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Title: **Interoperability and the Economics of Geospatial Technologies**

By: Raj Singh
Director of Interoperability Programs
Open Geospatial Consortium, Inc. (OGC®)
rsingh@opengeospatial.org

Interoperability has always been a key factor in the economics of geospatial technologies, but now it is arguably the main factor. Today's fast-paced economic climate demands that systems be delivered in months, not years. And the information landscape those systems must exploit is broad and diverse.

A number of published studies over the years have reported efforts to quantify the benefits of geographic information systems (GIS) and other geospatial technologies. Onsrud et al, "The Future of the Spatial Information Infrastructure," a chapter in A Research Agenda for Geographic Information Science, 2004, (Boca Raton: CRC Press) provides a good summary.

The topic is complex. Economists generally find it easier to measure market-indicated benefits than to measure social benefits. But with geospatial technologies, both kinds of benefits accrue. Also, how should benefits be quantified? One can measure increased efficiency (doing what was done before by other means, but now doing it faster and cheaper with the new technology) and increased effectiveness (doing a better job than before). But it is hard to measure the value of unexpectedly being able to do new things that were not imagined before, which often happens with geospatial technologies.

Despite these complexities, studies have shown overall that investment in geospatial projects and programs is justified by both market-measurable benefits and social benefits. This is borne out anecdotally by the steady and rapid growth of the geospatial markets, the popularity of location-based services delivered to wireless or desktop terminals, and the wonder and warm approval commonly expressed by people when they first learn about applications of geospatial information technologies.

This article looks at the role of interoperability in the return on investment in geospatial technologies. Open standards for system-to-system communication, now widely implemented in software products, improve significantly upon the earlier and still common "data interoperability" approach to data sharing. As explained below, data sharing is critical to return on investment.

The Costs of Data Non-Interoperability

Studies on the economics of GIS commonly point out that data costs usually greatly exceed software and system costs. This is true as well for related geospatial technologies in applications such as facilities management, digital cartography, location-based services, surveying and mapping, and transportation. Data costs are usually incurred after the purchase of hardware and software, and these costs often continue to accrue as long as the system is in use.

Geospatial technology users are therefore motivated to seek existing data that have been developed by others. Unfortunately, data are not easily shared, for many reasons:

1. Different kinds of data acquisition systems, such as surveying instruments and orbiting scanning imaging devices, produce inherently different kinds of data. Vector-based and raster-based systems by definition have completely different ways of processing these different kinds of data.

2. Different software vendors use different proprietary internal and public data formats, processing approaches, and subsystem interfaces. And their public data formats may change as they release new versions of their software.

3. Different users often create their data using non-standard data models or schemas, which makes data sharing difficult even with partners who have identical software. Sometimes use of non-standard schemas is arbitrary, based on ignorance, indifference or unwillingness to spend the time to learn to use a standard. But different professions, disciplines and special projects in most cases require at least partially different data schemas.

4. Similarly, metadata (data about the data) is often lacking or based on arbitrary schemas that cannot be easily “understood” by digital data cataloging systems.

5. Though people commonly think there is a single and fixed “latitude/longitude” coordinate system for locating features on the Earth’s surface, data developers may in fact use any of more than a thousand different spatial reference systems that are based on different Earth spheroids and different coordinate systems and sphere-to-flat-map projection systems.

To overcome these obstacles to data sharing, expert practitioners of geospatial technologies in localities and application domains around the world have spent decades working on “data coordination,” that is, cooperative efforts to encourage people in “information communities” to adhere to standard data and metadata schemas and best practices. (A geospatial information community is a group of users who, at least part of the time, share a common way of describing geographic features in databases.) Considerable progress has been made, assisted by a growing appreciation of “Spatial Data Infrastructure” (SDI) concepts at the local, national and global levels.

