects to realize significant gains in productivity, data management capability, and flexibility once the transition is complete. With this move to a next-generation GIS-based system, NOAA MCD will continue to be the world leader in hydrographic information management.

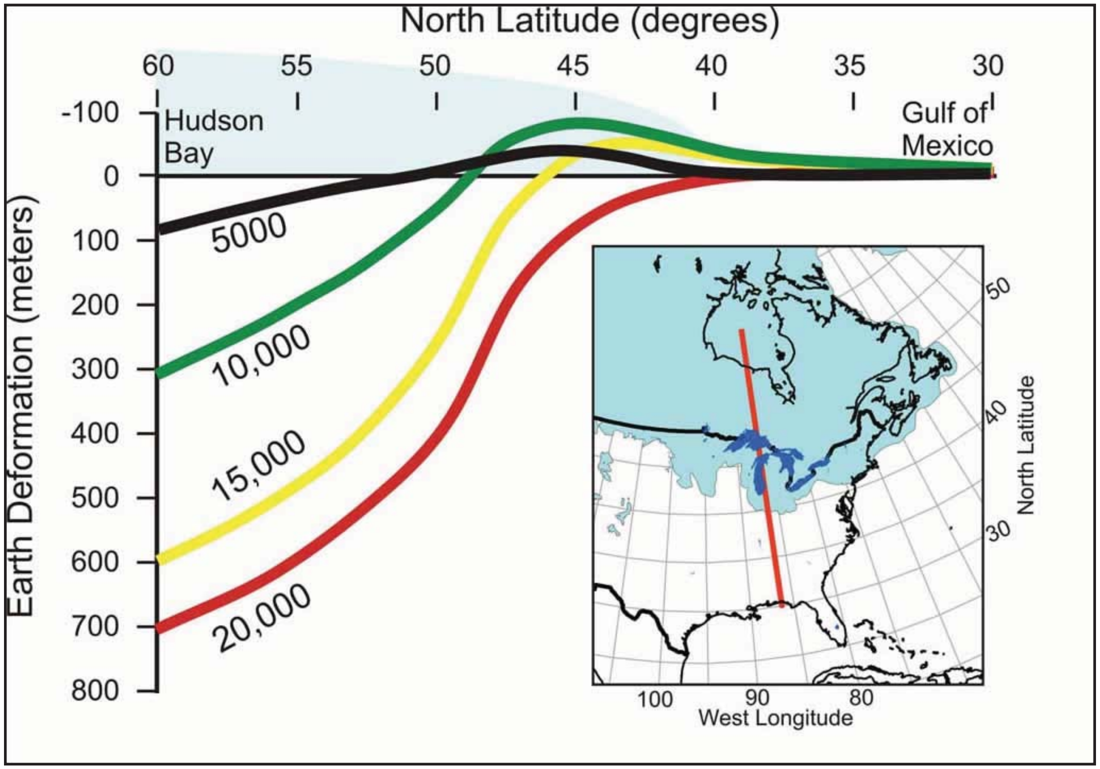
(Reprinted from the Summer 2007 issue of *ArcNews* magazine)

Shifting Shorelines

Modeling the 20,000-year history of the Great Lakes

By James A. Clark and Kevin M. Befus, Wheaton College, Wheaton, Illinois

Shorelines of the North American Great Lakes during the past 20,000 years were modeled using ArcGIS predictions of earth deformation and the hydrology tools in the ArcGIS Spatial Analyst extension.



This diagram shows the deformation of the earth's surface along a transect from Hudson Bay to the Gulf of Mexico. The transect is shown as a red line on the locator map. Curved lines are labeled with the age in years before present. Where the earth was deformed the most by the thickest portion of the ice sheet, the land rises gradually. Near the margin of the ice sheet, the land first rises and then subsides.

During historical times, water levels of the modern Great Lakes have fluctuated by more than a meter. This is largely caused by changing weather patterns and the associated rates of evaporation and discharge of rivers and groundwater entering and leaving the lakes. However, when one considers changes in the Great Lakes over the past 20,000 years, the level of the lakes has changed even more dramatically—by more than 100 meters.

These changes were caused not only by climate effects, but (more importantly) because the great ice sheet that covered half of the North American continent 20,000 years ago blocked the modern outlets of the Great Lakes, other outlets had to be used. The earth was deformed under the huge weight of the ice sheet, a further complicating factor. The Great Lakes region is between 41 and 49 degrees north latitude, and the ice sheet extended south to about 40 degrees.

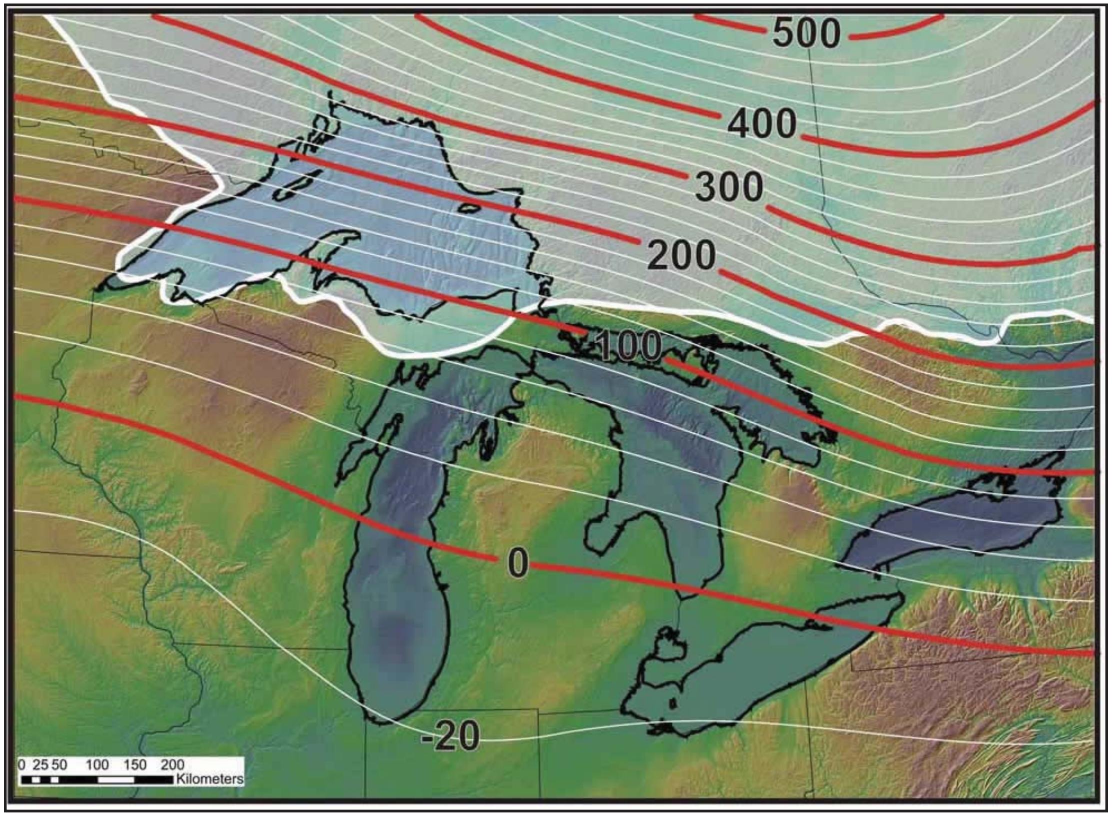
As the ice sheet retreated northward, outlets became ice free and controlled the level of the lakes. But these outlets were also changing in elevation because the earth was slowly rising to the undeformed position it held in the pre-Ice Age.

Creating Paleo-DEMs

Based on geophysical theory, it is possible to predict how the viscous mantle of the earth moves under surface loads. In this inquiry, the surface loads included changes in ice sheet thickness over Hudson Bay that were probably in excess of 3,000 meters and accompanied by changes in ocean loads as the melting ice sheets caused the ocean level to rise by approximately 100 meters.

Taking all time-dependent loads and the viscosity structure of the mantle into account, numerical geophysical models can predict the vertical deformation anywhere on the earth at any time during the past 20,000 years. As ice advanced over the Great Lakes region, the earth surface under the ice subsided, while the region beyond the ice bulged upward. In general, as the ice retreated, the process occurred in reverse. The land rose under the melting ice but subsided in regions near the ice sheet margin.

For any time period, the geophysical model can predict deformation at hundreds of discrete points over the Great Lakes region. These discrete predictions can be interpolated using the spline interpolation methods, available in the ArcGIS Spatial Analyst extension, to yield a deformation raster at each time of interest.



Contours of deformation at a time 13,000 years ago relative to the present (shown in meters). In the northern part of the map, land was more than 500 meters lower than present-day elevations. South of the zero contour line, land was actually higher than current elevations. The position of the ice sheet and a shaded relief Paleo-DEM are included.

Just as the locations of modern rivers and lakes are a result of topography, so too did topography in past ages control surface hydrology. To determine past topography, the deformation raster map was subtracted from a modern digital elevation model (DEM). The Shuttle Radar Topography Mission (SRTM) DEM was used over the land areas and combined with Great Lakes bathymetry data from the National Geophysical Data Center of the U.S. National Oceanic and Atmospheric Administration (NOAA).

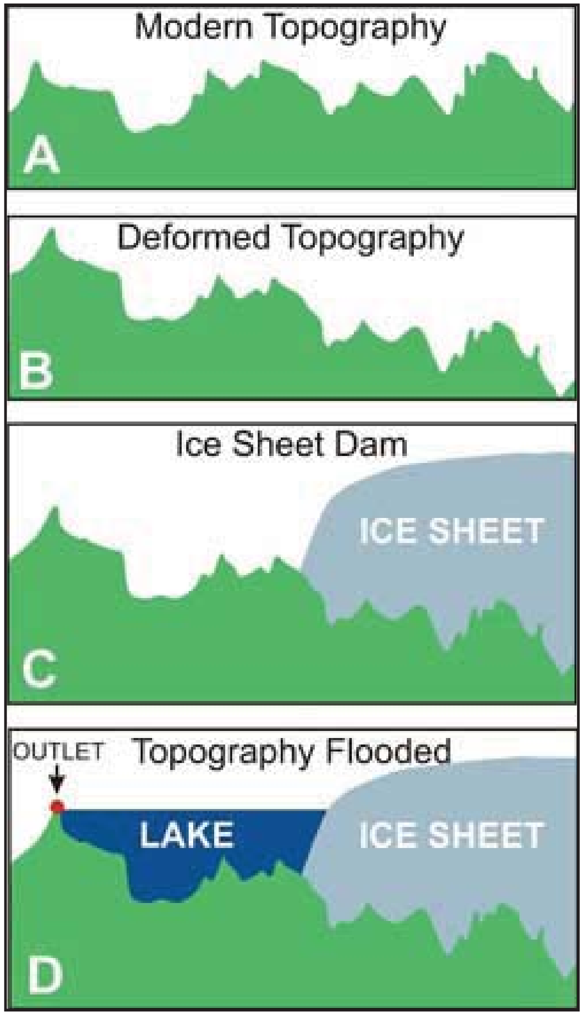
Because the bathymetry dataset was not complete, it was supplemented with Lake Superior bathymetry provided by the Large Lakes Observatory of the University of Minnesota. To speed calculations, the raster resolution was changed from 90 meters to 200 meters. The result was a series of Paleo-DEMs that spanned the last 20,000 years.

Mapping Great Lakes History

Through extensive fieldwork, geologists have determined the extent of the ice sheet as it retreated from the Midwest. Maps of the ice sheet extent were digitized. The ice sheet north of the margin was assigned an arbitrary thickness of 1,000 meters. By adding ice sheet raster maps to the Paleo-DEMs, the actual topography during late-glacial and post-glacial times was re-created.

With this topography, the hydrology tools in ArcGIS Spatial Analyst were used to determine paleohydrology. A first step in modeling modern hydrology, given a DEM, is usually to fill any closed depressions in the topography to correct for any small imperfections in the DEM that would incorrectly serve as sinks for water. In the present application, these filled depressions are critical to the solution because the lakes that formed on the ancient landscape are exactly those that result from filling the Paleo-DEM. Subtraction of the Paleo-DEM from the filled Paleo-DEM yields a raster of Paleo-lakes and their bathymetries.

Not only can the ancient distribution of lakes and shorelines be predicted but so can the volumes of those lakes. Using the Hydrology Flow Accumulation tool, which determines the number



GIS methodology: The present topography (A) is warped vertically by the predicted deformation to yield the Paleo-DEM (B). The ice sheet is added (C) to form the actual surface landscape at given times in the past. The Paleo-DEM is filled to eliminate closed depressions (D) and the difference between the filled Paleo-DEM and the Paleo-DEM (C) is the predicted lake. Outlet location is on the lake margin where the greatest flow accumulation value occurs.

of raster cells above a given cell that would contribute overland water to that cell, the locations of ancient stream channels could be predicted on the filled Paleo-DEM. In addition, the outlet of each lake was located. It was identified as the single raster cell on the margin of each lake with the highest flow accumulation value.

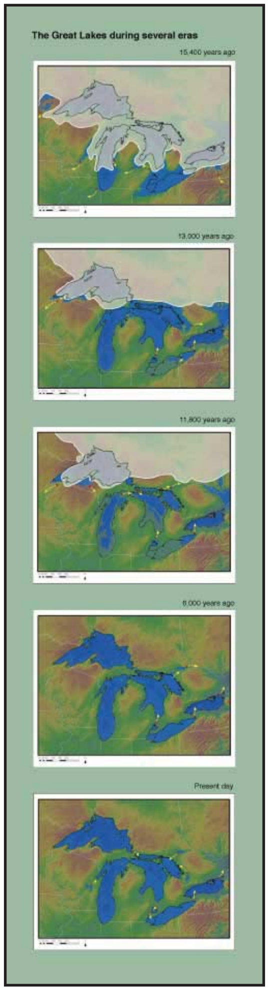
While the locations of hundreds of lakes are predicted for each time period, most of these lakes are very small. To limit the analyses to the largest lakes, the paleolakes raster was searched for all lakes with contiguous areas larger than a specific minimum area. These steps were automated using a Python script. A record of the 20,000-year history of the Great Lakes was produced after only about three days of computational time on a PC.

