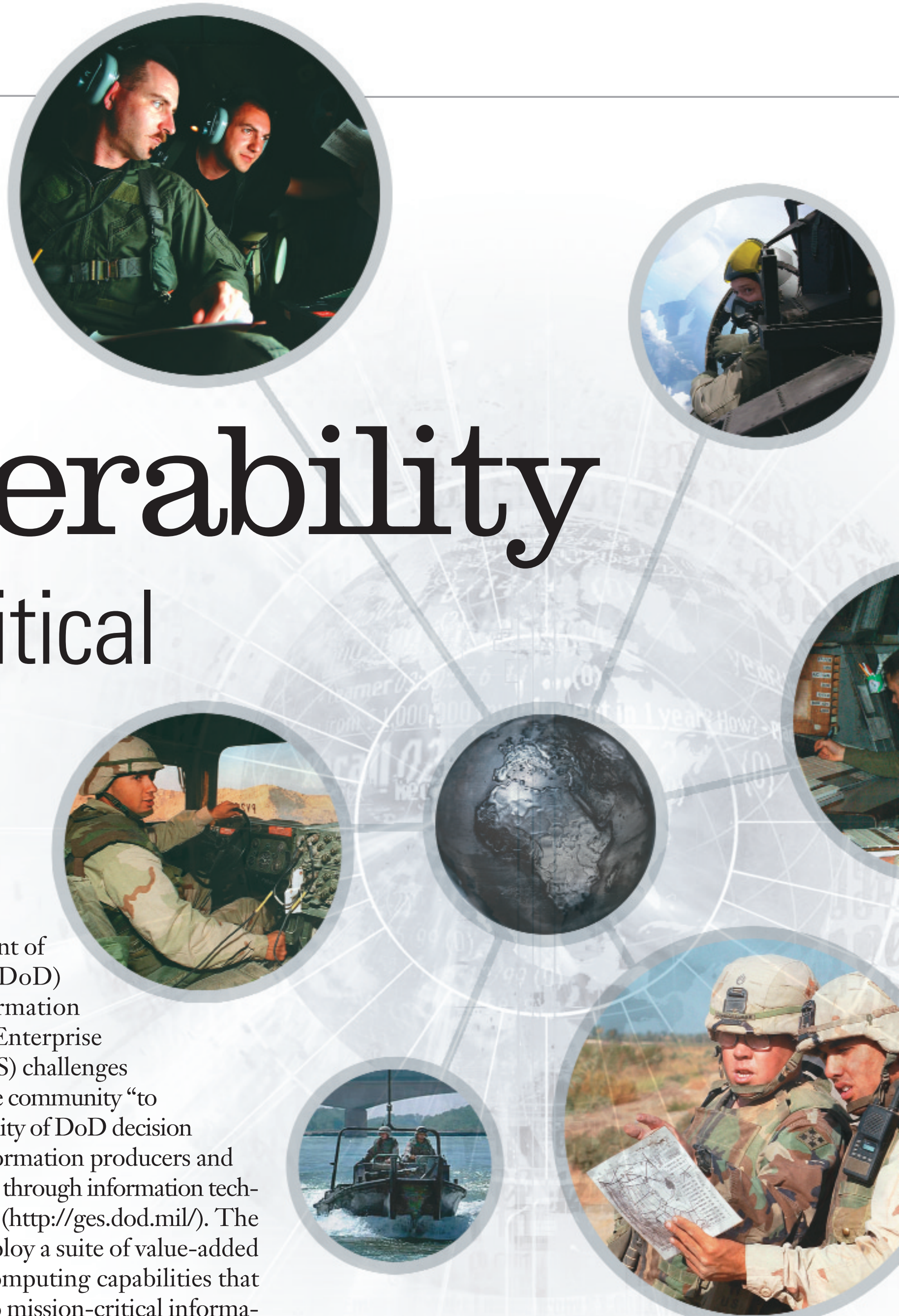

Interoperability

It's Mission–Critical

Interoperability is key to improving the speed and quality of DoD decision making, as described in this first installment of a series.

KURT BUEHLER, Open GIS Consortium

The Department of Defense's (DoD) Global Information Grid (GIG) Enterprise Services (GES) challenges the defense and intelligence community "to improve the speed and quality of DoD decision making by connecting information producers and consumers more effectively through information technology and net-centricity" (http://ges.dod.mil/). The challenge of GES is to deploy a suite of value-added information, Web, and computing capabilities that will improve user access to mission-critical information. Much of this information has a geospatial component.

