Northrop Grumman and

Integrated Spatial Solutions, Inc.

Geospatial Enterprise Integration Maturity Model

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By:

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Geospatial Enterprise Integration Maturity Model (GEIMM)

EXECUTIVE SUMMARY

This paper proposes a maturity model for the integration of geospatial capabilities within enterprise information systems. The model centers around specific goals for three primary areas of information system maturity: process, policy and data. Organizations can use the model to improve processes, data infrastructure and policy frameworks associated with geospatial technology.

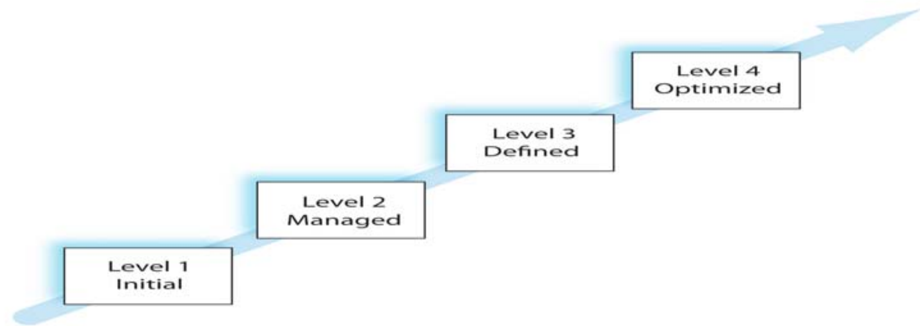
Our vision for this model is simple. We would like to provide an effective, open framework for integrating geospatial capabilities into enterprise information systems across the IT industry. Also we would like to assist organizations in building enterprise spatial data infrastructures(SDI) which can become part of a larger fabric of SDIs across industries, nations and the globe.

The model belongs to the community that it serves. Anyone and everyone is free to improve, extend, adapt or criticize. If you elect to use the model, we ask that you cite the source – that helps improve the model. Also, IDC holds the copyright on a couple of the graphics and those are noted. If you use those, just cite the source.

The Geospatial Enterprise Integration Maturity Model (GEIMM) builds on the current Computer Maturity Model Integration (CMMI) developed at Carnegie Mellon's Software Engineering Institute[1]. CMMI is a robust, mature set of general process integration methods, goals, best practices and specifications. Northrop Grumman has adopted CMMI as a foundation-level management tool and has found it to be fundamentally useful.

As shown in Figure 1, GEIMM involves the increasingly effective implementation of process, data and policy goals through four maturity levels. GEIMM goals may be used to supplement goals within a CMMI effort.

FIGURE 1: GEIMM MODEL LEVELS



Northrop Grumman's experience with CMMI produced a number of tangible benefits including improved workflow, lower cost implementations, selection of appropriate technology alternatives, and more effective use of geospatial data within enterprise information systems. We expect other organizations to find similar benefits.

This model is based on seven basic premises.

- Like any other systems integration, geospatial integration centers around supporting business processes. Recognizing the critical role of process integration, the IT industry has created, through hard experience, process integration models. It makes sense to build on hard-won experience reflected in those models. Accordingly, GEIMM is based on an established process integration model.

- Effective information systems are an inseparable part of business operation and management. So, geospatial data and other information system components must be designed and managed as a part of most business activities.

- A process maturity model enhances communications among the people involved in designing and implementing systems.

- Information systems are now highly-networked and interconnected. As a result, information systems have to be based on established standards for inter-process services. Most geospatial integration will involve standards-based services at some level.

- The appropriate use of open geospatial standards can reduce costs and simplify integration. The use of standards based architectures and technologies will also provide greater capacity for organizations' to adapt to future requirements and new technologies. So, selecting the right standards is an important aspect of geospatial integration.

- GEIMM will be most effective when it is adapted to complement the workflow design and business management methods already in use within an organization.

- Process maturity model targets essential business objectives rather than specific disciplines. This approach effectively avoids the tendency toward an organizational "stovepipe" mentality.

Finally, we see this paper as a starting point for discussion and refinement. We will depend on the many dedicated professionals in the industry to refine and test this paper's concepts.

INTRODUCTION

Geospatial technology has evolved remarkably over the past several hundred years. Once the province of solitary cartographers and surveyors, geospatial technology permeates the Internet, distributed networks, wireless communications, semantic tools, and service-based architectures. These deeply interconnected technologies create an environment for radical changes in the understanding and use of geospatial capabilities. This new, highly-networked environment both enables and requires a deep understanding of information system integration.

One of the most significant but as yet unacknowledged benefits of this technology revolution is the opening of geospatial information to virtually all cognitive styles. Until recently, information technologies focused on single-point solutions targeted at a single use. While adequate for one thinking or learning style, typical geospatial technologies did not engage a majority of the ways in which people think about or use information. This has sacrificed cognitive diversity for expediency. With the Internet and widespread use of computer technology, more and more people access digital technology as part of their activities of daily living in the style that works best for them. Now, consumer tools such as Google Earth, in-car navigation systems and hand held GPS we are witnessing an explosion of creative applications that integrate geospatial capabilities. While these diverse applications are certainly engaging, they depend on well-designed information system integration.

Perhaps the most important potential of the new, networked IT environment is the possibility that organizations will develop spatial data infrastructures. There is a well-established economic case for stable, self-correcting data infrastructures within organizations. Sometimes called master data and sometimes called by other names, data infrastructures are increasingly recognized as critical enterprise assets. With increasing interoperability and with the implementation of common geospatial architectures, communities of interest as well as communities of place now engage in efforts to share data and collaboratively address issues of importance to them. As information systems mature, these enterprise spatial information infrastructures are able to evolve to be part of infrastructures which are have regional, industry, national or even global relevance.

So, our message is simple: geospatial information is now an integral part of broad information networks. To be successful, people and their organizations must recognize the influencing factors and requirements that reach beyond their own perspective and must seek to synthesize and balance their needs with those which are the common needs of the enterprise. No longer can the geospatial community afford to consider itself a niche component. Ready or not, it is time to strive for maturity - to fully integrate geospatial capabilities into enterprise information systems and business processes. This model is one step in that direction.

GEOSPATIAL CAPABILITIES FOR THE ORGANIZATION

Basic organizational needs drive enterprise integration: the need to simplify, the need to reduce costs; the need to adapt, the need to address customers, and the need to do all these things while contending with existing systems and resources. Effective enterprise integration is now a basis for survival for most IT-dependent organizations.

