Interoperability: The key to modern geospatial solutions for coastal applications

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Introduction

A wide range of digital geospatial technologies have long been used in the planning and management of ports, terminals and coastal zones. These technologies are becoming increasingly important as their capabilities increase, as their cost goes down, and as they become integrated via the World Wide Web. Their importance also increases with demands for safer, more efficient ports and terminals and for sustainable development along the world's coasts.

Interoperability among geospatial technologies and among different technology providers' products has become a key requirement. In almost any geographic region, and especially in heavily populated regions, people working in different sectors, disciplines, agencies, jurisdictions, and professions have a need for efficient sharing and integration of diverse kinds of information about their region. Fortunately, various standards efforts have made such sharing easier than before.

This article briefly describes geospatial technologies and explains how they are useful in marine and coastal applications, and we look at why it is important that different geospatial systems be able to "talk to" one another.

Diversity of geospatial technologies

The following technologies produce, store, process and display information about earth features and phenomena, where the information is usually referenced to an earth coordinate system:

- **Geographic Information Systems (GIS)** are geospatial database systems with analytical and display capabilities. Here are just a few GIS applications:
  - Given "data layers" for vegetation cover, bathymetry and tidal flow rates, a new data layer can be produced and displayed that shows regions in which mangrove trees are in close proximity to deep tidal channels. (Some GIS tools enable modeling of three dimensional and four dimensional phenomena like tidal flow.)
  - Given precise land elevation data, perhaps from Light Detection And Ranging (LIDAR), collected before and after a hurricane, changes in sand dunes and shoreline contours can be displayed.
  - Given ship position, ship engine exhaust emission data, and a dispersion model based on data about prevailing winds in a port, a GIS can calculate and display projected ship exhaust emission plumes.

