Revista Internacional de Ciencia y Tecnología de la Información Geográfica
International Review of Geographical Information Science and Technology

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11.
ISSN: 1578-5157

A VISION FOR A NATIONAL GEOGRAPHIC INFORMATION SYSTEM

JACK DANGERMOND
President, ESRI
Redlands, California. USA

1. Background

Geographical maps have been a critically important tool for human beings for hundreds of years as we explored, traveled, inhabited, fought over and planned the territories of our earth. In the United States maps have become an essential part of the public, private and not for profit planning and execution efforts at the local, state, federal and international levels.

Maps tell us where we are. They help us understand our surroundings. They help us draw ideal routes from here to there. With knowledge and wisdom maps can be a means for human beings to settle disputes; with ignorance maps create conflict. Maps can convert the unknown into the known making it much easier for us to answer the question: What should we do?

As with every other walk of life, maps have been transformed by computers and advanced communications systems. In the old days maps were line drawings; today maps are data. Today maps are built with GIS technology, remote sensors, complex algorithms, and story telling. The declining cost and capability of storage, processing and dissemination has made it possible to build maps with nearly unlimited amounts of data and analytical capacity.

Two parallel and related developments have proceeded from this change. First the quality, efficiency and productivity of government actions have improved. Second, a new profession – GIS architect – has emerged to provide tens of thousands of good paying private and public sector jobs as new businesses have sprung up to create new products and services that take advantage of GIS's extraordinary utility to human endeavors.

Today, at the Federal level the US Government makes considerable use of digital map data and GIS technology in nearly every department ranging from emergency management and national

Recibido: 12/06/2008
Aceptada versión definitiva: 17/06/2008

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11.
ISSN: 1578-5157

security to environmental science, conservation, and human health (figure 1). These applications and their many benefits are well documented and continue to grow. Historically, many of these GIS applications have been project, focused and related to single missions. However, as cities, counties and states have increased their usage of GIS there is an unmet need to develop a more comprehensive enterprise approach and national system.

Such a system would integrate the management of the nation's key geographic datasets and support various government agencies with geospatial services and applications. While there have been many excellent efforts, they have fallen short of anything resembling an operational system.

2. An Integrated National Geographic Information System (GIS) is possible

Today's enabling technology--software, hardware and networks make it possible to consider the creation of a GIS for the nation. Such a system would provide a comprehensive and authoritative description of our nation's geographic knowledge. It would also be used to support a host of federal applications such as emergency response that requires cross cutting geographic information coming from multiple sources. The information in this system would be maintained by existing on-going business processes across existing government agencies and integrated periodically by a special organization in the federal government.

A) A nationwide GIS would include:

- A series of standard geographic datasets (framework layers) that are systematically organized in data bases and made available for supporting many applications (i.e. in government, academic settings, and the private sector). Some progress has clearly been made at the federal level at defining, building and assigning responsibility for managing some of these key framework layers.

- A series of workflows that would transactionally maintain (update) these datasets as part of various on-going government workflows. The concept here is that the national GIS would be maintained directly through participation and collaboration with existing government agencies. The system would integrate information from many sources and authors – using standard data models. The result would be a standardized, harmonized and consistent body of knowledge for the country.

- Data management responsibility (governance) for the data layers would be organized by the federal government but managed by the most capable organizations, i.e. federal, state and local government agencies and in some cases, the private sector (imagery, roads).

- A suite of applications that leverage (use) the geographic information in a host of mission areas including operational, planning, reporting, decision making, and policy guidance.

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11. ISSN: 1578-5157

- A stable organizational and political environment is needed. Key to the long term viability of a national GIS will be the creation of a centralized organization that is mandated to provide an integrated GIS system and maintain it.

- Leaders and liaisons working full time on collaborative efforts and partnering. These individuals would create collaboration partnerships between and among all levels of government and private industry. While most government agencies are willing to informally share their data sets, their willingness to participate in a collaborative and inter-dependent system will require the establishment of a centralized organization with funding, leadership and the ability to provide benefits back to participants. Bottom up approach for data sustainability, funding down data up.