Well-integrated geospatial technology and data can add specific value to enterprise information in a number of ways. For convenience, we group geospatial capabilities into the following five categories.

- **Spatial Context** – Location along with time are fundamental ways that we order our lives. In an information system, location provides a useful context that makes other data more meaningful.

- **Quantification/ Measurement/ Analysis** – In information systems, geospatial data and technology add unique spatial characteristics like distance and physical relationships between objects. These characteristics enable a broad range of unique quantification, measurement and analysis capabilities.

- **Reference** – Reference data are used to group, cluster, or categorize other data found in a database or for relating data in a database to information beyond the boundaries of the enterprise. Example: State abbreviation tables or tax district boundary files.

- **Visualization** - Perhaps the most familiar use of geospatial technology is for visual display of data on maps. The map metaphor also provides a useful visual index into some types of data. Simple, effective visualization within Google Earth currently drives significant interest in geospatial technology worldwide. This factor also significantly increases the need for a well-defined, user-driven integration methodology.

- **Collaboration** – Location provides a useful framework for organizing and enhancing collaboration among individuals and social groups. Location-enhanced collaboration can also extend to self-correcting mechanisms for workflows and processes

- **Discovery and Access**– Querying the spatial characteristics of information often provides the most intuitive and effective approach to finding information and relating it with other information. New search technology is increasingly making search and discovery a viable option for some integration. Discovery also facilitates data access when users can locate appropriate data.

Geospatial capabilities can be valuable across the whole organization and can impact processes throughout the enterprise. It follows that location information should be available to people within an organization who can benefit, including those on the front line. This common-sense approach is appealing from both financial and productivity perspectives.

Primary among the benefits of the integration of geospatial capabilities with information systems across the enterprise are:

- Improved communication
- Increase sharing of corporate and individual unit data assets
- Increased sharing of innovation
- Reuse of applications and services across the organization
- Shortened timeframes and reduced costs for technology and system implementation
- Reduced costs through use of standardized best practices
- Increased awareness of organizational strengths and weaknesses

GEIMM Objectives

We have five specific objectives for GEIMM:

- Provide an open model for integrating geospatial and spatiotemporal technology and data into enterprise information systems.
- Provide a forum for industry-wide discussion of geospatial integration issues, methods and best practices.
- Complement current enterprise integration and business process reengineering models with specific considerations for geospatial capabilities
- Provide a guide for assessing the maturity of how data, process and policy support geospatial integration.
- Lower cost of geospatial integration.

FUNDAMENTALS OF GEOSPATIAL ENTERPRISE INTEGRATION MATURITY

Requirements for Enterprise Integration

We believe that the following six requirements must be met for effective enterprise IT integration to occur.

- Information systems (IS) must support the business. Whether an information system is initially driven by technology or a business need, the system is only as valuable as its contribution to the business. IS must have direct and current links to business issues.
- IS must adapt and evolve incrementally and quickly. IS technology and policy must decouple different business areas, business rules, and technology infrastructure so that those areas can adapt to business requirements independently, but within a consistent policy framework.
- The enterprise must have a clearly defined vocabulary and policy to share business knowledge across different business areas, minimizing historic gaps between enterprise objectives, business processes and IS development. An organization's policy is its cumulative knowledge of what works and how work is done. Ideally, policy drives information and technology architectures.
- The enterprise must use consistent methods and architectures that scale from small projects to long-lived, mission-critical systems, both within and across enterprise boundaries. These

methods and architectures must be governed by a consistently applied body of policy.

- The enterprise must be prepared for and capable of integrating its information systems with other systems regardless of whether those systems are from the same organization or external systems from customers, providers or even competitors.

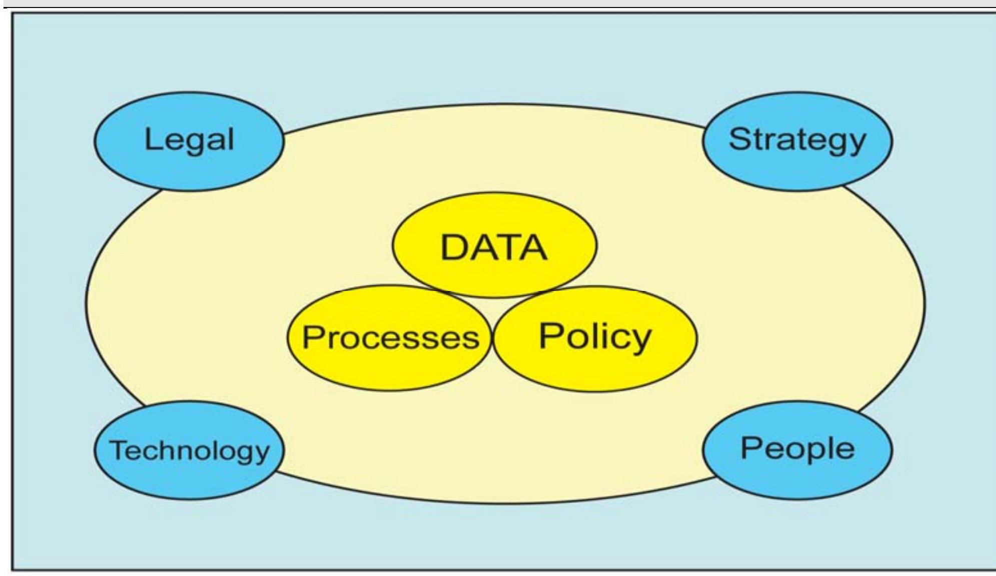
- Geospatial technology must be an integral element of enterprise systems rather than a separate discipline. As such it also must enable external integration/collaboration/interoperability in order for the organization to use and contribute to data and services which are provided through spatial data infrastructures.

Elements of Geospatial Integration

CMMI deals primarily with process integration in organizations and information systems. However, in describing the role of geospatial capabilities within information system processes, we found it necessary to create more granular approach. We identified seven elements as shown in Figure 2. This multi-element classification allows an organization to specify appropriate goals for logical geospatial elements and to, thus, simplify the management of those critical elements.

The three primary elements, process, policy and data, are the focus of the model presented in this paper. The other four elements are significant influences in the success of enterprise integration. While vital to success or failure they are not addressed in this paper. We expect that the geospatial community will further develop maturity goals for these influencing elements in the future.