Modeling Results

When ice covered much of the Great Lakes basin, water flowed out through Chicago, down the Illinois River, and into the Mississippi River. When ice had retreated north of the Great Lakes, an outlet in Canada that had been depressed under the weight of the ice became the lowest outlet. It captured the drainage as soon as the outlet became ice free. This caused the lakes to drain rapidly. Lake Michigan, which experienced a 125-meter drop in lake level, became separated from Lake Huron. Subsequently the northern controlling outlet rose as the earth readjusted to the reduced load of the melting ice until the outlet reached the same elevation as the more southern outlets. When that happened, drainage of the Great Lakes shifted to the south and the modern outlets. Lake Erie, which almost drained completely because its northern outlet was low, gradually filled as its outlet slowly rose to its present position.

Conclusion

These lake-level predictions were suggested by a century of fieldwork by geologists mapping old shorelines of the Great Lakes. (This work is summarized in Jack L. Hough's classic work, *Geology of the Great Lakes.*) These geologists observed that ancient shorelines were tilted relative to modern shorelines and attributed the tilting to earth deformation forced by ice sheet loading. The results of this analysis demonstrated that when the physics of viscous mantle flow is combined with ArcGIS methods, these ancient shorelines can be reproduced.



The Great Lakes during several eras: (A) 15,400, (B) 13,000, (C) 11,800, and (D) 6,000 years ago, and (E) the present day. Controlling outlets are indicated by red dots and the direction of outflow shown by arrows.

Using this GIS methodology makes it possible to verify shoreline positions by uploading shapefiles of the predicted shoreline to ArcPad installed on GPS units and locating shorelines in the field. Differences between the observed and predicted locations suggest how the geophysical model should be improved, either by altering the viscosity structure of the earth model or adjusting the ice sheet thickness chronology.

Acknowledgments

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Kevin Befus is now using shallow surface geophysical methods to characterize the Boulder Creek Critical Zone Observatory while pursuing a master's degree at the University of Colorado in Boulder, Colorado.

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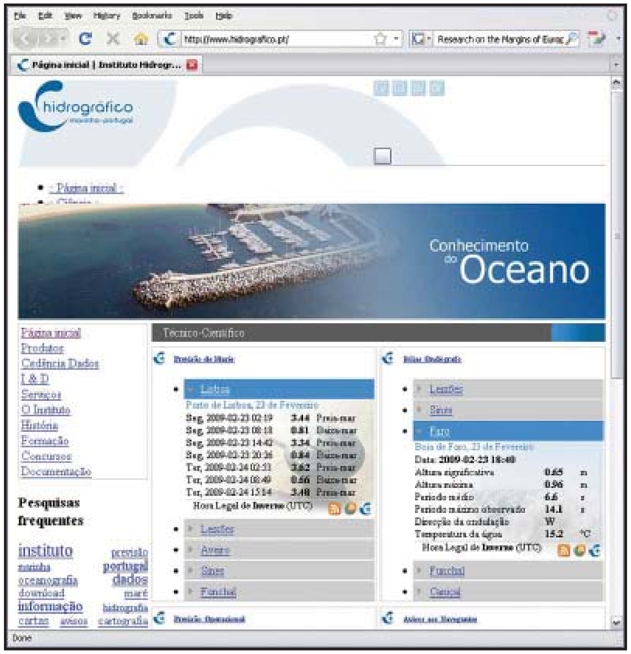
A Geospatial Foundation

Public, private, and military applications flow from SDI

By Miguel Bessa Pacheco, Instituto Hidrografico, Portuguese Navy

The marine spatial data infrastructure (SDI) developed by the Portuguese Instituto Hidrografico (IHPT) provides information to decision makers and information products for environmental protection activities, research and development, private industry, military activities, and public information.

IHPT is the naval organization responsible for producing official nautical paper and electronic charts as well as conducting studies and research in marine-related disciplines such as physical oceanography, hydrography, marine geology, chemical oceanography, and navigation safety.



Information products are publicly disseminated and are available from the public Web site at www.hidrografico.pt.

For the last several years, IHPT has been developing an SDI called IDAMAR (an acronym in Portuguese for spatial data infrastructure for the marine environment) to support the production of technical and scientific data and information product management. It began as a departmental GIS named SIGAMAR, but the scope of the GIS was subsequently broadened, and the IDAMAR SDI now also provides the institute with the ability to respond to ad hoc requests for information from decision makers.

IDAMAR SDI Architecture

To conform with military communications security rules, the IDAMAR SDI is actually composed of two similar systems: one connected to the Internet and one connected to a private military network. The public portion, available to all users, includes communications networks, databases, metadata, software, hardware, specialized human resources, outreach and support, data policy, internal data management processes, distributable information products, and online services.

Communications networks

Three communications networks support data transfer and online access to the SDI: an Internet connection, a private unclassified military network, and a private classified military network. The Internet connection supports data acquisition from several environmental sensors (e.g., wave buoys, radar stations) and the public dissemination of information products through www.hidrografico.pt. The private military networks provide access to the full system and support specific data and information requests. These networks support all internal processes for data and information product management.

Databases and data models

Several databases were developed using either DBMS- or file-based systems. The choice of system was based on the type of data stored and how that data could be most efficiently used. Data models for DBMS storage were internally developed for information processes except for chemical lab analysis data. A commercial laboratory information management solution, Thermo Nautilus LIMS, was acquired and extended so chemical data could be easily integrated with the entire system. Internally developed data models (when applicable) follow the S-57 standard for hydrographic data transfer. [S-57 is a digital data format standard.] The most relevant developed data model supports the hydrographic data warehouse (HDW). This database stores bathymetric soundings acquired by the IHPT and represents a major improvement in the cartographic production process because it reduces production time, eliminates procedures susceptible to human error, and improves the quality of the final product.

Data stored includes data about the sea state (e.g., wave height, wave period, wave direction, and sea temperature) from ocean buoys; tide predictions and observations, horizontal control points; nautical chart and cell coverage; chemical analysis of seawater and sea bottom sediments; bathymetric navigation warnings; and medium-resolution satellite imagery. Not all data was supplied by IHPT—some data is related to activities of the Portuguese Navy.

Data policy

A data policy document sets out rules that govern data management and access in the IDAMAR SDI. This document stipulates policies for data classification, data access (both format and eligibility), and the associated costs. Some datasets are freely available to the public: near real-time sea state data; water temperature; sea state predictions for locations in the Atlantic and near Portugal; tide predictions for all principal and secondary ports in Portugal as well as locations such as Angola, Cape Verde, Guinea-Bissau, and Mozambique; some maritime administrative limits; small-scale bathymetric lines; and a small-scale converted Electronic Navigation Chart (ENC) cell for continental Portugal and the Madeira and Azores archipelagos.

Metadata

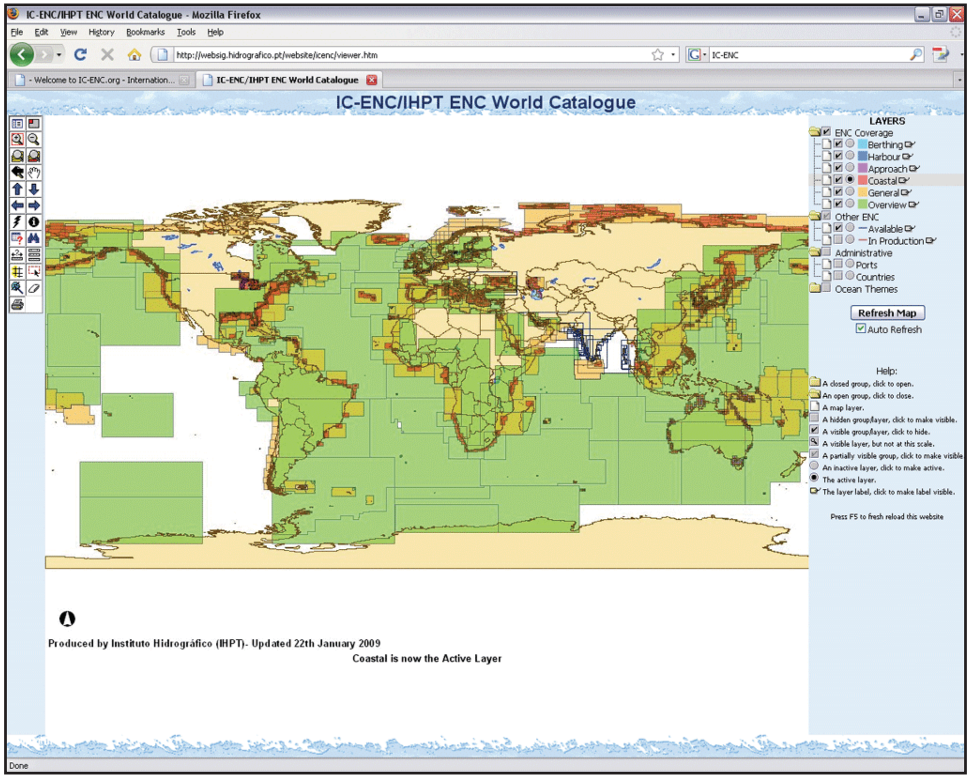
Metadata fact sheets are essential for inventorying, locating, and assessing the quality of geospatial data. These documents, which contain information about why, when, and where data was originally collected, are valuable from both a scientific and economic standpoint because they enable data reuse. Metadata is produced for all data, products, and services provided by the IDAMAR SDI. In accordance with the Infrastructure for Spatial Information in Europe (INSPIRE), metadata complies with the ISO 19115 standard. The metadata search engine was created to aid public access to the data.

Specialized human resources

Expertise in systems analysis, database systems administration, GIS, and Web programming was required for this project. Most contributors to the project have backgrounds in geography or earth sciences as well as master's degrees in various information technologies. This staff has developed the SDI and worked on ad hoc projects.

Outreach

Because some geospatial analysis tasks should only be performed by scientists, courses that range from three to five days were developed to introduce scientists to GIS concepts and software. These courses are tailored to the needs of scientists and help spread GIS knowledge throughout the organization's scientific community while also providing tools that enable scientists to use GIS independently. This has allowed the organization's specialized staff time to work on both the SDI and advanced information projects.



The Electronic Navigation Chart (ENC) World Catalog is one of the most relevant data catalogs available.

Software The IDAMAR SDI relies on Microsoft for its operating system, Oracle for DBMS, and Esri's ArcGIS for its GIS software. Specifically, the IDAMAR SDI makes use of ArcSDE, ArcIMS, and ArcGIS Server applications as well as single use and floating licenses for ArcView; ArcEditor; and the ArcGIS Spatial Analyst, ArcGIS 3D Analyst, ArcGIS Publisher, and ArcGIS Geostatistical Analyst extensions.

Hardware The SDI is supported by four servers—two internal and two external. A variety of IHPT devices (PDAs, laptops, PCs, workstations, printers, plotters, and high-resolution scanners) are used for some SDI functions.

Internal processes

Implementing the SDI reengineered some IHPT production processes and introduced new ones. Setting up rules and workflows was necessary because making internal production more efficient was a main objective of the project.

Offline products

Generated in response to ad hoc requests for information, offline products are normally distributed as CDs or DVDs. Although not necessarily related to the internal products generated by IHPT, the SDI answers specific information needs, and offline operations are advantageous from a naval security standpoint. In addition, some paper products are still used for a variety of purposes including thematic cartography. In the last three years, more than 30 ad hoc GIS projects based on the SDI have been developed.

Online products and services

Online products and services provide broad access to the SDI. They are the most visible part of the public system that includes data catalogs, information products, and data services. Two Web portals (one internal and one external) allow users to obtain information products and services and provide the front end for data catalogs, data visualization applications, the metadata search engine, download services, and data services.

Information Products

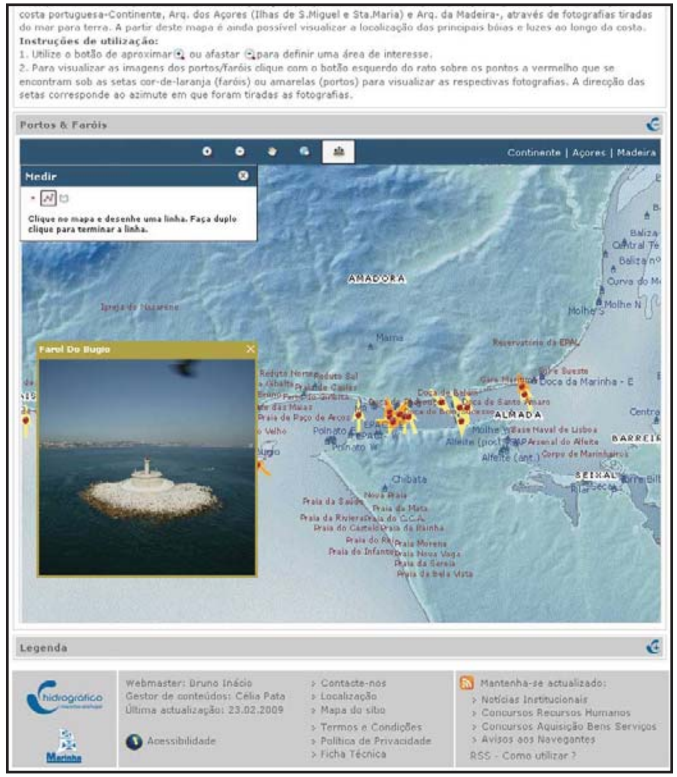
Some information products are available from one or both of the Web portals, while others are furnished offline. The scope of products supplied depends on use and encompasses public services, commercial services, environmental protection, naval missions, and research and development. The list of products included here is not exhaustive, only representative.

Exploring data with online data catalogs, data visualization, and metadata

Several data catalogs allow users to explore data in IDAMAR SDI databases. Geographic interfaces assist in visualizing data such as horizontal control points, chart folios coverage, hydrographic surveys coverage, hydrographic soundings, sea bottom sediment samples, chemical analysis for water and sea bottom samples, tide observations, and sea state buoy observations.

The ENC World Catalog is one of the most relevant catalogs available. Although not entirely related to IHPT (because its geographic extent is the world), this catalog helps sea navigators identify the available cells relevant to their route. The coverage data, collected by the International Centre for ENCs (IC-ENC), is available at websig.hidrografico.pt/website/icenc and is updated monthly.