The Benefits of System-to-System Interoperability

As mentioned above, geospatial interoperability was originally conceived as “data interoperability.” In the past, two organizations would use the same software and adhere to identical data models so that they could use physical media or a local area network and later the Internet to easily share batch data files. Very significantly, this kind of interoperability is now rapidly becoming outmoded by the advance of “technical interoperability” or direct communication between dissimilar systems via open interfaces. Use of the same software is no longer required.

Anticipating the growing importance of computer systems being able to “talk to one another” in geospatial terms, companies, agencies and research organizations have worked together in the Open Geospatial Consortium, Inc. (OGC®) since 1994. Their goal has been to develop open standard specifications for software interfaces, data encodings and best practices that make it possible for multiple systems to behave as if they were loosely connected components of one integrated system. That is, software from one vendor should be able to invoke an operation on another software package from another vendor to return, for example, all the road segments in a certain region. This should be possible whether the two systems are running simultaneously on the same computer or they are connected to the same local or wide area network.

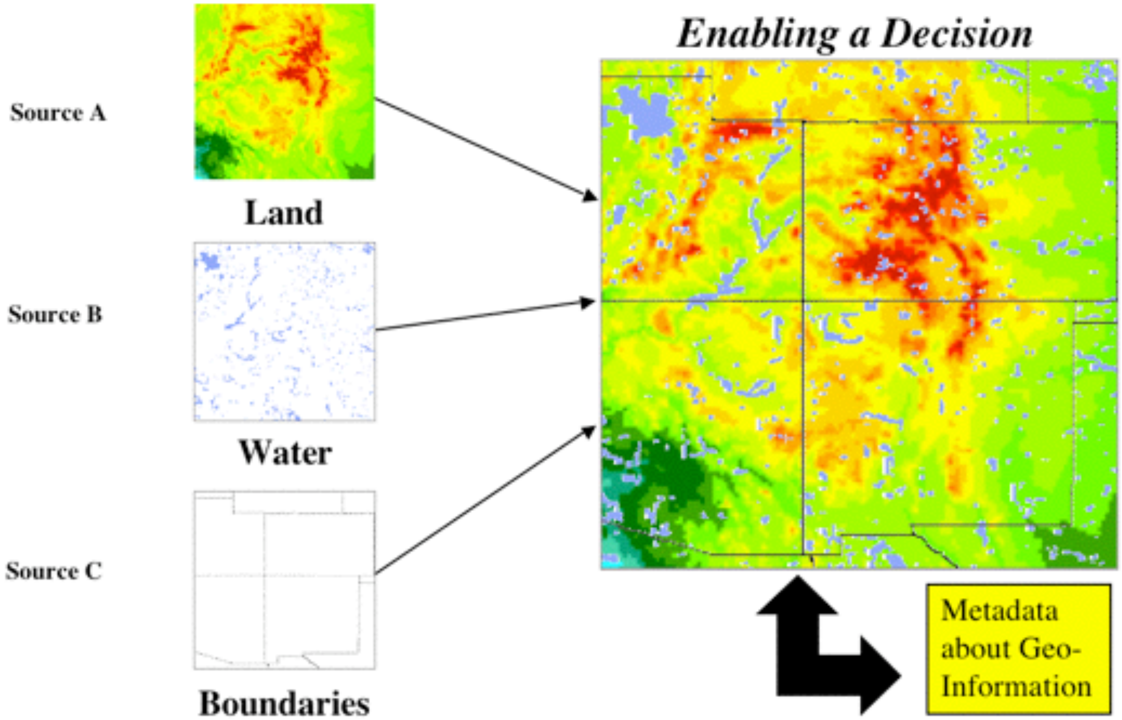

Figure 1: Interfaces that implement OGC's OpenGIS® Web Map Service Specification enable overlay of geoscience data, products and models from multiple web map servers, using only a browser.

The OGC has been successful in developing and promoting its “OpenGIS® Specification” standards. Virtually all the major geospatial software vendors implement at least the most basic OpenGIS Specifications, such as the following “OGC Web Services”:

- OpenGIS® Web Map Service (WMS) Implementation Specification: Provides operations in support of the creation and display of registered and superimposed map-like views of information that come simultaneously from multiple sources.