FIGURE 2: ELEMENTS OF GEOSPATIAL INTEGRATION



Primary Elements

Data – Geospatial data is the foundational resource for any spatially-enabled information system. Maintaining data integrity across and among information systems is a fundamental element of process integration. GEIMM assumes that a foundation set of geospatial data will be managed as enterprise master data in higher maturity levels.

Processes – Processes are the events and relationships that make up the enterprise's workflows. Information technology and data support those processes.

Policy – Policy is the cumulative knowledge of how processes work and are governed. Clear, responsive policy is a necessary element in the continuing operation of any organization or system.

Influencing Factors

People - The employees and their skills, norms of behavior, and training and development. Included are processes to determine staff needs, hire, retain, train and manage employees and their performance

Technology - The scientific, engineering, mathematical or design software and hardware and the standards used. This includes the interface specifications, encodings and standards for hardware and software systems for access, communication, transport and storage and processing functions.

Strategy - the vision, direction and the way in which the organization implements its vision and direction. This includes long range strategic plans, organizational guidelines and allocation of budgetary resources to achieve its goals and objectives

Legal - the laws and regulations which govern the business and conduct of the organization. This includes national, state or local legislative or regulatory requirements and guidelines.

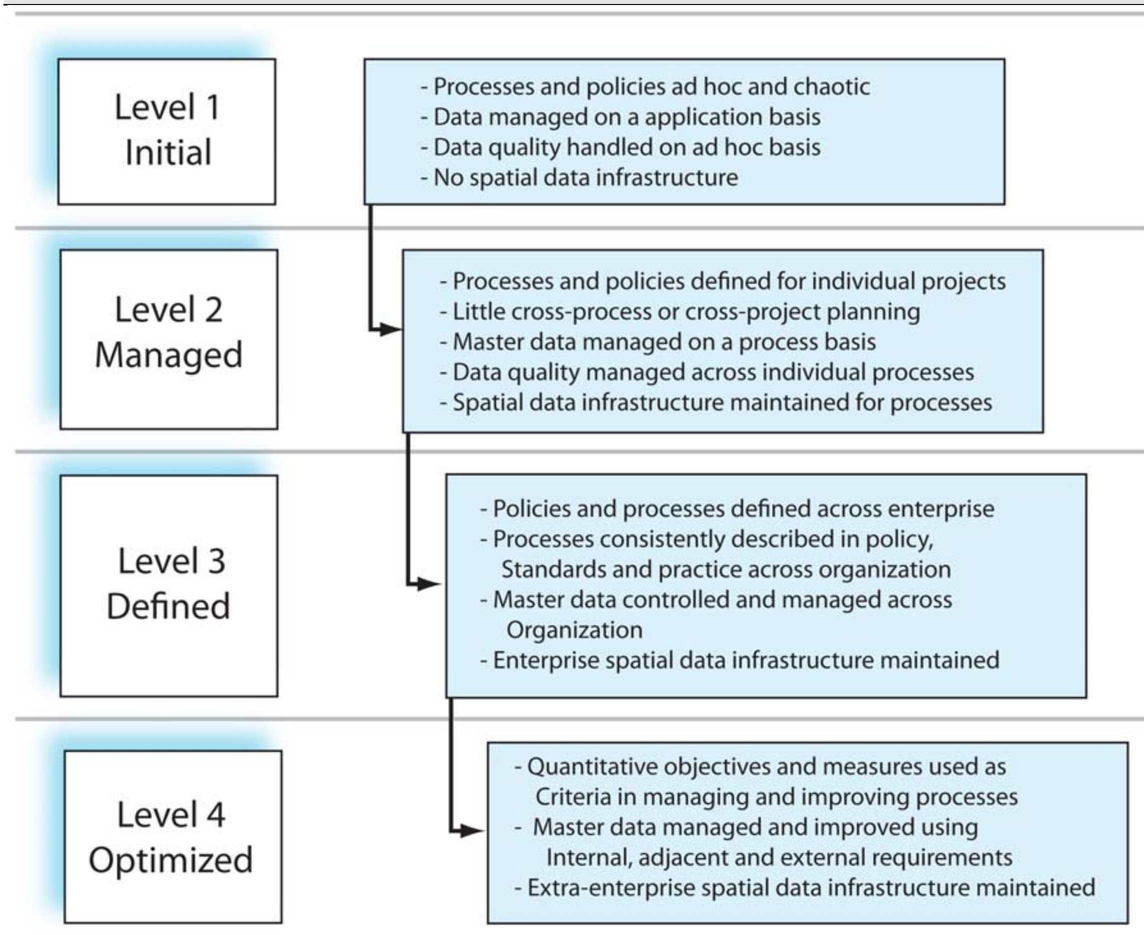
The management of copyrights, terms of use and other legal devices is becoming an increasingly important aspect of integrated systems. While outside the scope of this model, organizations should pay particular attention to rights management and insure that legal constraints do not inhibit enterprise integration.

THE GEOSPATIAL ENTERPRISE INTEGRATION MATURITY MODEL

Model Levels

As shown in Figure 3, each model level builds on the previous. Moving through the levels incurs both benefits and costs. Each organization should weigh those costs and benefits as they consider the maturity levels appropriate for their situation. However, based on the use of similar models like CMMI, there is a rich body of evidence that demonstrates that organizations will generally see a positive ROI from reaching higher maturity levels.

FIGURE 3: GEOSPATIAL INTEGRATION MATURITY LEVELS



Level 1 Performed/ Initial

Processes are usually ad hoc and chaotic. No coherent policies for the management of geospatial technology or data exist. Business processes are supported by independent applications or information systems.

Level 2 Managed

The geospatial information requirements of an organization are managed. Individual projects are planned, performed, measured and controlled. Little cross-process or cross-project planning or policies exist. Geospatial master data is managed and maintained on a project by project or system by system basis. The organization uses data resources available from external spatial data infrastructures (SDI) to a limited degree.

Level 3 Defined

Processes that use geospatial technology are well characterized and understood. Processes are consistently described in standards, procedures, tools and methods across the organization. Geospatial master data is managed in a central policy hub with other enterprise master data.

A critical distinction between Level 2 and 3 is the scope of standards, process descriptions and procedures. At Maturity Level 2, the geospatial standards, process descriptions and procedures may be different for each information system and the processes that the system supports. At Maturity Level 3, the standards, processes and procedures are tailored from the organization's set of standard processes to suit a particular project or organizational unit.