Information on the appearance of the coastline as it appears from the sea is very useful for sea navigation. A compilation of visual aids to the navigation of the Portuguese coastline is available from a customized ArcGIS Server Web site. This site provides links to photographs of coastline landmarks that help inexperienced sailors learn to recognize coast features.



As an aid for navigators, photographs of landmarks along the Portuguese coastline are available from the public Web site. This picture shows the lighthouse at the entrance to the Lisbon harbor.

Mission impact diagrams, which display anticipated environmental impacts by military activities, are important to mission planning. Assessing impacts by using only a table was very time consuming and could be confusing. Since 2006, IHPT has been supporting the navy and national military joint staff with geospatially based, color-coded mission impact diagrams. This product, which is used on a daily basis, provides an exhaustive and efficient interface that shows factors relevant for a specific point of interest.

Supporting marine research and development is another major objective for the IDAMAR SDI. Several information products have been developed that help scientists perform integrated analysis for a variety of marine disciplines, plan fieldwork, and communicate research results to the public. The Hotspot Ecosystem Research on the Margins of European Seas (HERMES) project is a perfect example of this type of support. More than 50 European partners are working on this project in seven different areas of the European shelf. A project GIS has been set up for each region to share data, coordinate fieldwork, and present results.

Geospatial metadata has long been recognized as critical to the full utilization of SDIs by users and administrators. Three key aspects of metadata are data inventory, data search, and data quality. There are other aspects related to metadata that are valuable, but these are the major ones for the IDAMAR SDI.

For an organization with environmentally based processes, maintaining a geospatial data inventory is fundamental. Gathering environmental data, especially marine data, can be very expensive. Performing the same measurement twice is a waste of time, money, and human resources, to say nothing of the cost of delays in acquiring necessary information. Currently available sampling methods (e.g., sensors, platforms) do not yet supply data sufficient to completely learn how the ocean works, so needless redundant sampling is a serious problem.

Geospatial metadata search mechanisms are more complex than traditional, text-based methods because these methods require dealing with multidimensional (i.e., spatial and attribute) data. Geospatial fact sheets allow fast and objective searches for data of interest. As geospatial databases increase to terabytes in size, metadata becomes even more important.

Data quality documentation is necessary to ensure that data can be reused in research and applications. Documentation prevents the use of data with inappropriate quality parameters that would adversely affect the quality of output and the decisions based on that output.

Accessing data through RSS

In addition to traditional geographic interfaces for accessing data, the IDAMAR SDI also provides access to some technical and scientific data via Really Simple Syndication (RSS). This protocol is useful for accessing data through low bandwidth connections or devices such as PDAs or cell phones. Tide predictions for the current date and the next three days, as well as near real-time data from sea state buoys located off the shore of continental Portugal and Madeira Island (updated every two hours), are disseminated using RSS. Navigation warnings are also issued via RSS. All links to this data are compiled at www.hidrografico.pt/rss.php, and only an RSS reader is required to obtain this data.

Ad hoc independent projects

Many projects developed from the IDAMAR SDI have been distributed via CD and DVD. ArcReader is used to explore the information supplied for these projects. Applications have been developed that address maritime safety; assist police investigations; support the numerous activities of the navy; and inform ship sinking crisis management and many other areas of public, commercial, and environmental protection service. Nearshore drift modeling, wave energy systems location, aquaculture structures location, and historical cartography are examples of applications under development.

Future Work

The IDAMAR SDI is a valuable asset that supports its main mission objectives: ensuring safe sea navigation, supporting the navy's activities, protecting the environment, and contributing to knowledge of the ocean.

Ongoing data acquisition activities include converting historical analog data and products to digital format and registering this data in the system. A geospatial portal for better visualization is also being developed. Future enhancements include the implementation of GeoRSS feeds for the dissemination of technical and scientific data and the development of multicriteria geospatial analysis for mission impact diagrams that will improve environmental tactical decisions.

(Reprinted from the Spring 2009 issue of *ArcUser* magazine)

Making Standards Shipshape—Esri's Rafael Ponce Discusses Working with International Hydrographic Organizations

By Karen Richardson, Esri

National hydrographic organizations, commercial chart producers, and naval commands are discovering that GIS technology can streamline the production and maintenance of their nautical data. Esri is assisting this effort by working with international organizations on the development of new standards.

Leading this charge is Rafael Ponce, program manager for Esri's maritime team in the Professional Services Group. Before joining Esri, Ponce spent 24 years in the Mexican Navy serving on various ships as well as ashore, participating in hydrographic surveys, bathymetric analyses, tidal analyses and nautical chart production. He was the commanding officer of a navy hydrographic ship and the deputy director at the Mexican Office of Hydrography and Cartography.

Rafael Ponce is the program manager for Esri's maritime team in the Professional Services Group. Previously, Ponce spent 24 years in the Mexican Navy.

Esri writer Karen Richardson recently discussed with Ponce Esri's involvement in International Hydrographic Organization (IHO) standards and activities around the world.

Esri: Can you explain the mission of the IHO?

Rafael Ponce (RP): IHO is the technical expert body recognized by the International Maritime Organization, a United Nations agency that provides standards and recommendations for all hydrographic activities throughout the world. This includes survey planning, data collection, postprocessing and data product creation.

The Esri maritime team's primary objective is to serve this community by providing the best quality software and most efficient services. Our commitment does not begin with the production of excellent software and end with providing technical support; it goes beyond that. We are invested in creating standards and product specifications to continually improve our software.

Esri: How exactly does Esri contribute to the development of IHO standards and product specifications?

RP: The maritime team represents Esri at key IHO technical working groups, such as the Transfer Standard Maintenance and Application Development Working Group. We provide expertise for defining and documenting specifications and GIS tools for testing data against them. For example, Esri assisted in the development and extension of the S-57 standard, the IHO transfer standard for digital hydrographic data, as well as the new IHO Universal Hydrographic Data Model, known as S-100. Working with IHO, we are also developing the next generation of Electronic Navigational Chart (ENC) product specifications, S-101.

Esri recently joined the Chart Standardization and Paper Chart Working Group to help write documents that help preserve the fundamental concepts of marine cartography. Additionally, we will start working with the Marine Spatial Data Infrastructure Working Group to develop better marine SDIs and help hydrographic offices connect with their national SDIs.

Last but not least, Esri is involved with the Radio Technical Commission on Maritime Services (RTCM), which informs international agencies on maritime radio navigation and radio communication policy issues, changes, and technical standards development. Esri represents RTCM as a nongovernmental organization at the Hydrographic Services and Standards Committee (HSSC).

Esri: You mentioned the Radio Technical Commission on Maritime (RTCM) Services at the IHO Hydrographic Standards and Specifications Committee; can you tell me more about RTCM?

RP: RTCM was founded in 1947 as an international nonprofit scientific, professional and educational organization. RTCM works closely with many international bodies to develop standards for different maritime services. RTCM has several special committees and Esri's interest lies in the Special Committee (SC) 109 on Electronic Charts and the fairly recent e-Navigation concept, which aims to harmonize ship- and shore-based systems through a communications infrastructure. Working with this committee, Esri hopes to provide the technology to make this concept a reality.

Esri: Tell me more about Esri's relationship with IHO.

RP: Esri's relationship with IHO began with the International Hydrographic Bureau, which works as the secretariat for IHO. Esri maintains communications with delegates to the bureau, who include administrative personnel and retired hydrographers from various member states.

The IHO recognizes Esri as one of its main stakeholders in the private industry, allowing the Esri maritime team to participate in IHO's technical working groups and contribute to improving hydrography around the world. For example, Esri attended the Hydrographic Database workshop hosted by the Colombia Hydrographic Office in Cartagena last year.

Esri: Are there other groups within IHO in which you are involved?

RP: Yes, besides technical committees and working groups, the IHO has a capacity building committee (CBC) and several regional hydrographic commissions. I also have the privilege of being the technical coordinator for the Electronic Chart Committee (ECC) of the Meso-American and Caribbean Hydrographic Commission (MACHC).

Esri: Can you describe your role as technical coordinator of the ECC in MACHC?

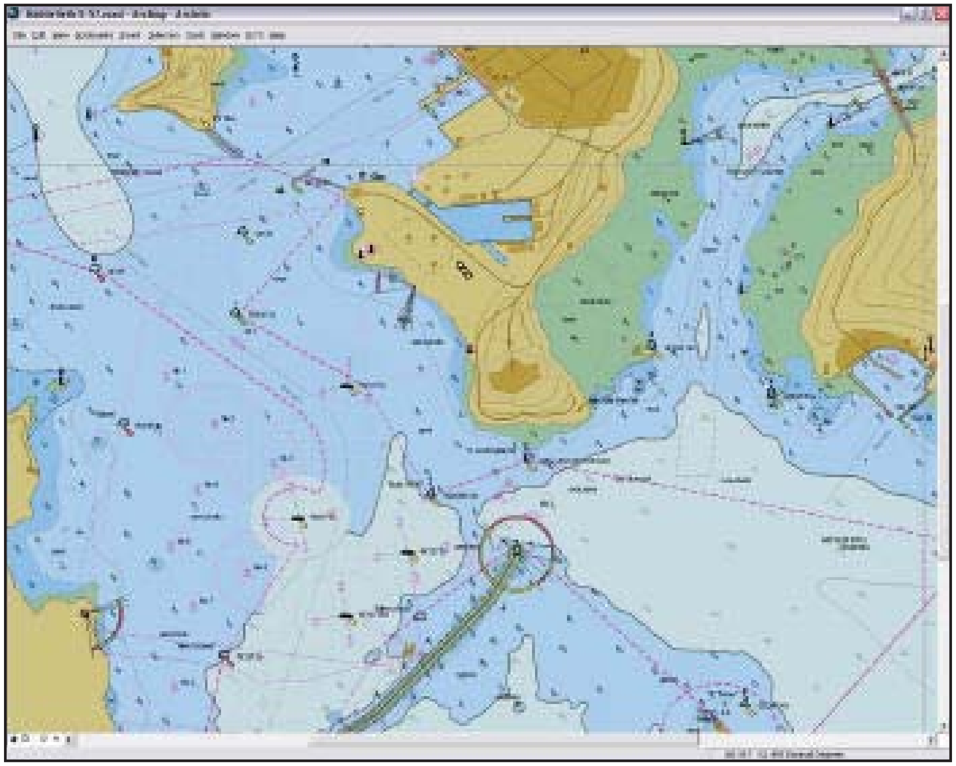
RP: I support the committee as a facilitator in determining the level of ENC coverage in the region using Worldwide ENC Database (WEND) principles as a guide. The WEND principles are a series of guidelines on how IHO member states should produce, organize and distribute their ENC data. Because ENCs cannot overlap for safety purposes, I help identify issues where there is a problem and facilitate a resolution. For example, two different ENCs may pinpoint more than one object at the same location. It is impossible for more than one object to be in the same spot on the earth, so I work with the conflicting states to rectify this. I also provide advice if some member states require rescheming of their ENC catalog. I basically try to ensure that member states follow the IHO production and distribution of charts to their end users, who are mariners worldwide.

Esri: Is Esri involved in any other maritime organizations?

RP: Yes, Esri recently joined the Technical Advisory Group on Port Security, which serves the Inter-American Committee on Ports (CIP) at the Organization of American States. This group provides guidance to port authorities in the Americas on all aspects of port security so that they have the information and necessary means to mitigate risks, improve security and increase efficiency at ports throughout the Western Hemisphere.

Esri: What can we expect from Esri's involvement with IHO and other maritime organizations in the coming year?

RP: Esri is committed to continuing our efforts with IHO and its member states particularly, participating in the development of S-101 and any future specifications. Our work with RTCM will continue, specifically in the Special Committee 109 for Electronic Navigational Charts as well as continuing to represent the group at HSSC if they allow us the honor.



Showcase 1: Electronic Navigational Charts are becoming increasingly important in providing up-to-date navigational information, and can be created, maintained and shared using GIS technology.

We look forward to promoting the Marine Spatial Data Infrastructure initiative by IHO among its member states. We are particularly looking forward to working on other international projects like the Infrastructure for Spatial Information in Europe (INSPIRE), where we were recently accepted to participate in the development of product standards for bathymetry and oceanography.

(Reprinted from the Summer 2010 issue of *Compass Points newsletter*)

Remote Communities Prevail with GIS

Small Island SDI Is a Huge Success

Highlights

- GIS managers feel a sense of community even on small islands in the middle of the ocean.
- The islands use ArcGIS as the backbone for spatial data sharing.
- Benefits are derived from land being carefully mapped and documented with GIS.

GIS for spatial data infrastructure (SDI) is used throughout the world to instill cooperation and collaboration in sharing spatial data to better address social, economic, and environmental issues. It seems logical that large countries like the United States have invested in SDI, such as the Geospatial One-Stop, and national unions, such as the European Union, have come together to share data and resources via the Infrastructure for Spatial Information in Europe (INSPIRE). Does SDI make sense for smaller countries and communities? Arguably, even smaller nations benefit from land being carefully mapped, public works and utilities documented, environments and biodiversity protected, and resources assessed and strategic planning completed.

Thanks to special funding through the joint United Kingdom Foreign Office/Department for International Development Environment Programme, a group of UK overseas territories and the member states of the Organization of Eastern Caribbean States are able to rely on GIS for SDI, using the solution for data quality and control, information sharing, and delivering finished products for use between governmental agencies and private organizations. Calling themselves "tiny SDI," these small islands use ArcGIS as the backbone for spatial data sharing.

A few thousand of the half million wide-awake (sooty) terns on Ascension Island (photo credit: Alan Mills).

Most islands were using Esri GIS software products in some form or fashion before SDI was implemented. As Alan Mills, principal with Alan Mills Consulting, Ltd., and one of the thinkers behind using SDI to help manage smaller islands, explains it, "We realized there was synergy in sharing the same add-on applications developed with GIS across the islands. Along with the backup support from other islands doing the same functions, the GIS managers on these remote places would feel a sense of community and have a place to go when they needed help. This is important when you live on a small island in the middle of the ocean three days' boat ride from the nearest airport, and you have to be the expert in GPS, databases, cartography, digitizing, and changing the ink in the plotter. Many of these projects produce baby steps in making SDI, but these smaller islands should not be excluded from making best use of GIS for their own special purposes."