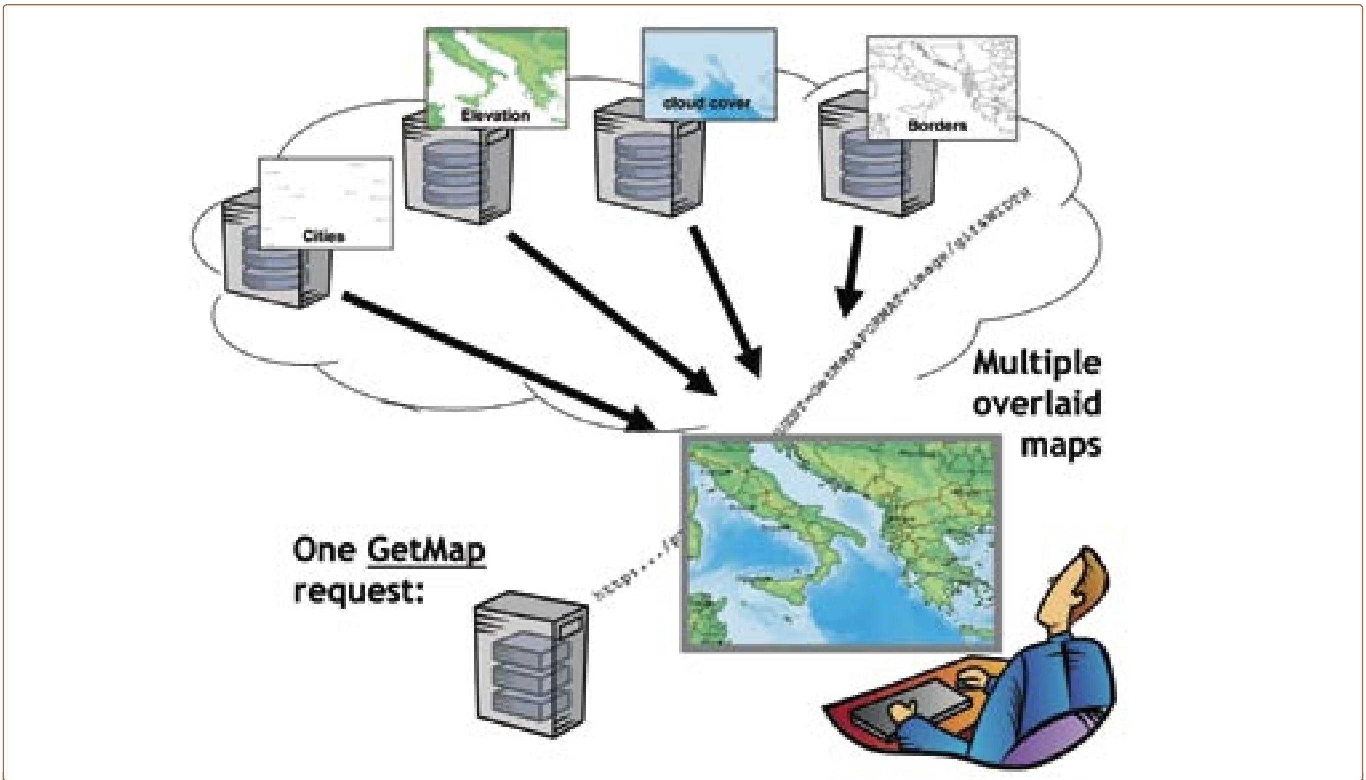

Figure 1: A GIS can combine different data layers. In this figure, map views of different kinds of data are being accessed simultaneously from different sources on the Web. The four "map servers" shown can be running different kinds of software from different vendors, but the Web-delivered digital map images still overlay automatically, thanks to their compliance with the OpenGIS® Web Map Server Specification, an OGC standard. Such capabilities once required an expensive GIS system, but the user shown in this figure requires only a Web browser.

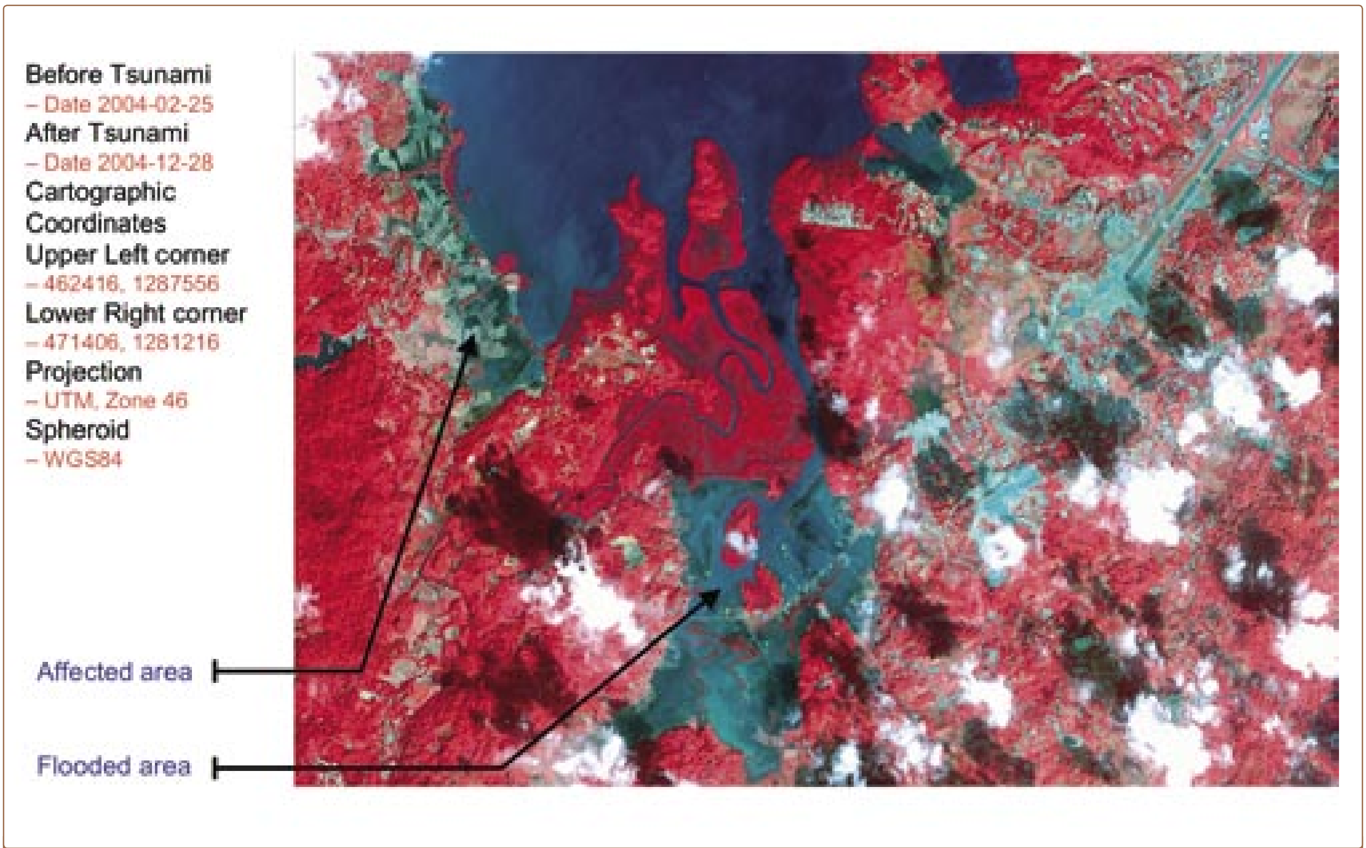

Figure 2. "False colour" earth image showing areas affected by the December 2004 Indian Ocean tsunami. (Original image is from Spot Image, Inc.)