At Maturity Level 2, geospatial requirements may be managed separately from other process and information requirements. At Maturity Level 3, geospatial requirements are managed within the organization's overall set of standard processes and procedures and the organization is maintaining an enterprise spatial data infrastructure which frequently uses resources of external SDI’s.

Level 4 Quantitatively Managed and Optimized

At Maturity Level 4, the organization uses quantitative objectives and measures as criteria in managing and improving processes. Quality and process performance are understood in statistical terms and are managed throughout the life of all of the organization's processes. Geospatial technology is simply part of the overall management process. The organization directs process change and improvement with executable policy.

Special causes of process variation are identified and where appropriate, the sources of special causes are corrected to prevent future occurrences. The organization maintains its infrastructure as a contributor or part of external SDI networks.

Spatial Data Infrastructures

A fundamental premise of this White Paper is that as organizations achieve higher levels of Geospatial Enterprise Integration, they become more able to interact and interoperate with those outside their own organization/enterprise.

As they reach higher data management maturity levels, most organizations will develop spatial data infrastructures. A spatial data infrastructure is generally defined as the technology, policies, standards, and human resources necessary to acquire, process, store, distribute and improve utilization of geospatial data.

Data infrastructures are increasingly recognized as critical enterprise assets. Geospatial data is particularly well-suited as a data infrastructure component because it has a common, well-established reference framework – the geodesy that describes the earth's surface. This common reference frame provides geospatial data a common reference across any information system.

It is our hope that communities of interest as well as individual organizations will engage in efforts to share data and collaboratively address issues of importance to them. As information systems mature, individual enterprise spatial information infrastructures will evolve in their ability to integrate with SDI's of community, regional, industry, national or even global relevance.

Specific Goals for Primary Geospatial Elements

GEIMM centers around performance goals for each primary integration element: process, data and policy. The model describes logical goals for process, data and policy at each maturity level.

> NOTE: Institutionalization is a critical aspect of enterprise process improvement and is an important concept within each maturity level. When mentioned in the maturity level descriptions, institutionalization implies that the process is ingrained in the way the work is performed.

Process Maturity Goals

The organization can achieve progressive improvements in its process maturity by first achieving stability at the project level and continuing to the most advanced-level, organization-wide continuous process improvement using both quantitative and qualitative data to make decisions. Because process maturity goals are similar for any process, GEIMM uses the standard and well-tested CMMI process maturity goals.

A managed process (Level 2) is institutionalized by doing the following:

- Adhering to organizational policies
- Following established plans and process descriptions
- Providing adequate resources (including funding, people, and tools)
- Assigning responsibility and authority for performing the process
- Training the people performing and supporting each process
- Placing designated process elements under appropriate levels of configuration management
- Identifying and involving relevant stakeholders for each process
- Monitoring and controlling the performance of the process against the plans for performing the process and taking corrective actions
- Objectively evaluating the process, its work products, and its services for adherence to the process descriptions, objectives, and standards, and addressing noncompliance
- Reviewing the activities, status, and results of the process with higher level management, and taking corrective action

A defined process (Level 3) is institutionalized by doing the following:

- Addressing the items that institutionalize a managed (level 2) process
- Establishing the description of defined processes for the enterprise and each organizational unit
- Collecting work products, measures, and improvement information derived from planning and performing defined processes.

A quantitatively managed and optimized process (Level 4) is institutionalized by doing the following

- Addressing the items that institutionalize defined (level 3) processes
- Controlling each enterprise process using statistical and other quantitative techniques such that product quality, service quality, and process performance attributes are measurable and controlled across the enterprise
- Addressing the items that institutionalize a quantitatively managed process
- Improving the process based on an understanding of the common causes of variation inherent in each enterprise process such that each process focuses on continually improving the range of process performance through both incremental and innovative improvements.

Data Maturity Goals

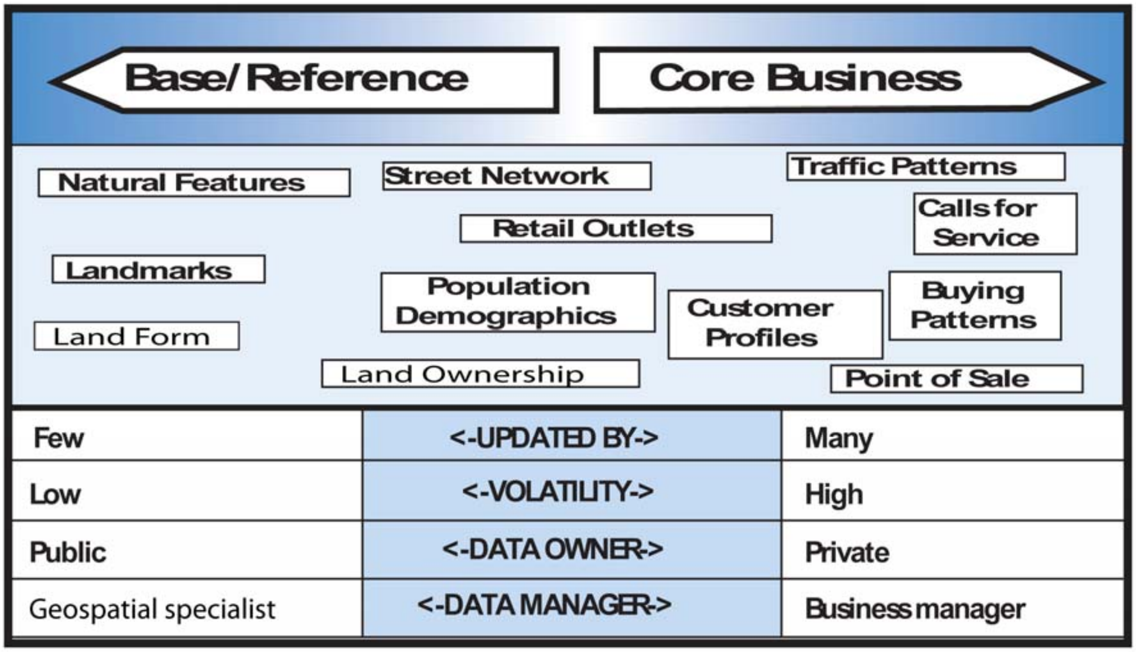
In this section we discuss the unique characteristics of geospatial data and propose data management goals for each maturity level.