Ascension Island Discovers Data Sharing

One island that has many unique needs housed in a small space is UK overseas territory Ascension Island, situated in the sea halfway between Africa and Brazil. Only 34 square miles in area (approximately 88 square kilometers), the island is inhabited by about 1,000 people. Because the island is a relatively recent volcanic emergence close to the Mid-Atlantic Ridge, there is little natural vegetation except for a few species of ferns and spurge, a plant that exudes a bitter milky juice. The island became a refuge for a wide variety of marine species and is the second largest Atlantic nesting site for green turtles.

Humans discovered the island in the 1500s, and since that time, the island's ecology has changed significantly: invasive plant species have run rampant over parts of the island and rats and cats have decimated the bird populations. Bird and turtle populations have oceanwide impact on biodiversity, and the Conservation Department established by the small Ascension Island government is mandated to protect and enhance the crucial nesting sites, as well as conserve the local plants, crabs, and invertebrates.

Since 2005, GIS has been used to synthesize disparate databases and datasets and create new maps and images for environmental management. GIS also assists with other applications, including the Environmental Health Department's rat control mapping, and documenting of an eclectic set of historical sites, such as the guns of the sunken HMS *Hood,* Dampier's Drip (the original freshwater source for the island), and concrete water catchments in the mountainside that collect scarce cloud water for the island's predesalination plant.

Using ArcView, a component of ArcGIS Desktop, the system works well. Says Dr. Edsel Daniel, professor, Vanderbilt University in Nashville, Tennessee, a codeveloper of the SDIs for Ascension and St. Helena and a colleague of Mills, "The software is easy enough to be handled by nonexperts. We are able to use a flexible framework that accepts new monitoring data and can integrate datasets from a wide variety of sources and types."

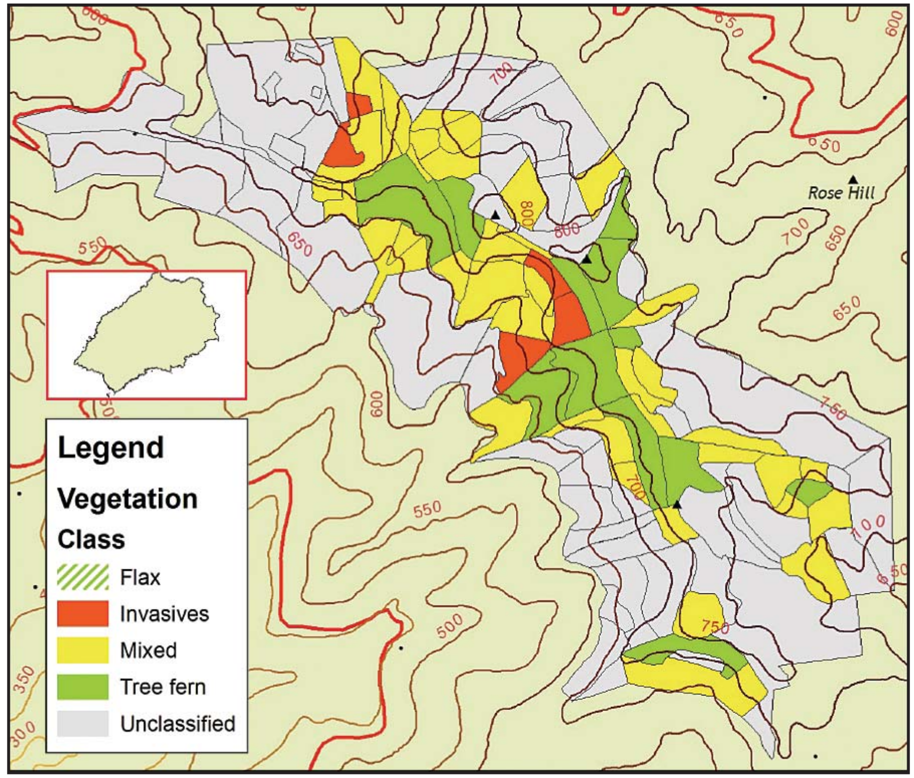
ArcView integrates all the data necessary for the government to make informed planning decisions to balance environmental, amenity, and infrastructural priorities. Clear protocols and procedures have been determined to pass data from the field to the end user.

"The key to this system to function in such a small area so economically with great benefit is the fact that data gathered for one purpose can be shared in many applications," asserts Mills.

St. Helena Finds Cooperation Is the Key

St. Helena, about 750 miles (1,207 kilometers) southeast of Ascension, cannot be reached by air. Instead, a visitor must take the RMS *St. Helena,* which plows between Cape Town, South

Africa; St. Helena; and Ascension each month. Approximately 3,500 hardy settlers live on the island, many above the precipitous cliffs or in a narrow canyon where the well-preserved Georgian capital of Jamestown nestles, near landscapes of rocky desert, rolling pastures, and eucalyptus and pine plantations. Near the coast, humpback whale mothers and calves shelter themselves, and thousands of seabirds cling to cliff edges and stacks.



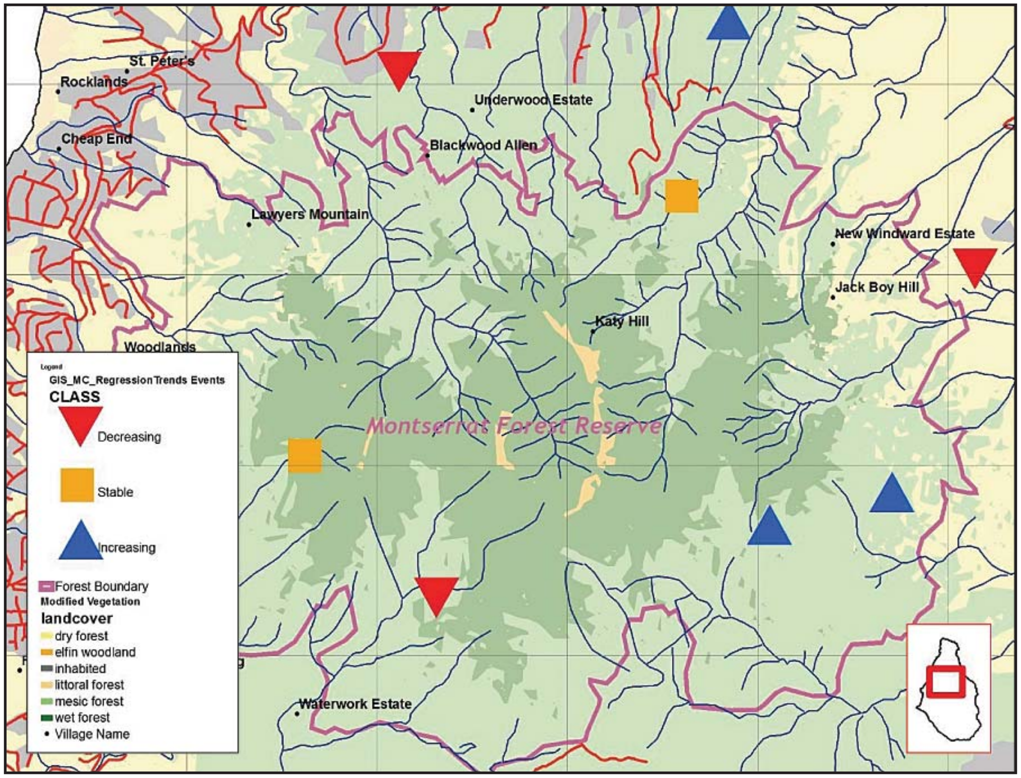
This map shows endemic tree ferns, trees, and threatening weeds on St. Helena's Diana's Peak (as of 2007).

At first, GIS was used to determine the best locations to place freshwater boreholes. In 2004, other projects began, the largest being building the island's cadastre. The St. Helena Agriculture and Natural Resources Department (ANRD), along with the St. Helena National Trust, implemented ArcView and a Microsoft Access database to monitor clearance of invasive flax and other plants and manage the growth of endemic cabbage trees and tree ferns. Len Coleman, GIS manager, St. Helena, says, "The emergence of a map showing the recolonization of endemics over a 10-year period gave other departments the idea to link their monitoring data with the mapping being accomplished."

A single system was then designed to minimize duplication of effort and share the burden of data collection and management. The St. Helena Legal, Lands, and Planning Department was keen on expanding its new cadastral GIS and database, and working with ANRD meant environmental concerns were known by the planning unit for both strategic plans and the development control process. Sharing resources also makes it easier for training sessions to be organized and held for occasional users of GIS. Data is not duplicated, and there is better quality control and attribution when it is used for multiple applications. Visiting scientists and consultants can search the data catalog and have a recognizable way of contributing information back to the system in a structured manner once their project is completed.

GIS Keeps People and Mountain Chickens Safe on Montserrat

In the eastern Caribbean Sea, Montserrat is another UK overseas territory, approximately 12 miles (20 kilometers) west of Antigua. After a volcanic eruption in 1997, the population dwindled from 11,000 to 3,500 and is now settled in only one-third of the island. These few people on the island are in need of GIS to assist them in mapping safe zones and planning for permanent homes and services away from the dangerous area around the volcano. GIS is also used to map endangered species in the Center Hills area, including the curiously named mountain chicken, a frog that is a local delicacy and has been unfortunately decimated by a fungal disease. Work by the Department of Environment in Montserrat—supported by the likes of the Durrell Wildlife Conservation Trust; the UK Royal Society for the Protection of Birds; and the Royal Botanical Gardens, Kew—is helping protect endangered species like the mountain chicken.



A map defining trends of the mountain chicken habitat of Montserrat.

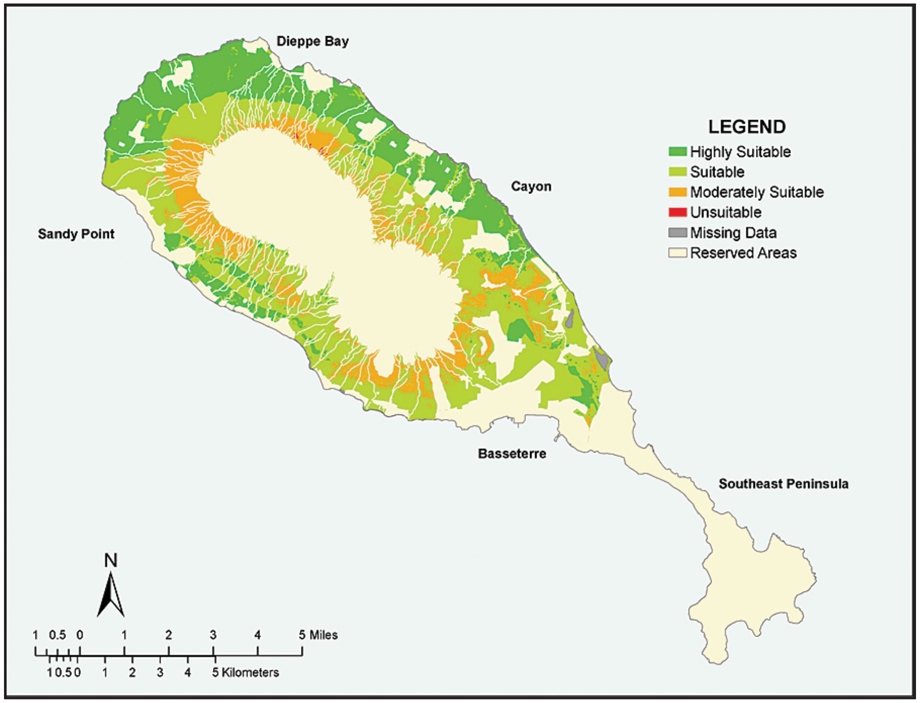
Led by GIS manager Lavern Rogers-Ryan, who works in the Montserrat Physical Planning Department, the GIS team uses ArcGIS to cover the requests of clients on the island, including updating the land cadastre and mapping for natural disasters and environmental protection. Comments Rogers-Ryan, "Assisting the Department of Environment in mapping its data opened our eyes to the spatial comparisons across the island."

Mills assisted in developing a database and training field staff in how to make simple maps. Rogers-Ryan emphasizes, "This assistance helped me better structure my data to provide wider services to several government departments without being overwhelmed by the work."

GIS Used to Evaluate Land Resources for St. Kitts in a Postsugar Era

St. Kitts (also called St. Christopher) is part of an independent, twin-island federal state with the island of Nevis. Both islands have a total population of 39,000 and achieved their independence in 1983 when the British made them the smallest independent state in the Western Hemisphere. St. Kitts has a land area of 65 square miles (168 square kilometers) with extremely fertile soils used primarily for sugar production for the past 350 years.

Fluctuating commodity prices and reduced European Union trade preferences have made the island's reliance on single-crop agriculture an economic vulnerability. To address such vulnerabilities, in 2005 the government of St. Kitts and Nevis (GoSKN) made the decision to close the sugar industry and vigorously pursue its economic diversification by placing emphasis on more viable alternatives, such as tourism and nonsugar agriculture, including field crops and livestock. One of the major challenges of this effort is adopting careful planning to ensure that the island's land resources previously utilized by the sugar cane crops are optimized for the long-term economic, social, and environmental sustainability of the country.



St. Kitts' land suitability map for vegetables.

After the closing of the sugar industry, the GoSKN Physical Planning Department (PPD) and Department of Agriculture spearheaded the planning for the agricultural transition. A land resource analysis study was conducted using ArcGIS (ArcView) to identify the most suitable lands for six nonsugar agricultural activities: vegetable crops (e.g., tomatoes, peppers), pineapples, fruit tree crops (e.g., sugar apples, guava), field crops (e.g., cassava, sweet potato), livestock production, and pasture/grass (e.g., guinea grass for feeding livestock). "While specific areas have been quantified based on suitability," says Daniel (former PPD staff member and lead researcher on the study), "an added benefit of this study was the ability to identify, compare, and quantify areas for uses beyond agriculture. We were able to evaluate future land use, such as housing for tourism, industrial, and residential, along with suitable lands for nonsugar agricultural activities. Using GIS, we were able to see the bigger picture of how to develop areas for the benefit of the community."

Mapping Resources on Rodrigues Island to Sustain Human Activity

Rodrigues is a partly autonomous island found approximately 400 miles (650 kilometers) east of its sister island, Mauritius. Third largest of the Mascarene Islands, Rodrigues has 40,000 people who live off reef and subsistence farming and has few support services and only a fledgling tourism industry.