- OpenGIS® Geography Markup Language (GML) Encoding Specification is the XML grammar defined by the OGC to express geographical features. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet.

- OpenGIS® Web Feature Service (WFS) Implementation Specification: Enables a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services.

- OpenGIS® Web Coverage Service (WCS) Implementation Specification: Allows access to geospatial "coverages" that represent values or properties over a geographic extent (such as Earth images).

- OpenGIS® Catalogue Service (CSW) Implementation Specification: Defines a common interface that enables diverse but conformant applications to perform discovery, browse and query operations against distributed heterogeneous catalog servers.

Direct communication between different systems via open interfaces even provides an unprecedented environment for addressing non-interoperability due to different data schemas. Leveraging the power of the Web's eXtensible Markup Language (XML), GML and WFS can be used together in a "translating Web Feature Server (WFS-X)" that can be configured to enable a considerable degree of "semantic interoperability." That is, it is possible for two users to share data even though their data schemas may differ in some respects. Automated tools employing such a WFS-X also make it much easier than before for data coordinators to discover, evaluate and address the differences between two data schemas.

Awareness of interoperability based on the OGC's open standards has grown sufficiently that procurement specifications now often require that proposed tools and solutions include interfaces that implement these standards.

NASA's Return On Investment (ROI) Study

The ground receiving stations of the US National Aeronautic and Space Administration (NASA) collect and store terabytes of data daily from approximately 80 orbiting or outer space NASA instruments, data that are assimilated into forecasts and predictions. Making these resources available to a wide range of stakeholders is central to NASA's mission. For this reason, in September 2004, NASA's Geosciences Interoperability Office (GIO) funded an independent, industry led ROI study to assess the value of using open standards that enable geospatial interoperability.