Before we can set goals for the management of geospatial data, we must first define what understood as geospatial data and information. For the purposes of this document, we define geospatial information as information that identifies the location and characteristics of particular place on, above or below the surface of the earth or which has a component that includes a relationship with or connection to a location. Those entities may by physical objects like streets, buildings, rivers and mountains, or legal/administrative constructs like state boundaries, land parcels and tax districts. As shown in Figure 3, geospatial data covers a wide spectrum. At one end the data are stable and slow-changing. At the other end the data is in a constant flux.

> Note: Copyrights, terms of use and other legal devices can severely constrain enterprise data integration that touches proprietary data or applications. These legal devices are an important aspect of the economic structure of software markets. However, executives should negotiate terms of use that allow unconstrained integration across the enterprise. It is also important to allow for unanticipated uses of proprietary data.

FIGURE 4

Geospatial Data Spectrum



Source: IDC and ISSI, 2006

Geospatial Master Data

Geospatial master data is a special class of infrastructure data. Master data, in this context, is any geospatial data that is used across multiple applications. In Figure 4, geospatial master data tends to be on the left-side – stable and slow-changing. However, stability and rate of change are not the primary characteristics of geospatial master data. Geospatial like any master data are defined by its use.

Within an information system, geospatial master data will be used in one or more of the following ways.

- **Reference plane for other enterprise information**. E.g.: Street network used to organize and visualize customer locations in a retail chain or electronic navigation charts (ENC) used for navigation, collision avoidance, scheduling and fuel management on cargo ships.

- **Reference for interface with external systems**. E.g. Digital map of store and warehouse locations for use by customers or suppliers.

- **Reference framework for internal operations and analysis**. E.g. Digital database of a power distribution infrastructure used to calculate loads, identify and correct outages or project future demand.

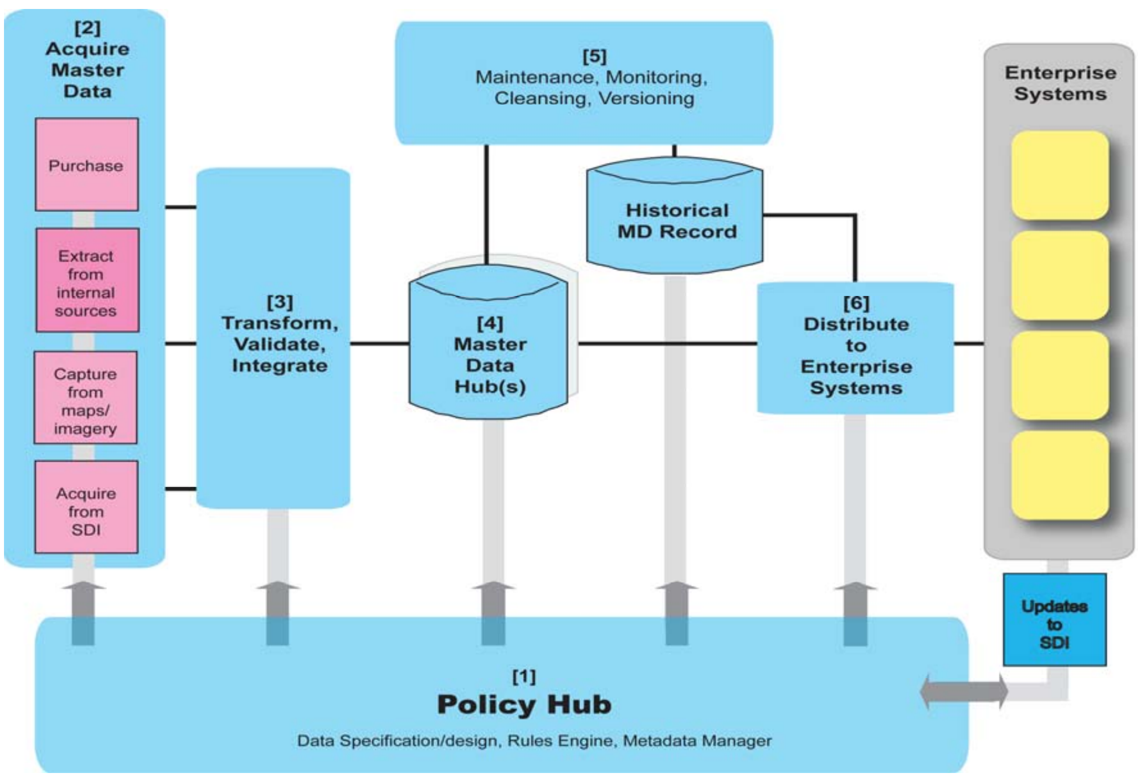
It is important to note that geospatial master data are not distinguished by the use of any particular technology. The technologies used to create and maintain geospatial master data are the same technologies used to create and maintain any other geospatial data. This means that, within a given information system, the master data policy hub is the locus for defining and managing geospatial master data as well as enterprise master data.

Geospatial Master Data Management Process

As illustrated in Figure 5, we define six steps in the geospatial master data management process.

FIGURE 5

Geospatial Master Data Management Process



Source: IDC and ISSI, 2005

1] Policy Hub

The master data policy hub is the central point for defining, managing and distributing infrastructure data including, geospatial master data (GMD). Ideally, the development of a policy hub begins with data design and specification. Along with general master data specifications, this design includes specifications for metadata, data quality; positional accuracy; relative accuracy; coordinate and projection systems; geospatial object definitions; vector and raster formats; object key definitions; and attribute linkages.

The policy hub also contains rules for integrating and validating geospatial data sets and rules for distributing GMD to enterprise applications.

2] Acquire Geospatial Data

Geospatial data may be acquired through four different channels. Each channel imposes its own unique capabilities, costs and limitations.

- **Purchase** – Most organizations purchase large, complex geospatial data sets like national street networks or electronic navigation charts. These data sets will come with extensive metadata, known data quality characteristics, and extensive attribution. Often these data sets are purchased with a subscription service that provides periodic updates and error corrections.

- **Extract from internal sources** – Some GMD may be extracted from internal sources. E.g. store and warehouse locations. Often these data have an implied location like an address. These implied locations are converted to absolute coordinates later in the GMD process.

- **Capture from maps or imagery** – GMD may be captured from existing paper or digital vector maps and satellite or aerial imagery. This is the domain of the established geographic information systems (GIS) community. Individual companies may only capture a few sales boundaries or may maintain large, complex geospatial databases of physical infrastructure.