Dawn Meyerriecks, Chief Technology Officer of the Defense Information Systems Agency, says, "By specifying 'hard' integration points, which are preserved across generations of underlying technology, we achieve our goals and provide interoperability across the broad spectrum of Department of Defense business processes and domains."

Fortunately for the GES effort, hundreds of organizations have worked in the Open GIS Consortium (OGC) since 1994 to develop global standards that enable cross-vendor, cross-platform user access to mission-critical geospatial data and geospatial processing services. Through its consensus-based standards specification process, OGC plays an important role in helping the defense and intelligence communities to meet the interoperability requirements of GES and much more.

The Key Role of Standards in GES

To put it simply, the GES is nothing more than a very large, high-capacity, high-availability, highly secure Internet- and Web-based global defense and intelligence information network for the United States and its allies. Because the technology for such networks is advancing so rapidly in the private sector, DoD system architects are designing the GES to use durable, commercial standards — such as hypertext protocol (HTTP) and TCP/IP for hard integration points. So why use such commercial standards?

First, vendor lock-down, once considered a bitter pill that one had to swallow to deploy a solution rapidly, is no longer deemed acceptable. The increased value and liquidity of data and applications that result from the use of standards has become much clearer to IT providers, buyers, and users. A custom or proprietary approach simply would not affordably provide interoperability across the broad spectrum of DoD busi-

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ness processes and domains.

On the other hand, the use of agreed-upon standards developed through a concensus-based process reduces risk, maximizes investment, and future-proofs critical applications. Further, such standards increase the likelihood of interoperability with other enterprises — that is, interoperability with coalition forces, other federal agencies with systems based on the Federal Enterprise Architecture, and state and local agencies who are partners with DoD in homeland security efforts. Such standards also allow the use of standards-based commercial off-the-shelf products.

Within this context, there is a clear and sudden shift in attitudes toward software standards. Along with a requirement for the effective use of standards and common interfaces is a requirement for a deployment infrastructure that supports the broad range of geospatially enabled applications within DoD.

The Role of Spatial Standards

Almost any planning, intelligence, logistics, or other application used in the defense and intelligence community requires the use of geospatial information and processing. Almost every asset and every threat — human and material — can be associated with a location or an area. If defense and intelligence personnel are to develop and share awareness of assets and threats using the GIG, geospatial information and geospatial processing instructions need to be easily and seamlessly accessed and moved freely between the different hardware and software platforms, applications, and subnetworks that make up that grid.

GLOSSARY

DoD: Department of Defense

GES: Grid Enterprise Services

GIS: Geographic Information Systems

GML: Geography Markup Language

OGC: Open GIS Consortium

SIG: Special Interest Group

SOAP: Simple Object Access Protocol

UDDI: Universal Description, Discovery, and Information

XML: eXtensible Markup Language

To enable such seamless access and communication, OGC member companies have worked collaboratively during the past 10 years to develop OpenGIS Specifications. In a global, open consensus process, OGC members are developing, testing, documenting, and agreeing on open interfaces and encoding standards that enable interoperability of geospatial data, services, and applications. Use of these interfaces and encodings can enhance interoperability in many technology and application domains, such as geographic information systems (GIS) and systems for Earth imaging, navigation, tracking, facilities management, cartography, location-based services, and surveying and mapping. New ways are being found to introduce multimedia data about places, including text references and sensor and video data, into the domain of geospatial searches and processing. The geospatial domain, long sequestered in stovepipes, is now rapidly becoming a pervasive and indispensable aspect of the IT computing infrastructure.

OpenGIS Specifications address interoperability between different vendors' GIS programs running on the same computer. Some are high-level, platform-independent specifications, useful for implementing geospatial interoperability in special purpose non-Web networks.