Shoals Rodrigues, a nongovernmental organization working closely with the island's government, the Regional Assembly, conducts marine research, education, and training about the extensive reef area, which extends over twice the size of the land itself. One major activity is assessing the extent and health of the marine resources, including the corals, sea grasses, and mangroves. With the support of the Universities of Newcastle and Bangor in the United Kingdom, Shoals Rodrigues created a map of the basic reef structure using supervised classification of Landsat Enhanced Thematic Mapper data, with an eye to using QuickBird satellite imagery and ArcView in the near future for the more detailed map of the resources, as well as in educational work and governmental planning.

(Reprinted from the Fall 2009 issue of *ArcNews* magazine)

Enterprise Product on Demand Services

Automated Map and Chart Creation at the NGA

The National Geospatial-Intelligence Agency (NGA) is a U.S. Department of Defense (DoD) 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 and 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 known now 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 data in all domains, including aeronautical, nautical, and topographic, for selected customers. The ability to design and print custom maps was also high on the list of desired functionality.

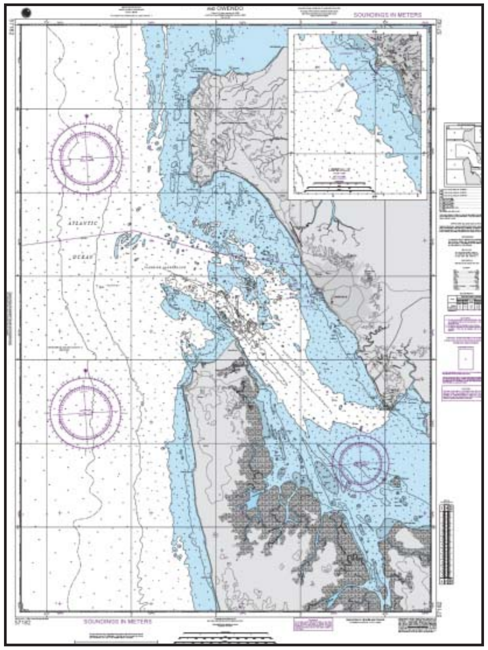
The ePODS initiative yielded a Web portal allowing users access to the system from specific NGA networks built on service-oriented architecture (SOA) using Esri's ArcGIS system. ArcGIS Server and ArcIMS provide the GIS Web portal and services functionality, respectively. Esri Mapping and Charting provides 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 print it or download a source package that includes data, instructions, and media to work locally on the maps for further refinement. Output is produced in several formats including PDF, GeoTIFF, JPEG, CADRG, and geodatabase/ ArcMap document (MXD) downloads.

As it continues to mature, ePODS offers more products to NGA's user community. In April 2007, the ePODS program moved from being a prototype 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. Other services to undergo an ORR/ OAR include

Topographic Line Maps (TLM) (summer 2009) and OPAREA and tactical pilotage charts (TPC). 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 and logistics support ships. While under way to an overseas port, the crew recognized a need for an updated harbor chart for their destination. The crew 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 it was received, a combined NGA and Esri team 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's crew to safely sail into the harbor. Using traditional production methods, this same chart would typically take six to eight weeks to reach operational users.



Updated Harbor Chart showing approaches to Libreville and Owendo used by the SS Curtis *while at sea.*

In the summer of 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 program has allowed and 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 its intended use, eliminating the need to spend hundreds of hours finishing a one-off product that will only be used for quick analysis.

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

(Reprinted from the Summer 2010 issue of *Compass Points* newsletter)

Keeping Nature and Man in Balance

GIS data portal enables ecosystem-based management

By Katie Budreski, Stone Environmental, and Karen Richardson, Esri

An online atlas and geoportal makes more than 400 datasets available for managing the shoreline of the North Atlantic Ocean, estuaries, and portions of two of the five Great Lakes that are within the State of New York.

Visitors seine for fish and crabs in the shallows of the Hudson River, part of the Esopus Meadows, which has abundant aquatic wildlife and forest ecology.

Developed by the New York Ocean and Great Lakes Ecosystem Conservation Council, the atlas and geoportal are used for ecosystem-based management (EBM). EBM is the study of activities within specific geographies with the goal of finding ways for humans and nature to coexist in a sustainable manner. Used mainly to study terrestrial environments, EBM has gained recent popularity in marine studies as communities search for solutions to ailing fisheries and ocean ecologies. Spatial data plays a key role in assisting communities practicing EBM because this management approach is place based and studies are focused on activities in specific geographies.

New York State uses EBM for managing the shoreline of the Northern Atlantic Ocean and its estuaries as well as portions of two of the five Great Lakes. To do this effectively, the state created The New York Ocean & Great Lakes Atlas (nyoglatlas.org) and geoportal (portalnyoglecc.nyoglatlas.org). The atlas is used by the general public as well as local, regional, and state decision makers to view and explore more than 400 datasets about the region. The GIS Portal Toolkit [now known as the ArcGIS Server Geoportal extension] helps visitors easily navigate the vast catalog of data accessed via the geoportal. The Geoportal extension includes a catalog service and a Web application.

An Innovative Way to Manage the Marine Environment

The New York Ocean and Great Lakes Ecosystem Council, created in 2006, is charged with protecting, restoring, and enhancing New York's ocean and Great Lakes ecosystems while taking into account sustainable economic development and job creation. The council is chaired by the commissioner of Environmental Conservation and composed of commissioners from Agriculture and Markets, Economic Development, and Transportation, as well as the secretary of state, the president of the New York State Energy Research and Development Authority, and the interim chancellor of the State University of New York.

Stone Environmental, an Esri business partner based in Montpelier, Vermont, helped create the atlas. When launched in July 2008, the atlas was composed of a Web-based mapping application and more than 200 datasets. Users could view the datasets, download metadata and spatial data in multiple formats, and view attributes of the data. While the council had technically met its mandate, it was clear that an online catalog would be necessary to help navigate the available datasets.

The deep-water harbor of Greenport has been a working seaport since the 18th century and continues to be a vital hub both environmentally and economically for the area.

Portal Makes Data Searchable

After reviewing several technologies, the council implemented the GIS Portal Toolkit because it had—out of the box—the functionality that the council required. Sophisticated searching capabilities, the ability to establish user accounts and data provider access, and flexible metadata authoring tools were very important and readily available in the software. In addition, Esri's open software environment aligned with the council's vision for future enhancements outlined in its five-year strategy document.

The portal provides a robust way for users to search all the data holdings at the atlas. Users of the portal can perform metadata searches by keyword, data type, data category, date modified, and geographic location. Information for specific areas of interest can be easily found and compared in this manner. Once found, the search results can be saved in several ways: to a user profile, to a GeoRSS feed, or as an HTML page or HTML fragment that allows users to embed a defined block of HTML inside documents at key locations. Data can also be downloaded in various GIS formats, including Esri shapefile format, via an FTP link.

One-Stop Shop for Data

When Stone first began looking for relevant data, it discovered this was a huge task. To find the data included in the atlas, the company employed Web searches, phone calls, e-mails, and face-to-face conversations with staff from more than 300 organizations. Since the first launch, more data has been added for a total of nearly 400 searchable datasets.

Data includes administrative boundaries; elevations; cadastre; environment and geoscientific information, such as geology, groundwater, and soils; marine data, such as fish distribution and habitat, and invasive species; as well as cultural information including historic sites and settlement information.

Many datasets are from organizations that had never before distributed geospatial data widely. For example, the Facility Limit Measurement Violation data from the New York Department of Environmental Conservation (NYDEC)—Water Division provides information necessary for the Clean Water Act National Pollutant Discharge Elimination System Program that had been identified as a priority through a data needs workshop. The agency had resource and technical constraints with sharing the data internally. Providing the data via the atlas—without having to host the data—allowed this important dataset to be shared.

Facility Limit Measurement Violation data from the New York Department of Environmental Conservation (NYDEC)—Water Division provides information necessary for the Clean Water Act National Pollutant Discharge Elimination System Program that had been identified as a priority through a data needs workshop. The agency had resource and technical constraints with sharing the data internally. Providing the data via the atlas—without having to host the data—allowed this important dataset to be shared.

Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs. These wetlands located in Wilson, New York, on Lake Ontario are an example of one of the "biological supermarkets" that can be managed using The New York Ocean & Great Lakes Atlas.

Publishers Control Data

When the Atlas Data Portal was first launched, the council published the data and metadata provided by the data providers. Moving forward, the council will encourage data providers to publish metadata records directly to the portal and, when possible, host their own data through subportals. Providing direct access will ensure that data is as current as possible for EBM planners and communities.

To make it easier, data providers have several avenues for easily publishing data using the portal. Records can be published by uploading metadata that has been created by a metadata editor based on Federal Geographic Data Committee (FGDC) and International Organization for Standardization (ISO) standards, like the metadata included within the Geoportal extension.

Metadata can also be created using a Web form. Data providers can establish a data harvesting relationship with the portal through a subportal or Web-accessible folder. This allows the data portal to collect desired Web pages and extract necessary data.

The Tug Hill Commission GIS Data Portal (24.39.214.21/GPT9/catalog/main/home.page) is an example of a subportal. Tug Hill is a 2,100-square-mile area in a remote rural region of New York located between Lake Ontario and the Adirondacks mountain range. Several geospatial datasets were developed as part of an EBM demonstration project in the Sandy Creeks watersheds on the eastern shore of Lake Ontario. A separate data portal, the subportal, was developed so the Tug Hill Commission could manage its own geospatial data holdings but still make the data available to New York Ocean & Great Lakes Atlas users.

Next Steps

This year, the New York Ocean and Great Lakes Ecosystem Conservation Council will work with Stone Environmental to integrate the Data Portal and Data Viewer, currently two separate applications, by upgrading to ArcGIS Server. Additional enhancements will include the incorporation of thesauruses for enhanced searching and the use of Web Map Services (WMS) and Web Feature Services (WFS) for data dissemination.

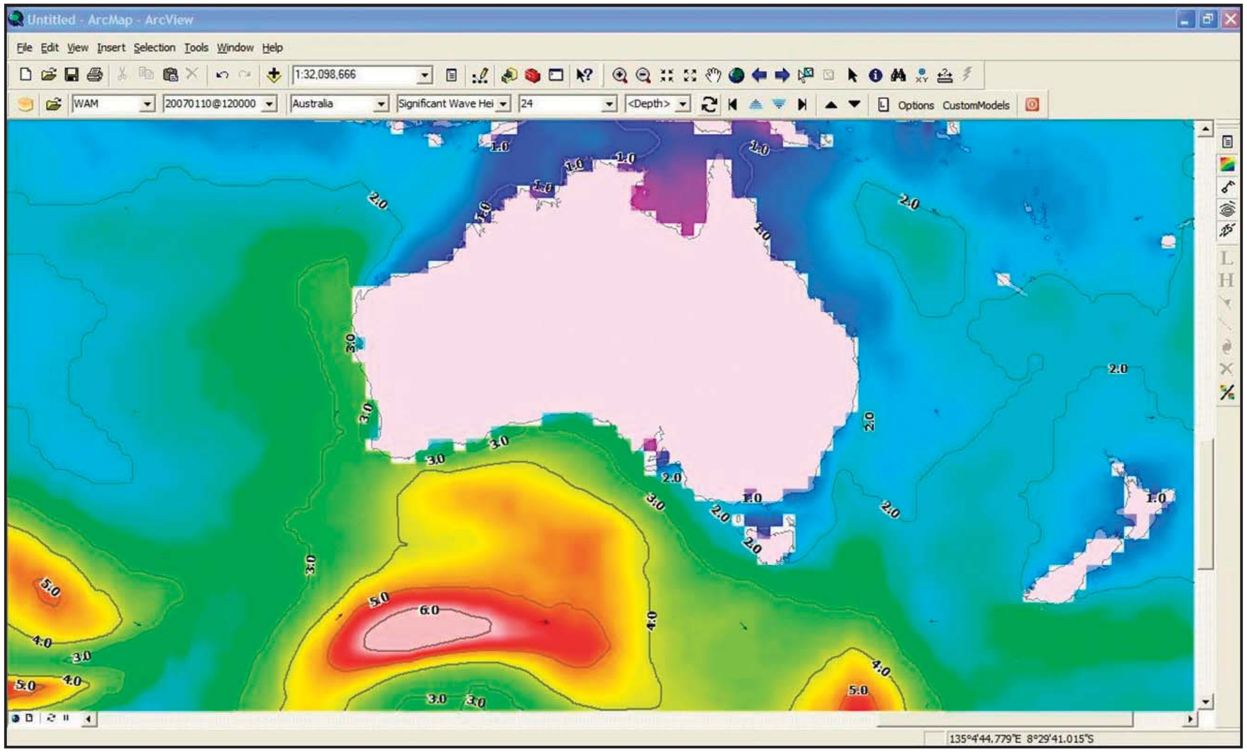
(Reprinted from the Summer 2010 issue of *ArcUser* magazine)