- **Extract from SDI Framework or Base Data Resources -** Spatial Data Infrastructures most often contain basic reference data. This data resource is often widely available and designed to serve a variety of users. For example, the US National Spatial Data Infrastructure (NSDI) framework is a collaborative community based effort in which these commonly needed data themes are developed, maintained, and integrated by public and private organizations within a geographic area. The framework is one of the key building blocks and forms the data backbone of the NSDI.

  It is interesting to note that the process of capturing large geospatial data collections involves several thousand government agencies and private companies and billions of dollars annually. IDC estimates that agencies worldwide spend at least $50 billion annually to collect and manage geospatial data collections. Data sets include national street networks, worldwide navigation charts, national topographic maps, national land ownership maps and worldwide climate maps. Most of these data sets are eventually used as master data within various information systems.

3) Transform, Validate, Integrate

Geospatial data from various sources must be transformed to a common format with a common coordinate system. Also, implied locations like addresses and place names must be converted to absolute locations through a standardization and geocoding process.

Once all geospatial data are transformed to a common coordinate system and format, they may be integrated into master data sets that are relevant to the organization's business processes. These integrated data sets are then validated according to rules laid out in the policy hub. (These steps often involve specialized geospatial expertise and may be outsourced to a service company or performed by a group of internal specialists.)

4) Master Data Hubs

Validated geospatial master data are stored and managed within master data hubs. Ideally, these hubs are also the repositories for all enterprise master data. The key to success here is an adequate policy hub that prescribes the relationship of master data to the enterprise systems that use the master data.

5) Maintenance, Monitoring Cleansing, Versioning

As enterprise systems use master data, the master data may be updated or modified. In this step the master data are monitored, maintained and cleansed to keep the data within specification. The master data are also versioned and a historical record is maintained for compliance reporting and to construct historical records as needed.

6) Distribute to Enterprise Systems and SDI Portals/Nodes

According to rules laid out in the policy hub, master data are distributed to various enterprise systems.

In addition to distribution for internal use, master data may have been obtained from an SDI Framework or Base Data Resource or may be suitable for addition to such a resource. As organizations develop data assets which can help build or improve a Spatial Data Infrastructure they may be made available in an SDI Network Portal or Clearinghouse Node for potential future use by a community of organizations. This establishes a cycle in which users obtain SDI data resources for their use and also add back their contributions to help build broader networks of high quality data to assist in addressing economic development, social, ecological and security issues.

Goals for management of geospatial data in enterprise systems

These are the specific performance goals for handling geospatial data at each maturity level.

Geospatial data is handled within a managed process (Level 2)process by doing the following:

- Establishing a geospatial data policy hub within an individual process.
- Acquiring and documenting geospatial data specifically for an individual process
- Transforming, validating and integrating geospatial data across information systems that support an individual process
- Establishing a master data hub for information systems that support an individual process. The master data hub will manage all data used by systems supporting an individual process
- Establishing a process-level mechanism for updating appropriate spatial data infrastructure(s).
- Distributing geospatial data from a master data hub to all systems supporting and individual process.
- Maintaining consistent maintenance, monitoring, cleansing and versioning of geospatial data across all systems supporting an individual process.

Geospatial data is handled within a defined process (Level 3)process by doing the following:

- Addressing the items that handle geospatial data within a managed (level 2) process
- Establishing a geospatial data policy hub across enterprise processes.
- Specifying and acquiring geospatial data for enterprise processes based on uniform master data requirements for the enterprise.
- Transforming, validating and integrating geospatial data across enterprise information systems

- Establishing a master data hub for enterprise information systems. The master data hub will manage all data and catalogues used by enterprise systems

- Distributing geospatial data from a master data hub to all enterprise systems.

- Establishing an enterprise-level mechanism for updating appropriate spatial data infrastructure(s).

- Maintaining consistent maintenance, monitoring, cleansing and versioning of geospatial data across all enterprise systems.

Geospatial data are handled within a quantitatively managed and optimized process (Level 4) by doing the following:

- Addressing the items that handle geospatial data within a defined (level 3) process

- Controlling and specifying geospatial data using statistical and other quantitative techniques such that product quality, service quality, and process performance attributes are measurable and controlled across the enterprise

- Improving the use of geospatial data within enterprise processes based on an understanding of the common causes of variation inherent in the data and data sources such that the process focuses on continually improving the range of data quality through both incremental and innovative improvements.

- Maintain an enterprise-level mechanism for updating appropriate spatial data infrastructure(s). At Maturity Level 4, the enterprise is involved in using and contributing to regional, industry and/or national level spatial data infrastructures.

Policy Goals

Policy is the cumulative knowledge in an organization about how work is done. Ideally, policy aligns enterprise strategies and processes so that work achieves strategic objectives. Policy is a very broad area.

For the purposes of this model, we will limit the consideration of policy to that which affects the ways that IT support enterprise strategies. More specifically, we will suggest ways that policy can create economic value through the use of spatial data infrastructures.

Business and government communities have developed a rich range of methods and tools for creating and implementing policies. We suggest that three of those methods be considered for spatial data infrastructure and technologies.

- **Service Level Agreements** – SLAs provide a formal structure for monitoring performance such as a contract between the supporting units providing spatial services and the operational units that they support. An SLA is a useful form for identifying critical capabilities and performance levels and for periodically reviewing and correcting deviations.

- **Internal Feedback Loops** – Regular feedback from internal clients can be even more useful in correcting tactical, day-to-day issues. A good internal feedback loop has to be designed, implemented and nurtured just like any other effective business relationship.

- **External Feedback Loops** – External feedback sources can invigorate and energize spatial data infrastructure and technology within an enterprise. Sources for external feedback include: spatial data and technology vendors, the Open Source community and other organizations that have spatial data infrastructure operations.

Geospatial Policy Goals

A managed geospatial policy (Level 2) is institutionalized by doing the following:

- Aligning spatial data and technology characteristics for individual enterprise processes to organizational policies

- Providing adequate resources (including funding, people, and tools) to execute the spatial data infrastructure and technology policies

- Assigning responsibility and authority for maintaining spatial data infrastructure and technology capabilities and specifications for each enterprise process

- Training the people performing and supporting geospatial data infrastructure processes.

- Placing designated spatial data infrastructure and technology elements under appropriate levels of configuration management

- Monitoring and controlling the performance of the spatial data infrastructure against the plans for performing each enterprise process and taking corrective actions.