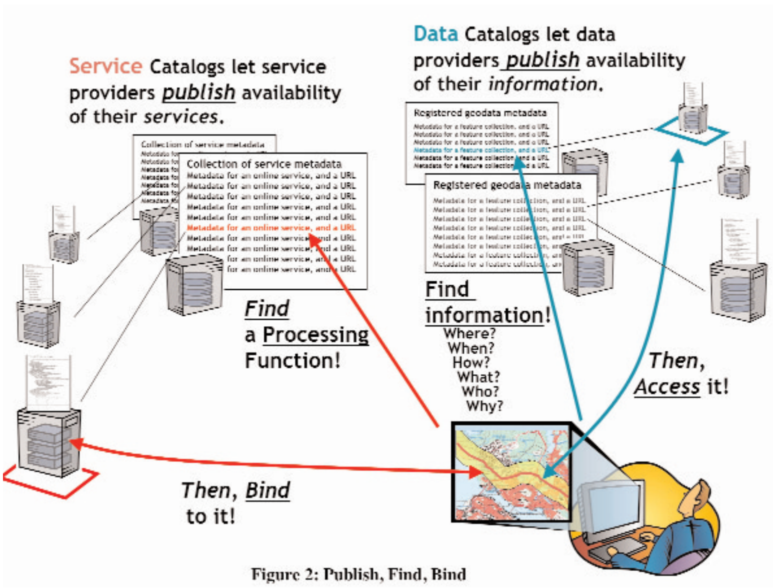
The OGC Process

Today, most OpenGIS Specifications begin as user-defined interoperability requirements in fast-paced OGC testbeds. In an OGC testbed, multiparticipant teams of OGC members define, develop, and test prototype interfaces that enable their software products to work together in real time across a network. The prototype interfaces are documented and introduced into the OGC Specification Program. This program provides a well-structured, formal consensus process required for member review, discussion, and adoption of a specification. The main bodies are the OGC Technical Committee and the OGC Planning Committee.

Through this process, OGC has addressed many technical challenges of developing truly interoperable environments, generating a number of specifications as a result.

The Need for Specifications

OpenGIS Specifications are the primary product of the OGC consensus process. The work of the members focuses on defining, testing, documenting, and approving interface specifications and payload encodings that support geospatial interoperability. The proof of success comes when these specifications are adopted and implemented in the marketplace. Decisions about what specifications are to be developed and approved



▲ **FIGURE 1.** Publish, find, bind is the way of Web Services.

are driven by member and market requirements. There is a growing focus on the development of interfaces for geospatial service interoperability. Why is this?

Geoprocessing services — data management and analysis tasks and computations — range from simple to complex. Here are some examples:

- Generate a simple map portrayal on the Web
- Add new features to a database
- Edit feature attributes
- Calculate line of sight
- Convert location in one coordinate reference system (such as latitude/longitude and World Geodetic System 1984) to location in another coordinate reference system (for instance, Ohio State Plane Coordinates).

GIS and other geospatial technologies provide scores of services such as these. However, different systems handle geospatial features and services in different ways. This is understandable because each technology provider has developed their own geospatial data models, access mechanisms, algorithms, and user interfaces. This incompatibility has, in the past, created integration problems, non-interoperable processing stovepipes, higher costs related to applications maintenance, and so forth. Today, through the use of interface standards and encodings such as those developed by the OGC, different geoprocessing systems from different vendors can be effectively integrated into enterprise applications and seamlessly exchange geospatial data and instructions. (It is important to note here that, while much work has been completed, particularly in enabling data access, much work remains.) Market requirements for enterprise-level integration of geospatial data and services drive much of the current thinking and specification development focus of the OGC membership.

Consensus Supports Integration

In practice, inter-enterprise integration has always required standards. Originally, the standards were usually proprietary and de facto standards, locking the user in as a customer of a single vendor. Users benefit immensely from open, vendor-neutral standards because they encourage competition, allow choice, and enable the possibility of easily adding or switching components. They enable users to maximize the value of previous investments.

Because OpenGIS Specifications are created in an open, international, participatory industry process, the specifications are non-proprietary and freely available to all (non-discriminatory). These specifications will continue to be revised in the open process, but because users play a major role in the specification process, new revisions of a given specification do not ignore the desire for forward and backward compatibility. Essentially, no restrictions exist on the use of OGC's OpenGIS Specifications, except that no royalties may be charged for their use.

Closely related to developing these interface and encoding specifications is how these specifications fit into the enterprise information and implementation architecture. Therefore, OGC's members are also working together to define and document reference architectures and to identify their consensus position on how future services, including core GES, are characterized.

Two groups in OGC provide a forum for the discussion and characterization of architectures that support the deployment of interoperable solutions. One is the Architecture Working Group of the OGC Technical Committee. In this group, technologies such as Grid Computing, UDDI, and SOAP are discussed and evaluated in terms of their impacts and use for enhancing geospatial interoperability. The other, much newer, group is an OGC Planning Committee Special Interest Group (SIG) — the Enterprise Architecture SIG. This SIG was formed to bring the integrator community together to provide the U.S. Government with initial recommendations on core services to be included in the DoD's Net-Centric Enterprise Services, GES, and the Federal Enterprise Architecture programs, among others. OGC provides the central forum for dialog on distributed geoprocessing topics that are the mutual concern of local, national, and federal agencies, as well as agencies in U.S. partner countries and private-sector companies.