- Given an aerial or satellite image of a harbour, plus a data layer representing channels and reefs, and a dynamic data feed of ship location coordinates, a "live" map of harbour traffic can be displayed. Ships too close to reefs can trigger an alarm.
- A data layer representing population density in a port region can be used with a transportation data layer to estimate the time necessary to evacuate people in the event of a hazardous fume release, tsunami, or threat of a tanker explosion. Phone numbers of residences and businesses in endangered regions can be called simultaneously and automatically to warn citizens.

Many other applications are possible, and the value of GIS is multiplied by the other geospatial technologies described below.

- **Earth observation systems** produce, store and manipulate digital images of the earth like that shown in Figure 2. The sensors (cameras) might be on satellites or airplanes, and the images might represent visible light, ultraviolet or infrared light, gravity or magnetic readings, elevation acquired through radar or LIDAR. Different earth features and phenomena radiate or reflect light in characteristic "signatures," that is, different intensities of radiation in different frequency bands. These signatures can be used to derive many kinds of information from the images. Processed images can be used in a GIS. Stereo images can be used with stereophotogrammetry to produce elevation data and three-dimensional images.
- **Automated Mapping and Facilities Management (AM/FM) systems** are similar to GIS, but are specialised for designing and managing facilities such as airports, manufacturing complexes, and infrastructure such as roads, pipes, and wires. Many GIS and computer aided design (CAD) vendors provide ways of integrating GIS and CAD for facilities management.
- **Global Positioning System (GPS)** receivers process timed radio signals from a constellation of precisely positioned GPS satellite transmitters to provide X,Y,Z earth coordinates. This technology is now in wide use in handheld units, navigation systems, and cell phones. Many cell phones can report position based on relative signal strength from multiple cell towers, though the accuracy does not match the accuracy of GPS.
- **Digital seismic survey equipment and echo sounders** often employ GPS for X and Y coordinates. Echo sounders send bursts of sound down through water and measure the echo time interval to determine water depth. Seismic survey equipment uses the same principle to determine the thickness of sediment layers and/or underlying geological features.
- **Total stations** (survey instruments that combine the angle-measuring capabilities of a transit with electronic distance measurement) produce precise digital locational data for land or marine surveys.
- **Digital navigation systems** typically display GPS points on digital maps or marine charts to help drivers and captains chart their courses.
- **Sensor networks** (sensors and digital cameras that are read and controlled via digital networks) can produce geospatial data if the location of the sensors is known. Sensors might be fixed or mounted on moving platforms. A network of water depth gages, for example, can provide a real-time data layer of tsunami or flood conditions.
- **Map servers** are Web servers that provide "web maps," such as .jpeg or .png files, depicting any of the kinds of data mentioned above.

Yesterday's geospatial "stovepipes" and today's open network

Geospatial technology products of the past did not usually work well together. Considerable expertise and patience were required to find data, move data between systems, convert between different coordinate systems, understand the data models, and manage many other data details. These difficulties will never completely go away, but several kinds of standards efforts have made geospatial data