- Objectively evaluating the spatial data infrastructure, its work products, and its services for adherence to enterprise process descriptions, objectives, and standards, and addressing noncompliance

- Reviewing the activities, status, and results of the spatial data infrastructure and technologies with higher level management, and taking corrective action

A defined geospatial policy (Level 3) is institutionalized by doing the following:

- Addressing the items that institutionalize a managed (level 2) spatial data infrastructure.

- Establishing the description of spatial data infrastructure and technology for the enterprise and each organizational unit.

- Collecting work products, measures, and improvement information derived from planning and performing defined spatial data infrastructure processes.

- Reviewing the performance of the enterprise spatial data infrastructure against enterprise strategies and goals, then taking appropriate corrective actions to maintain alignment.

A quantitatively managed and optimized geospatial policy (Level 4) is institutionalized by doing the following

- Addressing the items that institutionalize defined (level 3) spatial data infrastructure processes

- Controlling the spatial data infrastructure and technologies using statistical and other quantitative techniques such that product quality, service quality, and process performance attributes are measurable and controlled across the enterprise.

- Improving the spatial data infrastructure based on an understanding of the common causes of variation inherent in the infrastructure such that spatial data infrastructure processes focuses on continually improving the range of process performance through both incremental and innovative improvements

Conclusion:

The integration of geospatial capabilities into enterprise information systems hinges on the maturity of three key areas, process, data and policy. The use of open, standards-based, services-oriented architectures simplifies our ability of designing information systems which can tie together the growing number of creative applications to meet the needs of business and personal activities. As organizations achieve higher levels of maturity, the use of interoperability, standards and best practices will become normal business activities. This will enable the synchronization of policy, data and process and the implementation of enterprise architectures and information infrastructures that support the needs of society and business.

End Notes

[1] For complete CMMI documentation see http://www.sei.cmu.edu/

Appendicies

Appendix 1: Phases of NSDI Development

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In the United States, National Spatial Data Infrastructure development activities have been taking place for the past 15 or more years. In looking back, I believe that there have been a number of Phases which have occurred and that as we move further in the maturation of the NSDI, there will be additional phases occurring. These phases are definable, but they do not mean that all of the organizations involved in the development and implementation of the NSDI are in the same Phase at the same time. Rather they are a generalized description of how and when the US NSDI has evolved over time. An awareness of how this development has occurred may be helpful in understanding some of the future changes and opportunities ahead of us and in building future NSDI developments on the work of the past.

The identification of 7 Phases does not imply that the NSDI is complete at Phase 7. Rather it is meant to indicate that the NSDI has reached full maturity at that Phase and will continue to grow and evolve as a dynamic infrastructure, as policies, technologies, and needs influence it over time.

- Pre –SDI
  - Survey and Mapping Coordination
    - 1900 through 1990

- Phase 1 – Concept Development
    - Mid/late 1980's thru early 1990's
    - Key Activities:
      - 1990 A-16 revision
      - Mapping Science Committee Studies and Reports in 1993, 1994, 1995

- Phase 2 – US NSDI Establishment
    - Early 1990's thru mid 1990's
    - Key Activities:
      - FGDC implementation of 1990 A-16 Revision
      - EO 12906 of April 13,1994

- Phase 3 – Initial Development and Implementation
    - Mid/late 1990's thru early 2000
    - Key Activities:
      - FGDC 1997 Strategy
      - Partnership Programs – FGDC Cooperative Agreements Program
      - National States Geographic Information Council (NSGIC) growth

- Local and Tribal Government participation
- OMB Involvement
- OGC emergence in developing geoprocessing technology specifications in the Internet enabled world
- Global SDI Growth
- FGDC Standards and Geospatial Interoperability Reference Model development

- Phase 4 – Web-based, standards-based understanding of value of geospatial as an integrating function for the enterprise
  - Early 2000 – mid 2000's
  - Key Activities:
    - E-government with Geospatial One Stop as an important element
    - A-16 revision in 2002
    - Geospatial Profile for the Federal Enterprise Architecture
    - OMB decision to include a Geospatial Line of Business in FEA
    - Imagery for the Nation proposed by NSGIC to meet imagery requirements for NSDI
    - Geospatial Intelligence established as a tradecraft and as one of the critical intelligence disciplines

- Phase 5 – Implementation of service oriented architectures, development of implementation profiles and service chaining of Web services
  - Anticipated timeframe: 2006 – 2008

- Phase 6 – Enterprise connections enabled through semantic capabilities, embedded business processes, sensor integration, data discrimination services
  - Anticipated timeframe: 2008 – 2010

- Phase 7 – Intelligent SDI Networks are in place using metadata for data, service, applications and models etc, registries and catalogues, semantics, chained services, e-commerce, to provide cost/accuracy/time options to meet users requests
  - Anticipated timeframe: 2010

Appendix 2: National Spatial Data Infrastructures: Stimulus for Economic Activity

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One of the often overlooked components of the vision of an NSDI is the goal of stimulating and sustaining economic activity. The Mapping Science Committee in its 1993 Report: *Toward a Coordinated Spatial Data Infrastructure for the Nation* stated that one of the four critical principals of the NSDI should be to foster new applications, services and industries. The 1993 report of the National Partnership for Reinventing Government and the 1994 Executive Order which established the NSDI both identified geographic information as critical to promoting economic development. Likewise OMB Circular a-16 reaffirms economic development as one of the goals of the NSDI. Economic development is referenced through many FGDC and NSDI specific documents. Specifically the NSDI Vision of *Current and accurate data will be readily available to contribute locally, nationally* *and globally to economic growth, environmental quality and stability and social progress* is clear that economic activities is one of the key purposes of the NSDI. The National Academy of Public Administration Report in January of 1998 highlighted the economic importance of geographic information. That report identified the economic importance of the US commercial geospatial industry in providing geographic information capabilities and products worldwide. It also identified that geographic information played a role in about one-half of the economic activities of the United States.

However, economic development has remained an under appreciated value of the NSDI. Part of the reason has been that it is still difficult for government organizatons to quantify the costs and benefits of geospatial information in their business/mission activities. Perhaps now is the time to ere-emphasize the potential of a robust NSDI to economic development in the US. Geospatial Industries have now become big business collectively in the US. Market estimates vary with some as high as $30 billion annually. Geospatial Industries are also identified by the US Department of Labor as one of the industry sectors which will be a the high growth field in coming years and which will face a critical shortage of skilled workers. More attention is now being focused on Return on Investment analyses as private sector companies justify expenditure on geospatial applications and technology investments and as government agencies address their investments as elements of information technology programs. David Sonnen has described a Geospatial Value Measurement Framework for identifying and measuring the tangible value of geospatial information systems. Better tools are now available to evaluate and assess investments and a backbone of consensus standards and specifications are in place to build interoperable geospatial systems. Economic impact should be an important justification. This means economic impact not only for a return against the costs of a project or enterprise investment, but economic impact as measured by the value of geospatial tools in making decisions that affect the lives of business , communities and citizens everyday within our nation. I believe that if we seriously and objectively assess these impacts and their economic value we will find that the economic return on NSDI activities will far outweigh the investments made.