Many OpenGIS Specifications have been defined and optimized for use on the Internet and the Web. These OGC Web Services include interfaces for geospatial data discovery, access, and presentation, the encoding and communication of geospatial data, and common access to key geospatial processing services (**See Figure 1**).

Web Services

A Web Service is programmable application logic that is accessible using standard Internet protocols. Web Services combine the best aspects of component-based development and the Web.

Like components, Web Services represent functionality that can be easily reused without the user knowing how the service is implemented. Unlike current component technologies, though, which are accessed via proprietary protocols, Web Services are accessed via ubiquitous Web protocols (such as HTTP) using universally accepted data formats (including eXtensible markup language [XML]).

A properly implemented Web Services infrastructure makes it possible for applications to find and exchange information or find and invoke processes regardless of location, processing platforms, operating systems, or languages. Web Services can dramatically lower the costs of software integration and information sharing while providing extraordinary flexibility to introduce new capabilities. However, the use of Web Services also presents some interesting challenges, such as fault tolerance, availability, performance, and security.

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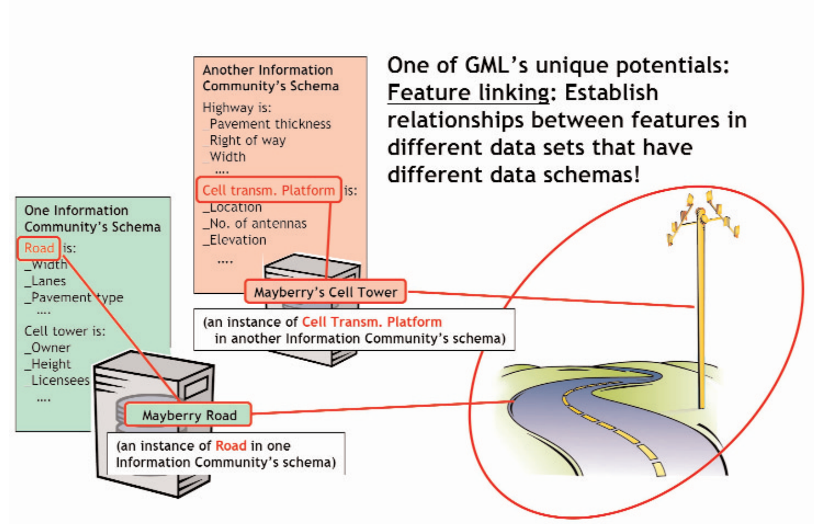
The Web Services infrastructure for "publish the existence and location of information or services," "find a needed information element or service," "bind a Web client process to a Web server process" greatly extends users' access to processing resources . The processing resources made available in real time to a soldier's handheld computer could include remote processes running on mainframes and supercomputers. And just as easily, a "servlet" running on that handheld unit could be configured to respond to requests from client processes running on other wireless devices.



▲ **FIGURE 2.** OGC's Geography Markup Language (GML) enables many new capabilities.

Geospatial Information Models

Let's take a look at the general characteristics of the geospatial information that is published, found, and processed by Web Services. First, all geospatial features have geometry and attributes (or in OGC terms, properties).

If we consider a humvee as a feature, its geometry can be expressed as a point location, or longitude and latitude, and a bearing. The attributes of the point geometry might also include elevation above sea level, coordinate reference system metadata, direction of travel, and velocity. Its other attributes might include vehicle registration number, military unit to which the humvee belongs, engine temperature, and mileage at last oil change.

The humvee is a relatively simple example. The geometry and attributes of a feature can be much more complex: Consider digital representations of phenomena like weather or calculated trafficability over terrain, based on soil type and rainfall. When one considers all of the possible geospatial feature types, geometry, properties of these features, and application uses of these features, the interoperability challenges can be daunting. These brief examples are enough to suggest the complexity of geospatial data modeling, access, and use that is necessary to meet current DoD requirements.