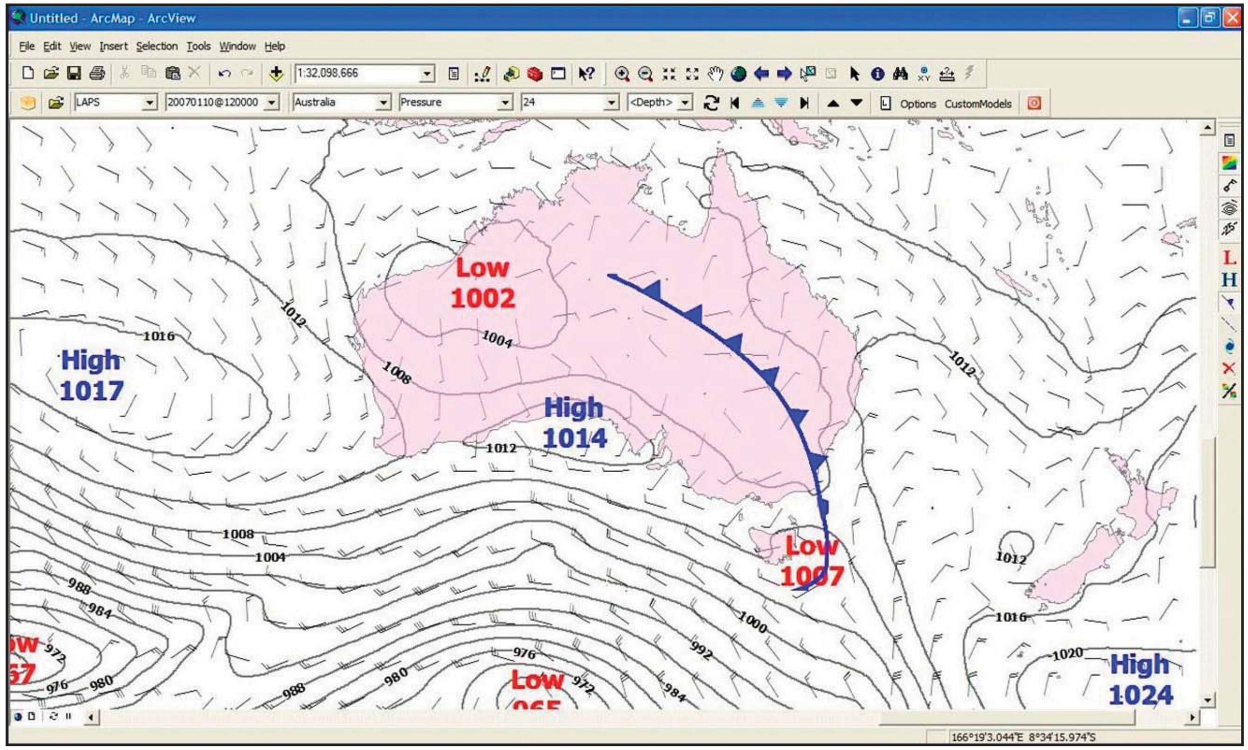
RAN Directorate of Oceanography and Meteorology

Providing Spatially Enabled Weather, Wave, and Ocean Forecasts

Overview

The Royal Australian Navy (RAN) Directorate of Oceanography and Meteorology, with support from ESRI Australia, Pty. Ltd., Esri's distributor in Australia, has developed a capability to spatially enable numerical weather, wave, and oceanographic forecast model data from the Australian Bureau of Meteorology (BoM) and provide these products to the Australian Defence Force via both a Web service and a custom desktop extension.

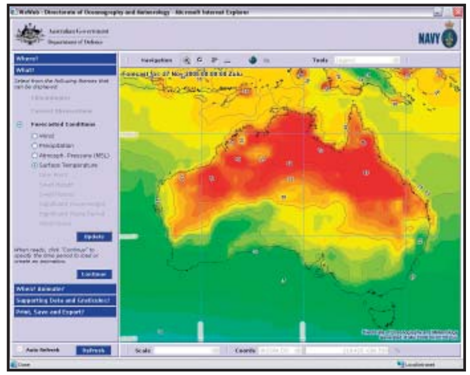


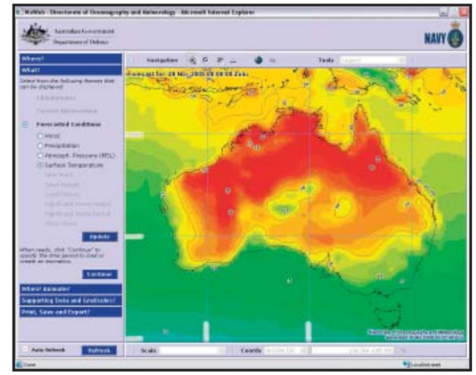


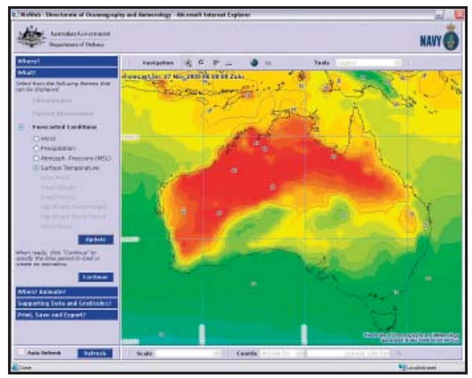
For units with Internet connectivity, the interactive Meteorological and Oceanographic Viewing Environment (iMOVE) is an ArcIMS software-based application providing a single interface to animated maps of forecasts supported by a range of background maps, climatological products, and historical and current observations.

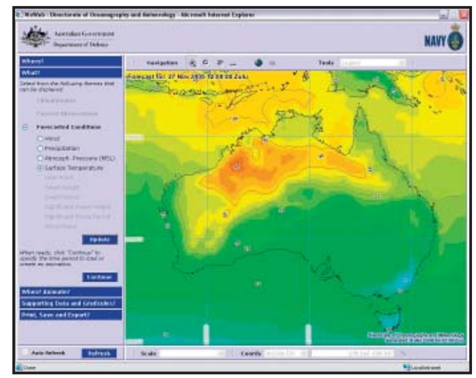
For units with only occasional e-mail access, the model data is written to a file geodatabase as a raster catalog and features, zipped, and transmitted as an e-mail attachment. The custom METOCViewer extension then unzips and loads the data into ArcMap for annotation and viewing.

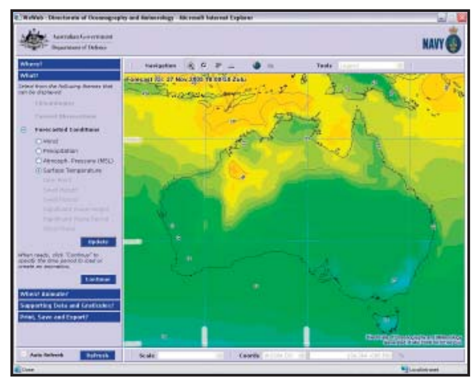
Examples of animated maps of meteorological forecasts:











Capabilities The Internet Map Server (IMS) interface

- Utilizes business logic to build a query based on where (location), what (models and parameters), and when (time or period)
- Distills gigabytes of data into intelligible graphic maps only hundreds of kilobytes in size
- Provides rapid access to modeled forecasts from BoM NWP supercomputers
- Allows animation or progressive time steps through forecasts
- Supports background situational awareness products such as nautical charts, maps, elevation models, and gazetteers
- Exports maps in image formats including GeoTIFF
- Has an interactive interface with zoom, pan, and preset areas of interest
- Is able to incorporate Web Map Server (WMS) or other ArcIMS image services.

The METOCViewer extension is fully integrated with ArcGIS Desktop and may be used to display model data, weather observations, and weather satellite imagery with full weather symbology.

Benefits Both iMove and METOCViewer provide meteorological products to the METOC officer wherever deployed via limited bandwidth defense communication networks, displaying tailored parameter-based views with minimal impact on the network bandwidth. The application is ideal for gaining situational awareness based on regional weather patterns, and resulting images can be exported for use in command briefings or as GeoTIFFs in other command and control systems.

(Reprinted from Volume 4 of the *GIS in the Defense and Intelligence Communities* brochure)

Taking NEXRAD Weather Radar to the Next Level in GIS

By Scott T. Shipley, Department of Geography and GeoInformation Science, George Mason University

The National Weather Service (NWS) currently serves near real-time radar information in GIS-ready formats through its radar integrated display with geospatial elements (RIDGE) service at http://radar.weather.gov. The current RIDGE service provides two-dimensional products as each radar scans through 360 degrees azimuth at its lowest beam elevation angle, which is nominally about one-half degree above the horizon. These products are generally seen draped on the surface as ground overlays, mapping radar reflectivity or radial velocity as a function of position (latitude-longitude) and animated in time. This is a fabulous and useful service, which is now being taken along on portable handheld devices. The message is clear to the casual user: any radar echo over your location means it should be raining, or snowing, or whatever it's supposed to be doing outside at the moment. But sometimes there are no radar echoes over a user's location, yet they're getting soaked.

So what's going on? The answer can be found in the third dimension.

Radar beams propagate horizontally through the atmosphere along Great Circles, but do not usually follow a straight path or ray in the vertical dimension. As shown in figure 1 for standard atmospheric conditions, radio beams are normally refracted downward toward the earth. Any departure from this standard path is known as anomalous propagation (AP). If the radar beam encounters an obstacle, such as terrain or buildings, power is removed from the radio beam and a radio shadow appears behind the obstacle. This effect is known as *occultation.*

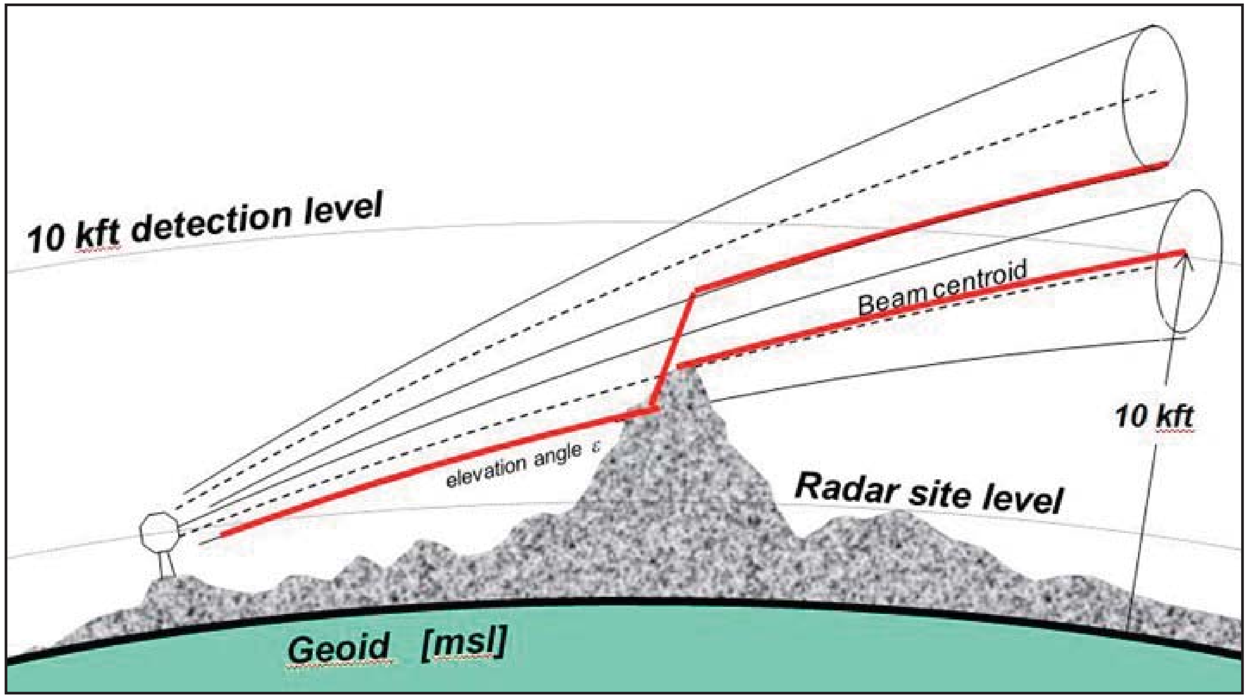


Figure 1. Radar propagation paths show occultation of the lowest elevation beam by terrain. When more than 50 percent of a beam is removed by occultation, that beam is considered blocked, and radar signals are obtained from the next-highest elevation scan.

Beam occultation by terrain raises the lowest detection altitude behind an obstacle, defining the lower limit, or floor, of the active radar volume. The degree of occultation is symbolized by the percentage of beam removed in tenths of vertical beam width.

Applying the 50 percent blockage rule to a radar collection provides an indication of the vertical extent for radar coverage in a region. This is shown in figure 2 for the five NEXRAD systems covering the Front Range of the Colorado Rockies. A regional floor is found by combining all radar grids with the *minimum* analysis condition and the application of SetNull, so that only detectable areas of the atmosphere are combined.

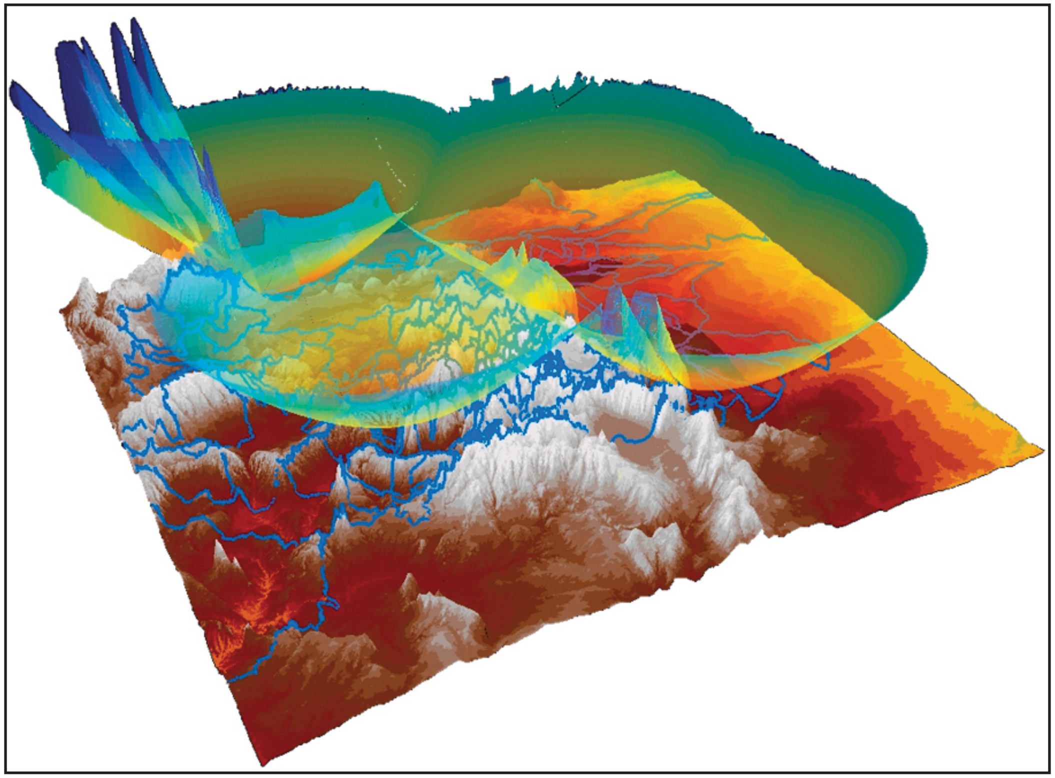


Figure 2. Mosaic of the floor for five radars over north central Colorado—Cheyenne, Wyoming (KCYS); Denver/Boulder, Colorado (KFTG); Pueblo, Colorado (KPUX); Grand Mesa, Colorado (KGJW); and Riverton, Wyoming (KRIW)—including the Front Range.