Appendix 3: The Convergence of Geospatial Infrastructures and Architectures

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A convergence of standards-based geospatial infrastructures and architectures is unifying the geospatial industry and enabling the community to have a common ground of agreement for practices, which will make geospatial information and tools more available, useful and interoperable in the future.

Across many industries, standards have been key for an industry to grow and become a commercial success. This was the case for railroads, auto industry and many other well-documented cases. In the geospatial community, there is a growing set of activities that are converging on common approaches and standards. The Geospatial Marketplace has for many years been one of individual segments with competing technology platforms within most of them. This provided the opportunity for competition and new approaches, which helped the industry, develop to a viable, albeit a niche, component of the ever-expanding information technology sector. In recent years as the industry matured and gained a growing base of users, many recognized that in order to move to a new level of use, geospatial information and technology needed a stable set of standards and specifications, which were developed and adopted through industry consensus processes. The work of ISO/TC211, the Open Geospatial Consortium, national standards bodies and government and industry initiatives are resulting in a maturing network of spatial infrastructures and a framework of standards for geospatial data, technology and services.

Across the globe many nations are developing Spatial Data Infrastructures. Based on previously conducted surveys, it is estimated that more than 50 countries are developing a Spatial Data Infrastructure to better enable them to access, integrate and use spatial data from disparate sources in decision making. These existing and developing spatial infrastructures have many common components even though their organizational and policy frameworks are often quite different. The components that are common to most of the SDI efforts are: metadata, catalogue-based clearinghouse or data portal network, base data, standards-based capabilities and definition of organizational roles. With the framework of standards that have been developed and which can be used for SDI architecture integration, these common approaches are supported by these common standards. SDI architecture integration is now supported by a framework of standards and geospatial enterprise architectures are coming into place with the most mature of them connected to a solid standards framework. Examples which illustrate the move towards standards based architectures are: the US Geospatial Profile for the Federal Enterprise Architecture; the NATO Core Geographic Services Architecture; the SDI work of the European Union's Infrastructure for Spatial Infrastructure Information in Europe; Australia's ASDI; Canada's CDGI and Japan's NSDI. This convergence is enhancing the ability of nations to address trans-boundary and multinational issues and is leading towards a network of compatible SDIs, which make up the Global Spatial Data Infrastructure.

Appendix 4: GEOINT Interoperability Demonstration

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For the past two years one of the key technology components of the GEOINT Symposium has been a GEOINT Interoperability Demonstration. The GEOINT Demo is a multi-participant activity by members of the United States Geospatial Intelligence Foundation presented to show the power of the integration of data and technology and the collaboration of many partners. Each of the two distinct demonstrations has featured data, tools and technologies from at least 25 organizations. The Demos have used realistic but fictional scenarios which illustrate geospatial intelligence issues and problems and have shown how new technologies and capabilities can provide global access to information and rapid response to meet today's challenges. The Interoperability Demonstrations show how the use of geospatial standards to connect data and technologies through web services enables the delivery of geospatial information to customers. The GEOINT Demo is an example of geospatial enterprise integration at a relatively mature level. The GEIMM presented in this paper identified six requirements for effective enterprise IT integration. The Demo addressed these six requirements in the following manner:

- Information systems (IS) must support the business.

  The Demos were based on a specific scenario focused on geospatial intelligence which contained business driven workflows. Each Demo had direct and current links to business issues.

- IS must adapt and evolve incrementally and quickly.

  One of the key points illustrated by the Demos was the ability to develop and evolve rapidly. While several months of planning and coordinating among the participants was necessary to identify the area of interest and the scenario the development of the actual Demonstration moved quickly and flexibly once the participants began to provide the data and technology to be used. In both cases the actual integration of technology into the operational Demo was completed in a matter of weeks through a series of intense working sessions of the participants. Key was the use of an agreed upon architecture and common services framework which were built on consensus standards.

- The enterprise must have a clearly defined vocabulary and policy to share business knowledge across different business areas, minimizing historic gaps between enterprise objectives, business processes and IS development.

  The Demo used a core set of standards to comprise a Common Services Framework. These standards were drawn from a government agency Standards Listing. These standards were identified for use in the Common Services Framework for each Demo.

- The enterprise must use consistent methods and architectures that scale from small projects to long-lived, mission-critical systems, both within and across enterprise boundaries.

  This requirement did not particularly apply to the GEOINT Demos as they were not constructed to be long-term systems. However, a key feature of the Demos was the connection of a number of different systems and projects across organizational boundaries. This was able to be achieved through the use of standards and a common architecture.

- The enterprise must be prepared for and capable of integrating its information systems with other systems regardless of whether those systems are from the same organization or external systems from customers, providers or even competitors.

  The GEOINT Demos illustrated this requirement very well. Each showed how data, technology and services from over 25 different organizations could be integrated into interoperable processes for addressing geospatial intelligence workflows. One of the key lessons of the GEOINT Demos was That through partnerships and collaboration, the capability that exists in many different companies can be integrated and deployed in a standards-based Internet Web Services environment to meet major geospatial intelligence functions.

- Geospatial technology must be an integral element of enterprise systems rather than a separate discipline.

  The GEOINT Demos were focused on the use of geospatial technology, but they included other information technology capabilities and the use of IT standards other than geospatial standards to achieve an integration of multi-intelligence capabilities.

The GEOINT Demonstrations were clear examples of how the geospatial community can leverage the investments made by government organizations and the private and other sectors in standards development, interoperability, and services oriented architectures, to implement approaches that use standards based data and service frameworks to share information and achieve technology integration across many delivery platforms. This has significant implications for future systems implementation and technology procurements as the adoption of standards based approaches will improve data reuse and enable greater technology integration more rapidly than at present. In addition, the GEOPINT Demonstrations highlighted that full implementation of interoperable spatial data infrastructures, are the result of partnerships and contributions of the capabilities of all sectors.