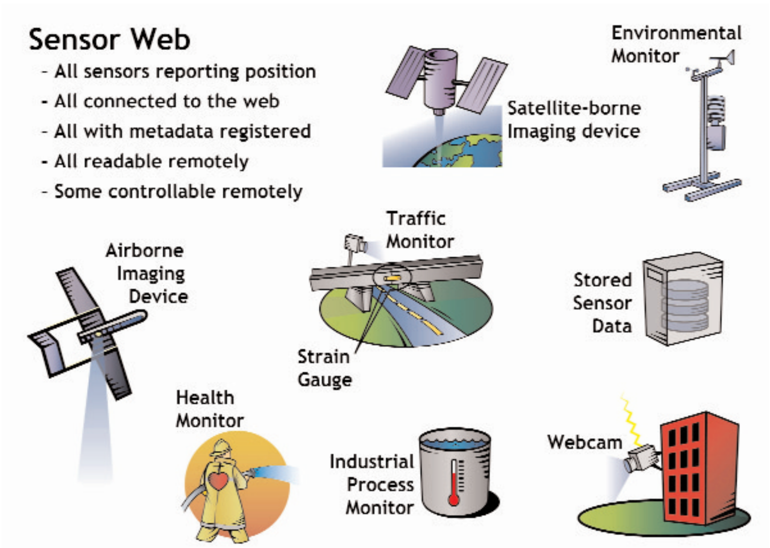
Semantics. While incredibly valuable, the consistent expression of geospatial data content — feature geometry and its attributes — is only one component of geospatial data interoperability. The second key component is semantic interoperability. Semantic interoperability must deal with the context of the data. Semantics, therefore, has to do with the meaning of a feature — its classification scheme, the reasons for its collection, how its attributes are defined and coded. OGC is now tackling the problem of incompatible semantics and data models (to be addressed in a future article). Much of this work depends on OGCs XML encoding of geospatial data, known as Geography Markup Language (**see Figure 2**).

Scope of OpenGIS Specifications

OGC is tackling other issues important to the defense and intelligence community as well. Many of these will be addressed in future installments of this interoperability series.

For instance, as described earlier, OGC Web Services enable real-time multisource integration across the Web and across defense and intelligence networks. OGC members will explain current capabilities as well as ongoing work to improve the ability of the defense and intelligence community to discover, access, integrate, and apply geospatial data to support planning and operations. Future articles will explain the rigorous and comprehensive work that is being done in the area of image exploitation, as well as the adopted specifications for raster and vector Web mapping that are already implemented in vendors' products.

Semantics. The diversity of geospatial information available to the defense and intelligence community results in a lack of semantic interoperability. OGC members will describe how they are addressing the information interoperability problem by using OGC's GML schemas to support on-the-fly translation to a common information model. Initial prototyping for National Spatial Data Infrastructure Transportation Framework data has been successful, and tools and techniques are openly available for use by the defense and intelligence community.



▲ **FIGURE 3.** OGC's Sensor Web Enablement provides infrastructure for Sensor Webs.

Sensor Web Enablement. The Web is increasingly being used to access, control, and "read" dynamic and in-situ sensors and imaging devices (see Figure 3). Sensor Webs that can be seamlessly accessed and described using standard interfaces and metadata encodings help satisfy defense, intelligence, and homeland security needs for integration of sensor data into the common operational picture. OGC members will describe Sensor Web enablement work that has already demonstrated the value of standard schemas for sensor description and standard interfaces for sensor control in applications to rapidly discover, task, access, and apply stationary and mobile sensors in sensor networks. This work has also produced a rigorously defined XML schema for observations and measurements.

Geospatial Fusion Services. Automated methods of integrating multimedia references into a geospatial framework introduce unprecedented efficiencies and capabilities into intelligence analysis. OGC members will discuss the potential for OGC's in-process GES specifications, in concert with OGC's adopted standards baseline, to effectively enable analysts to integrate/link textual documents, imagery, and Web content into an application. A standards-based process for maintaining and sharing linked information across networks will be discussed, as well as automated processes that OGC members have created to parse and isolate geospatial references from text material.

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Shaping the Next

To a considerable degree, U.S. defense and intelligence agencies have been involved in the OGC standards setting process from the beginning. As GES is being designed and deployed, it can use software in which vendors have implemented many of the OpenGIS Specifications. And it is not too late to introduce new interoperability requirements that will shape the next OpenGIS Specifications.

Integration of geospatial data and services via standard interfaces is critically important. Information access and use requirements related to such activities as rapid deployment, dynamic battlefield logistics, wireless and real-time sensor information, and the Internet means that the rapid and effective use of geospatial intelligence is more critical than ever. In this dynamic information world, one-off integration efforts are just too expensive to deploy and maintain, in terms of both time and money.