The challenge is to show where terrain is blocking the NWS weather radar network and to what degree. GIS provides a straightforward solution by comparing the vertical beam centroid (midpoint of the beam) as a floating surface to a digital terrain model at an appropriate spatial resolution. The resulting pattern for the Seattle, Washington, NEXRAD (KATX) is shown as a floating surface with ArcGIS Explorer in figures 3 and 4. The occultation patterns for all 155 NEXRAD systems are published as a globe service in ArcGIS Server 9.3 and are available for inspection, courtesy of WxAnalyst, Ltd., at http://wxanalyst.com/radar.

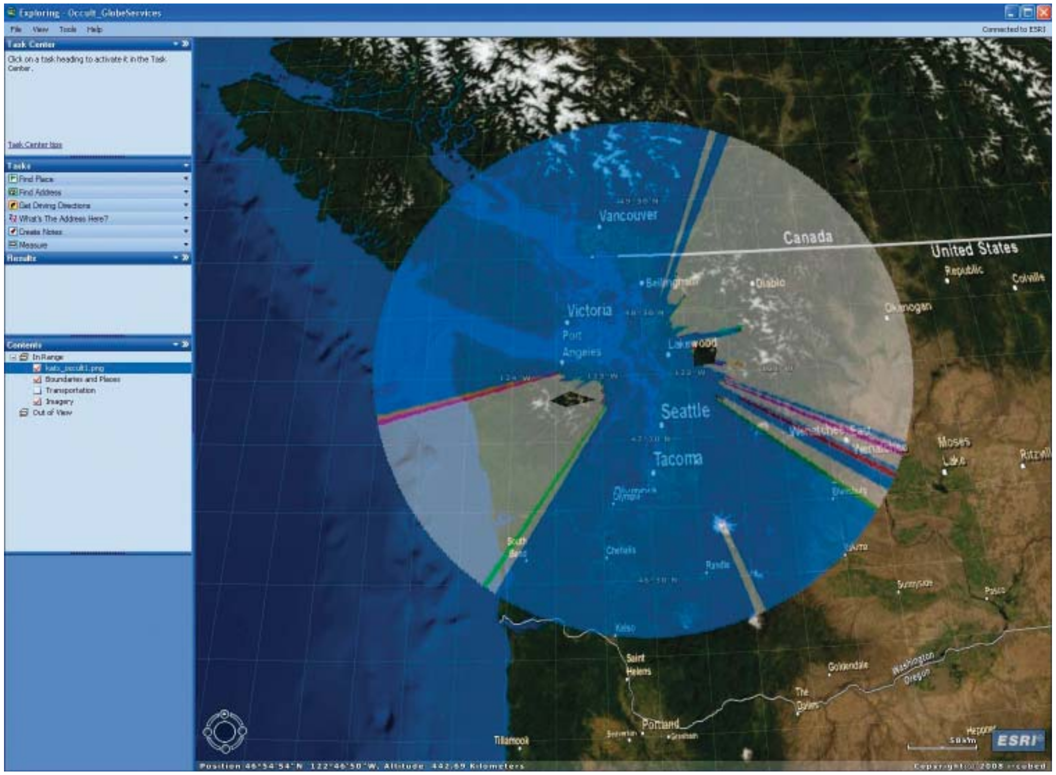


Figure 3. Occultation pattern for the lowest elevation scan of the Seattle, Washington, NEXRAD (station KATX) in ArcGIS Explorer. Note the total blockage of this elevation scan by terrain to the east and west and by Mt. Rainier to the south-southeast. The occultation pattern is a 3D service draped on beam centroid elevation. Areas where the terrain layer is higher than the beam centroid can be seen penetrating the coverage.

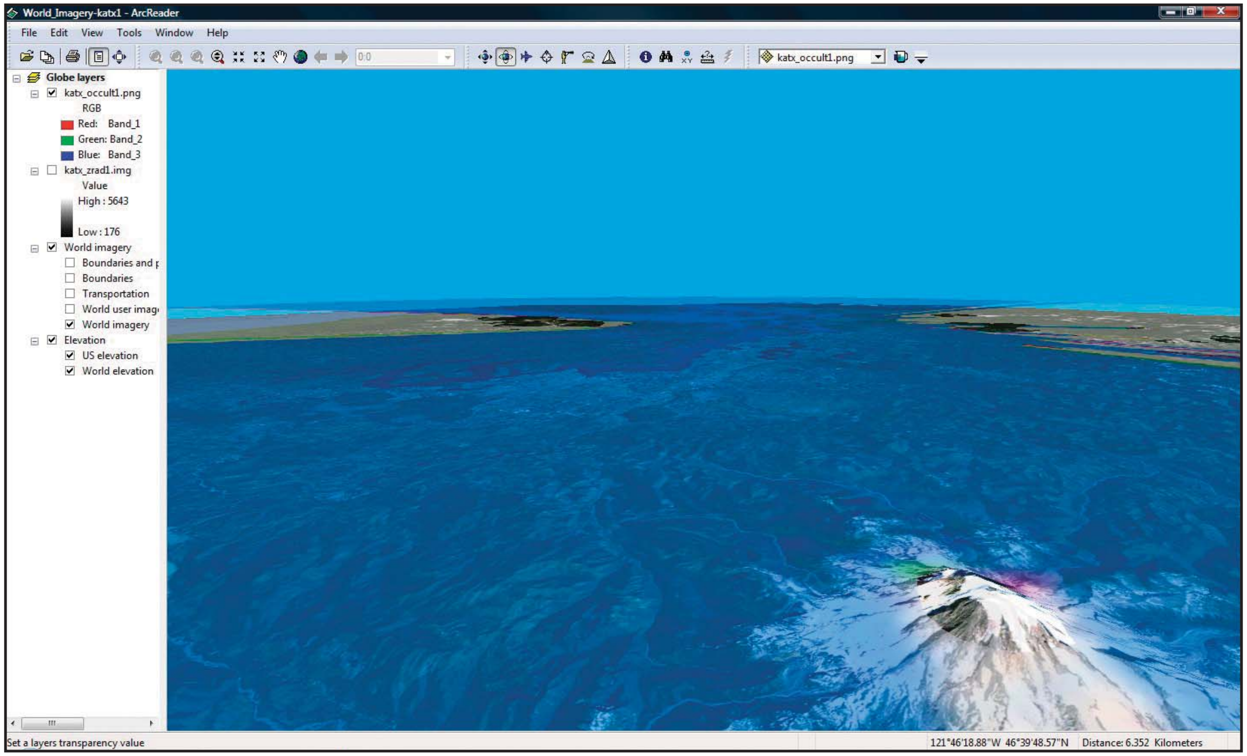
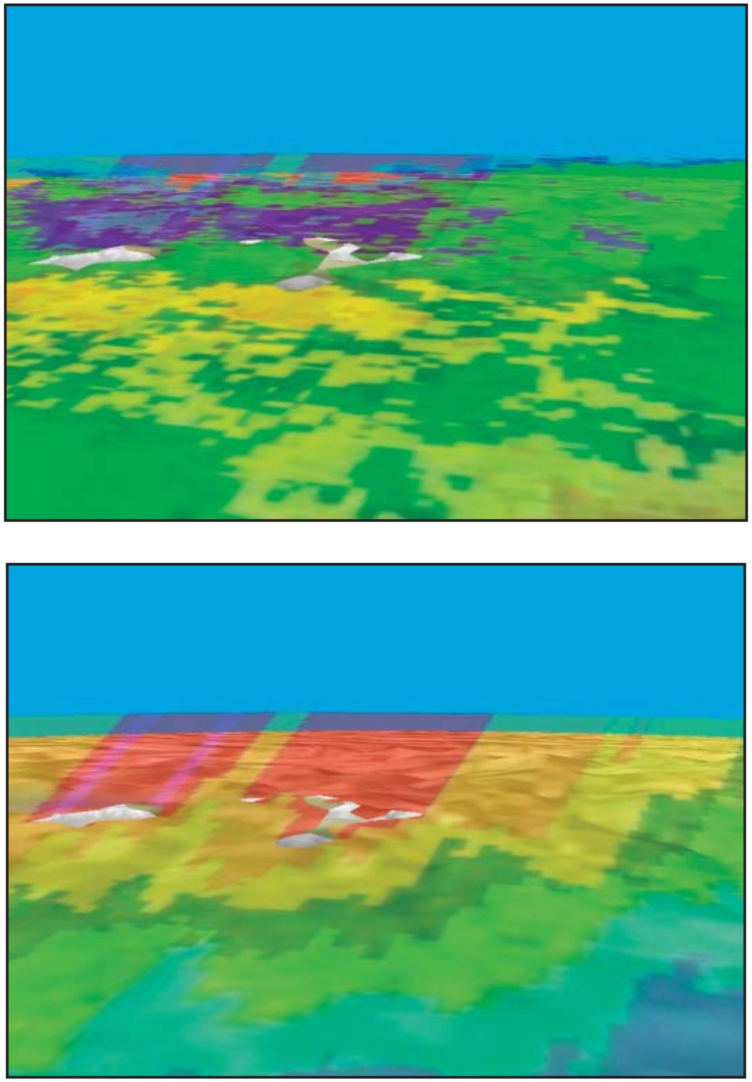


Figure 4. Close-up image of the KATX occultation pattern using ArcReader. The top of Mt. Rainier, at bottom right, provides a convenient ruler to verify vertical placement of the radar beam centroid.

The NEXRAD occultation patterns are also available in KML format, using collaborative design activity (COLLADA) to model the 3D surface.

The RIDGE radar data is now accessible in 3D using the same floating surfaces for each beam elevation angle. This is shown in figures 5a and 5b for the Sacramento, California, NEXRAD (KDAX) using RIDGE reflectivity from the storm of January 4, 2008.



Figures 5a (top) and 5b (bottom). KDAX (Sacramento, California), looking west over the Sierra Nevada Mountains. The top image shows a lowest elevation scan without radar reflectivity. The bottom image depicts a lowest elevation scan with radar reflectivity, showing the rain shadow behind the mountains due to occultation.

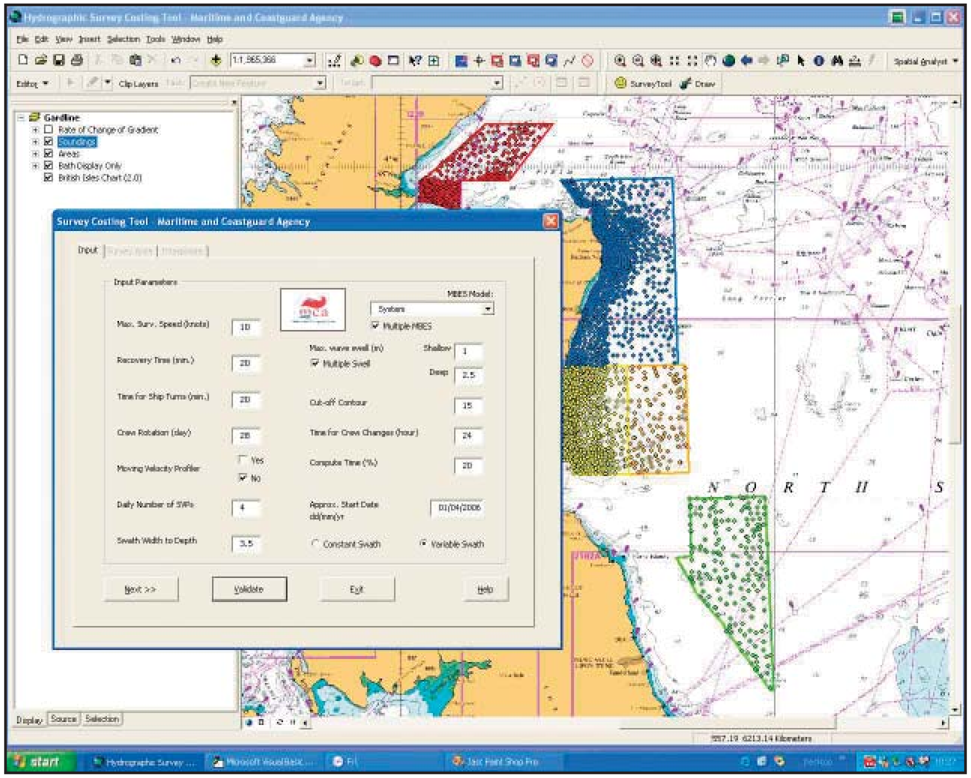
Acknowledgment—The author acknowledges the intellectual contribution of Steve Ansari of the National Climatic Data Center, which led to implementation of the 3D beam centroid surfaces in KML/COLLADA.

(Reprinted from the Spring 2009 issue of *Atmospheric Front* industry newsletter)

Maritime and Coastguard Agency Case Study toward a More Efficient Tendering Process

The Client

With 97 percent of all United Kingdom (UK) trade by weight traveling by sea, a vibrant fishing community, and many using beaches for leisure and sport, the Maritime and Coastguard Agency (MCA) has a remit to ensure "Safer Lives, Safer Ships, Cleaner Seas" on and around 10,500 miles of UK coastline. Headquartered in Southampton, the geographically dispersed, 1,170-person staff of MCA is responsible for implementing the government's maritime safety policy, which aims to prevent loss of lives along the coast and at sea, ensure that ships are safe, and prevent coastal pollution.