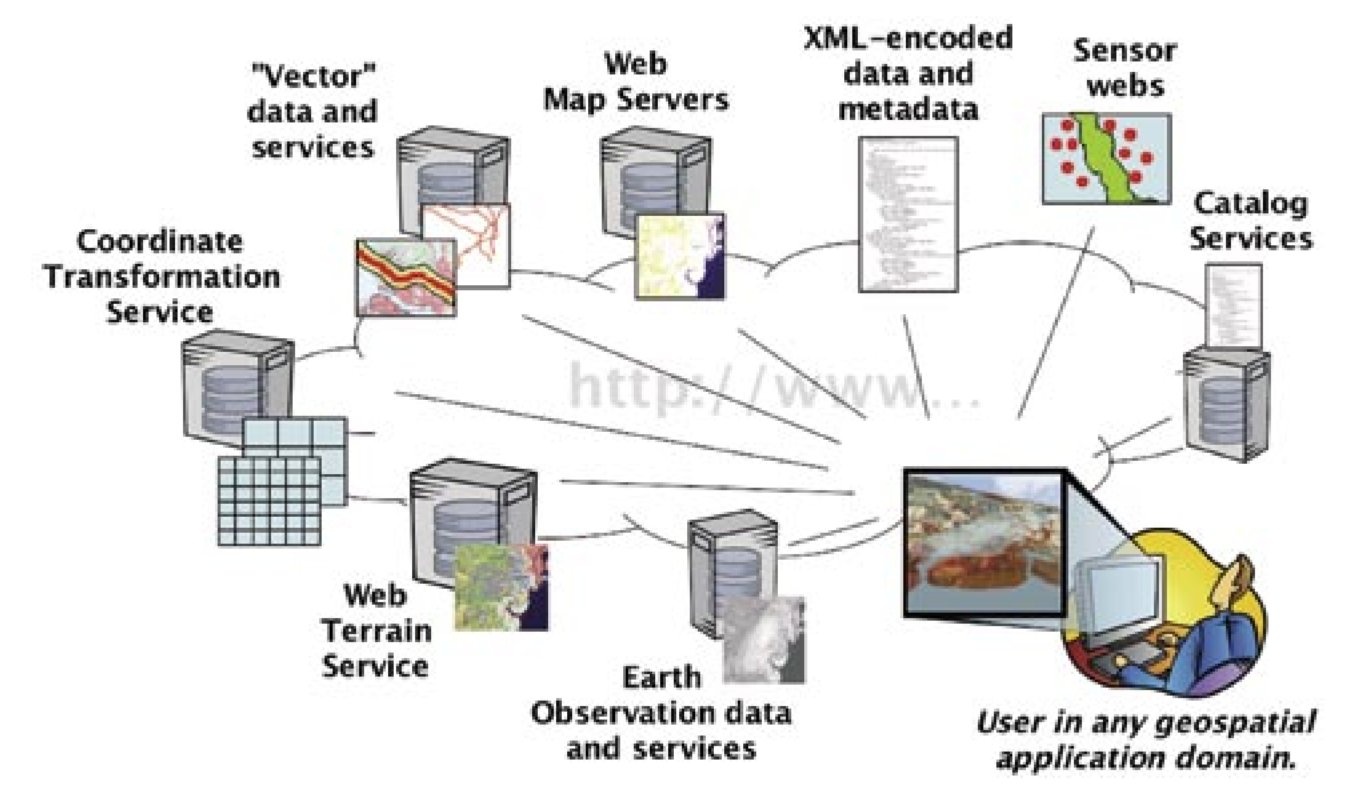

Figure 3. Geospatial web services based on open interfaces make many kinds of data and services available on the web.

much more useful and easy to use and share: Internet and Web standards initiatives, metadata standards initiatives, and interface and encoding standards initiatives.

- Organisations like the Internet Engineering Task Force (IETF), the World Wide Web Consortium (W3C) and OASIS have created an extraordinary world-wide network for information sharing that provides a foundation for efficient geospatial information sharing.
- Spatial data coordination groups, in many countries and disciplines, have helped their constituent geospatial technology users develop and use metadata standards. Metadata is "data about the data," without which it is difficult to learn about and use geospatial data. Metadata encoded in the Web's eXtensible Markup Language (XML) can be electronically cataloged, searched and presented in human-readable form, and software systems based on some of the OGC standards (see below) can be designed to automatically produce XML-encoded metadata. The international standards organisation ISO TC/211 has played an important role in metadata standards efforts.
- The Open Geospatial Consortium, Inc. (OGC), working with ISO TC/211, has, for 11 years, managed an international consensus process in which users and developers of geospatial technologies have created open interface and encoding specifications that enable different geospatial technologies and products to communicate directly. The emphasis in recent years has been on interfaces and encodings that enable "geospatial web services." Web services are geospatial data access and processing functions that are available on the web, typically to users who have no special software other than a web browser.

Today, organisations can "mix and match" geospatial technology components from different vendors, and they can easily integrate geospatial capabilities into enterprise systems. Legacy GIS systems can be "wrapped" with open interfaces to support enterprise integration and Web access. "Web-ready" geospatial products with open interfaces are major step forward and a great asset for port and coastal zone managers.

ABOUT THE AUTHOR

Sam Bacharach joined the Open Geospatial Consortium, Inc., in April 2000. He was a user of mapping data for many years as an Army officer, and then supervised terrain analysis and mapping production as a Topographic Officer before retiring from the service. He spent 5 ½ years in the industry and became convinced that open standards, specifically those from the OGC's open consensus process, were a requirement for geospatial knowledge to ever make its way out of the basement to full integration with information and communication technology. He holds a Bachelor of Science degree and a Master of Science, Geography, from the University of Idaho.

ABOUT THE ORGANISATION

The Open Geospatial Consortium, Inc. (OGC) is a non-profit, international, voluntary consensus standards organisation that is leading the development of standards for geospatial and location based services. Through our member-driven consensus programmes, OGC works with government, private industry, and academia to create open and extensible software application programming interfaces for geographic information systems (GIS) and other mainstream technologies.

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