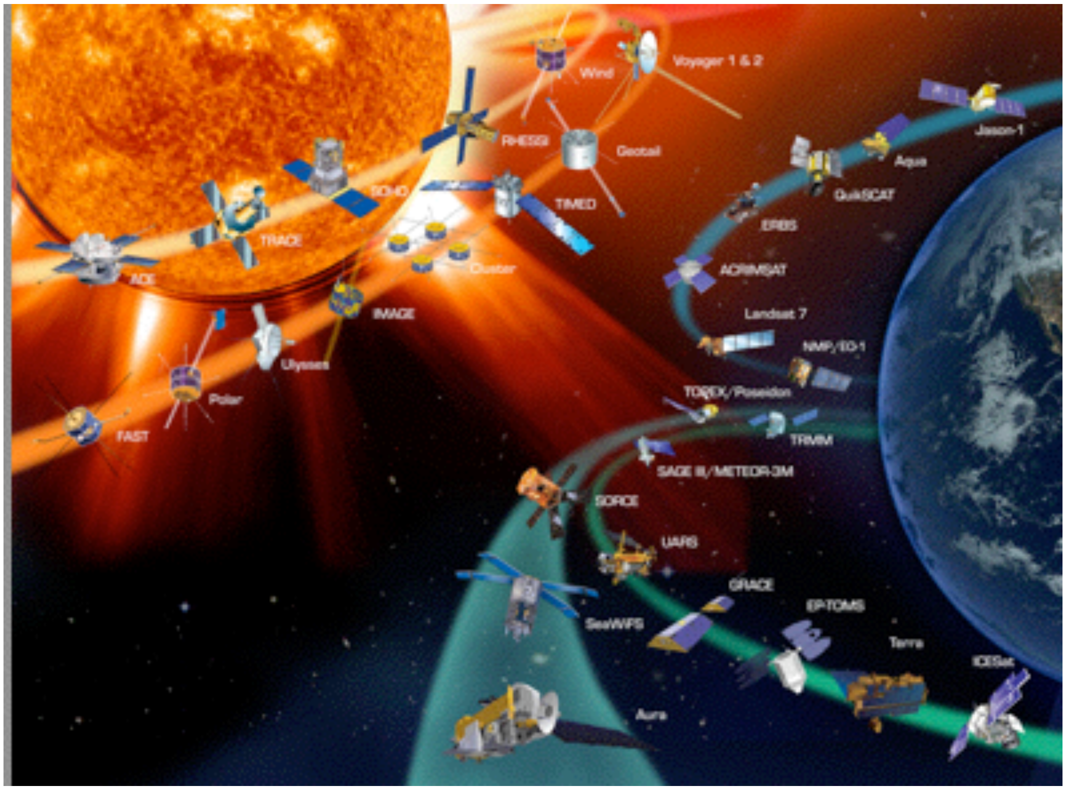

Figure 2: NASA has deployed 30 Earth-Sun System spacecraft carrying 80 instruments. The value of the data from these instruments is proportional to the number of stakeholders who can discover, access and use it.

Booz Allen Hamilton (BAH) delivered the study to NASA in May 2005. BAH compared one government program that was using open geospatial interface standards (Case #1) and one government program that was not. (Case #2). The identity of these programs was not revealed.

The Geospatial Interoperability Reference Model (GIRM v1.1, December, 2003) provided the interoperability standard by which Case #1 and Case #2 were evaluated. The GIRM was developed and is maintained by the US Federal Geographic Data Committee's (FGDC) Geospatial Applications and Interoperability (GAI) Working Group (see http.//gai.fgdc.gov/girm/v08/girm08.html). The ROI study focused on the use of the following standards:

- The abstract standards of the International Organization for Standardization (ISO) Technical Committee 211 (ISO/TC211), in particular the ISO 19100-series standards;

- The interface and encoding specifications of the Open Geospatial Consortium (OGC);

- The standards sponsored by the U.S. Federal Geographic Data Committee (FGDC).

Booz Allen Hamilton used the Value Measuring Methodology (VMM) to examine the life cycle costs and benefits of these projects. The VMM considers:

- Direct user (or customer) value
- Social (or non-direct, public) value
- Government foundation/operational value
- Government financial value
- Strategic/political value

The study showed that:

- There is a significant improvement when using open standards over proprietary standards. The project that implemented geospatial interoperability standards had a risk-adjusted ROI, or "Savings to Investment" ratio, of 119.0% over the 5 year project life cycle. Looking over a 10 year project life cycle, it had a risk-adjusted ROI of 163.0%. This project saved 26.2% compared to the project that relied upon a proprietary standard. One way to express this result is that for every $100M spent on projects based on proprietary platforms, the same value could be achieved with $75M if the projects were based on open standards.
- Standards-based projects have lower Maintenance & Operation (M&O) costs than those relying exclusively on proprietary products for data exchange. In fact, the majority of Case Study 2 costs were M&O costs (89%). This cost category is exposed to the greatest risk over time due to lack of extensibility and flexibility.
- Standards-based projects have greater system planning and development costs. But it can be anticipated for future projects utilizing open standards that planning costs will be significantly reduced once open standards and specs have been adopted.
- The value generated by the open standards solution was greater than expected. The open solution returned 55% more value to its stakeholders than did the proprietary solution. Thus the open solution would be preferable, even if its costs had been higher than the proprietary solution. Standards help to form an information culture and information economy that is content-rich and diverse in viewpoint. By clarifying functions, service invocations, and data definitions, standards make the distribution of geospatial information understandable, not just for government technologists, managers, and administrators, but for all stakeholders, including industry partners.

Conclusions

The validity of the NASA results is supported by the success of programs in Canada, the UK, Germany, Spain, Australia, the location-based services industry, and other communities. Projects and programs employing geospatial technologies produce a significantly greater return on investment when open standards are used.

Interoperability has always been a key factor in the economics of geospatial technologies, but now it is arguably the main factor. With OGC Web Services standards, the Web provides the infrastructure for what is essentially a huge global geoprocessing system, not limited by the previous boundaries between different geoprocessing systems. This has extraordinary economic value.

All images courtesy of NASA.