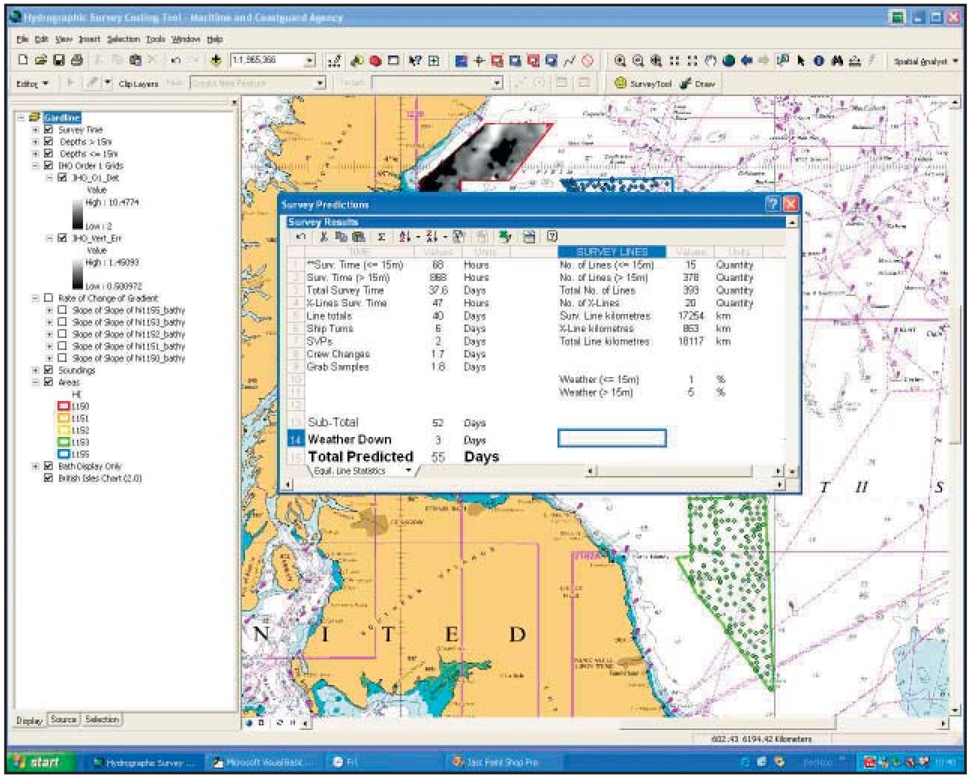


Hydrographic Survey Casting Tool.

The Challenge

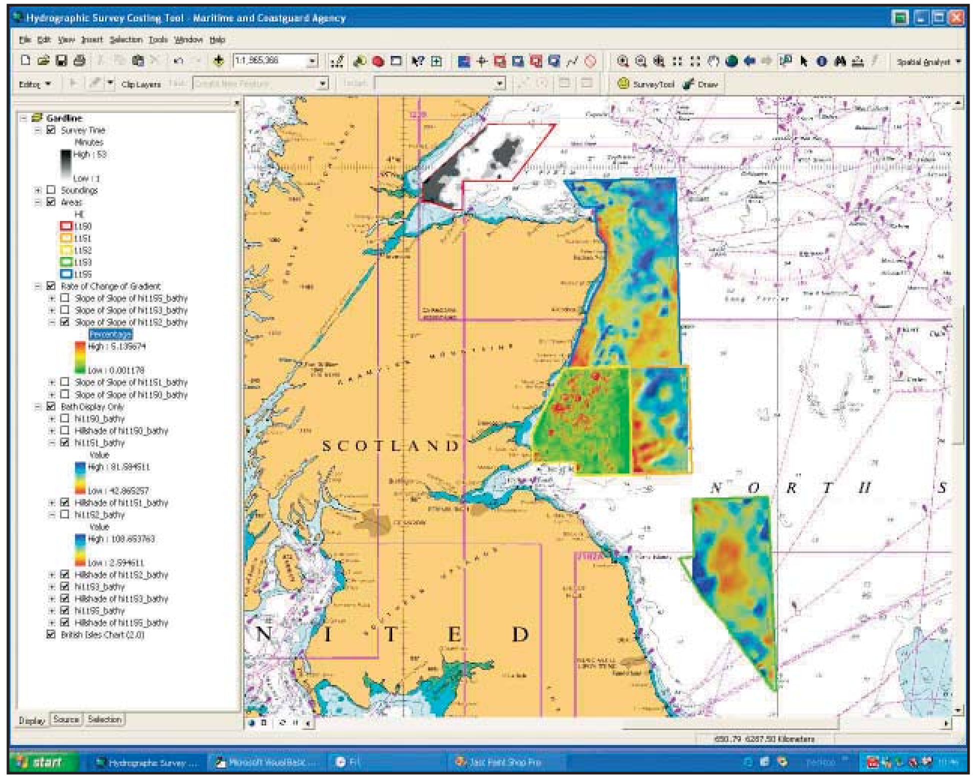
One of the key deliverables for MCA is the provision of survey information to maintain nautical charts (marine maps for mariners) through the Civil Hydrography Programme (CHP). The aim of CHP is to ensure that UK waters are adequately surveyed for safe passage of shipping in and around the coastal waters of the UK.

The 2004 survey season saw the first use of multibeam echo-sounding technologies to gather bathymetric depth information for inclusion in nautical charts. Although this technology provides greater efficiencies, it has made it difficult for MCA when responding to contractors tendering for work. The previous method of single beam survey made it relatively easy to estimate the cost of work on a km^2 basis. However, the introduction of different multibeam sensor models, used on different ships and operating in different sea conditions, means that quotes for work now vary dramatically from contractor to contractor.



Hydrographic Survey Costing Tool with Bathymetry.

MCA needed a solution that would enable the agency to validate contractors' bids in an informed, consistent, and fair manner to ensure that the £5 million survey budget is spent in the most efficient and effective way. Furthermore, it was necessary for the solution to provide a method for agreeing on payment for changes to the survey program that occurred midcontract.



Survey Costing Results.

Solution and Capability Delivered

The resulting survey costing tool allows a number of geospatial datasets and parameters to be analyzed to generate an estimated cost of survey. ArcGIS Spatial Analyst utilizes data including

- The type of echo sounder proposed by the contractor. The survey tool can be configured to take into account proposals that use different survey tools in shallow and deep survey areas. The tool creates a grid of the survey area based on the swath width of the sensors.

- The user-defined survey area polygon. This polygon is used to clip out the data required to perform the analysis. Clipping the data reduces the processing overhead. Data, including a grid based on soundings, is resampled to ensure that the pixel size matches that of the sensor swath width.
- Temporal information such as the maximum survey speed the ship may attain without degrading quality of survey data, downtime for crew rotation, and ship turns.
- The maximum, mean, and standard deviation of wave heights in the survey area. This information, provided by the Meteorological Office, enables the calculation of the likely downtime a survey vessel may experience per calendar month, depending on area and time; for example, a smaller ship won't be able to operate in rough seas.

All the spatial grids are added to allow a cost to be assigned to each pixel. This in turn allows the calculation of estimated survey cost. A map of the number of survey lines required to complete the survey, along with statistics on how the estimate has been generated, is automatically populated within a Microsoft Excel spreadsheet. This spreadsheet forms the basis for contract negotiations between MCA and survey contractors.

Benefits

The use of the survey costing tool has enabled MCA to analyze the datasets required to create accurate estimates for the commissioning of hydrographic surveys. The costing tool allows MCA to

- Manage contract variations with an agreed-upon costing methodology. This prevents contractors from over-quoting for variations (due to the fact they know they are guaranteed the work).
- Quickly determine the cost of proposed survey areas in advance (thereby ensuring that the "cost" in the cost-benefit equation is known precisely when choosing areas to survey).
- Analyze quantifiable and repeatable results rather than the old subjective, manual method of determining costs for surveys; it is also infinitely quicker in providing a result.
- Gather support for business cases it puts forward for additional funding for hydrography.

The Future

The survey costing tool could be made available to sister organizations around the world. Due to the parameterdriven nature of the application and its development in ArcObjects, the tool is easily customizable to allow for localized environmental factors.

There are plans for the costing tool to be enhanced to calculate risk to the mariner of not surveying a particular area (based on the depth of water, the amount of marine traffic, the age of the existing survey data, etc.). The tool could thus calculate risk and cost, and an algorithm could therefore be written to determine where MCA should survey to maximize the benefit from its budget.

The Technology

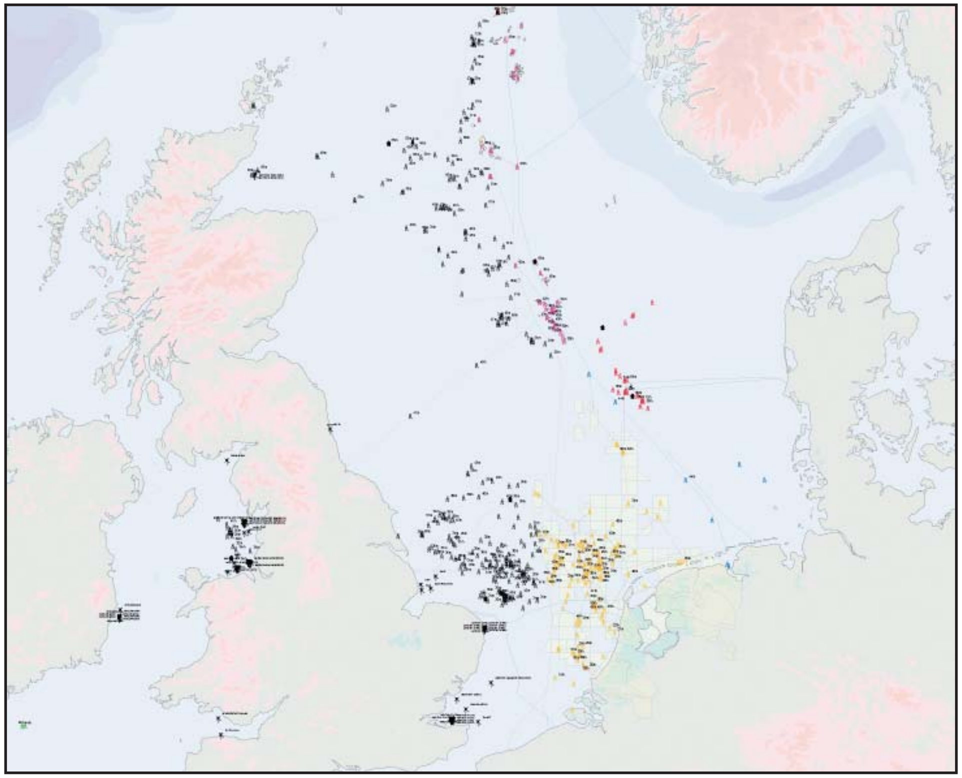
The survey costing tool has been built using core functionality of ArcInfo and ArcGIS Spatial Analyst. ArcObjects with Visual Basic was used to bring the required tools together and expose them in a unified user interface.

(Reprinted from Volume 4 of the *GIS in the Defense and Intelligence Communities* brochure)

NATO Maritime Component Command HQ Northwood, UK, Supporting Maritime Situational Awareness

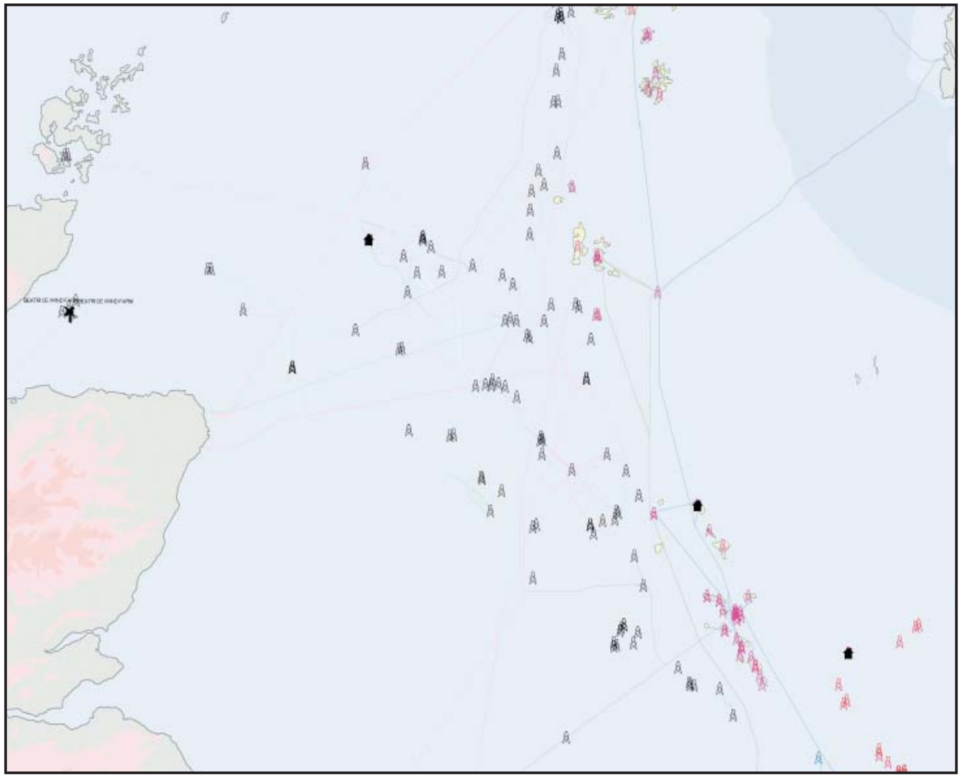
As part of the ongoing mission of the North Atlantic Treaty Organization Maritime Component Command Headquarters (NATO MCC HQ) Northwood to promote peace, security, and stability within the North Atlantic, the Operations Division (N3) of the HQ is focused toward Maritime Situational Awareness (MSA) that's defined as "the effective understanding of anything associated with the Maritime Domain that could affect the security, safety, economy, or environment of the Alliance, its member nations, its Partners and other nations it chooses to work with."

MCC HQ Northwood.



Maritime Data Collection.

An essential part of this MSA process is the 24/7 collection of maritime-specific data, including industrial infrastructure information, with various contributors providing data. Esri ArcGIS 9.1 software is used extensively to maintain a visual database of much of the data collected. This data can be used by HQ staff for briefings/presentations, as exports are made in various formats from ArcMap or even combined with other maritime data and imported into other GIS-capable computer systems within the headquarters.



Oil and Gas Industry Data.

(Reprinted from Volume 4 of the *GIS in the Defense and Intelligence Communities* brochure)

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Esri applications, running on more than one million desktops and thousands of Web and enterprise servers, provide the backbone for the world's mapping and spatial analysis. Esri is the only vendor that provides complete technical solutions for desktop, mobile, server, and Internet platforms. Visit us at www.esri.com.

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