B) Implementing such a system would require:

- A common geospatial data model (based on multiple application requirements and community agreement). This model would be used in every city and county in the nation and also be the basis of a national system.
- Data management workflows implemented within different organizations for maintaining (via transactions) the different layers of data. This should initially be developed in a series of case study cities and continuing work in collaboration with regional governments.
- Enterprise system architecture based on modern web service standards and implemented in a distributed environment. Implementation would involve a series of distributed subsystems organized around specific business processes (i.e., water resources, geology, transportation planning, etc) and specific geographies (i.e. states and regions).
- Technical and management leadership – geospatial professionals who can design and manage. Leaders who can transform the vision into action and develop a plan to sustain and maintain systems.
- A strong legislative mandate and an organizational framework.
- Funding for implementing and maintaining such a system. Such funding should probably be centralized (Federal Government) and where possible, require matching participation from partners (existing federal programs, and state and local government). Local government must receive consistent funding from state and federal for maintaining critical framework data, which then gets supplied to state and federal as part of a national plan.
- Local governments need to maintain the most detailed GIS layers with accuracy and scale to serve local applications. This same data would be resampled or generalized for state and federal use. Minimizes duplication of effort.
- Funding and support will be required for rural/unincorporated areas with no GIS capability.

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11. ISSN: 1578-5157

C) Steps for designing, building and managing a National GIS would include:

- A broadly accepted vision of national needs for a GIS needs to be developed. This vision should include the key application areas and information products, as well as the necessary resources that will be required to build such a system (i.e., people, technology, databases, organization, collaboration, funding, etc.).

- A strategic plan should be formulated. The government should hold a series of short specialist meetings to discuss and establish the key issues, opportunities, and solutions for developing an operational system. This should bring together the most capable people in the nation to help define and address the key requirements. Participants should include GIS professionals and policy makers who have experience in designing and implementing large programs and operational systems of this type. This should be headed by someone who has facilitated sessions of this kind before.

  The primary result of these meetings should be a strategic plan. The plan should include vision, architecture, tasks, timelines, responsibilities, and priorities. The plan should be peer-reviewed by individuals with the eye on refining the plan with real application services.

- Sell the strategic plan to policy makers. This means clear definition of the program and its benefits to individual agencies and the government as a whole. This must lead to enabling legislation outlining the mandate and how the program is to be implemented (i.e., organizational structure, operating plan, and budget across government, etc.).

- Develop a specific plan. This involves creating a more specific architecture and organizational/institutional structure for implementing the national system. This plan should be done by GIS system architects who have actually engineered and implemented major, successful systems.

  The specific design should be based on a clear definition of critical information products and services that would be generated by this system. While it is not necessary to develop a comprehensive inventory of all outputs, an attempt should be made to lay out those priority products that are representative and considered most critical.

  These outputs (together with their metrics of use) should be used to help drive the data model, applications, system architecture, and ultimately the structure of the organization that will manage the system.

- Widely review the plan with the objective of refining the system and building a broad community of interest across the geospatial field – "Harnessing an army of people to work on all aspects of the system".

- Implement the plan rapidly. The system should be implemented by using a prototyping methodology with a series of small incremental efforts that are short in duration, and focused on producing high value information results. This effort should be led with a

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11.
ISSN: 1578-5157

motivated and experienced team working closely with various government partners and private sector organizations.

- The system should generally avoid new research efforts, however, for complex problems, a series of specialist meetings should be held to define and provide guidance on specific issues with a view of discovering solutions. The results of these meetings should be identification of key areas for further research within universities and other organizations.

D) Data integration challenges

One of the biggest challenges for a national GIS involves the integration of data being created and maintained in multiple organizations. These challenges stem from the fact that traditional agency specific data sets have typically been developed independently, to support focused missions (i.e., soils for agriculture, hydrology for water resources, etc.). This often means that data may not necessarily have been designed to integrate with map layer data from other sources. While geography provides the geospatial framework for integration, many subtle integration issues arise when maps are overlaid (i.e., semantic and geometric inconsistency). Also there are issues related to data resolution, accuracy, scale and differing techniques originally used for data collection, etc.

E) Solutions for overcoming these data integration problems

Create common geographic data models. Further complicating this context is that for certain datasets it will require blending (harmonizing) a mosaic of state and local datasets into national layers (i.e., cadastral data). This is technically and scientifically possible, but for a variety of reasons (largely due to organizational structure, budgets and mandate), has not been attempted at the national scale.

Perhaps the most critical things to be done are the creation of a widely accepted set of integrated data models that would be used at all levels of government. If this were widely accepted, the scientific issues of data integration would be minimal. These models need to become standards by the federal government and linked to various funding programs across the nation (figure 2). Also, they must reflect the various missions and uses by all levels of government. Finally, they must work together as an integrated model of geographic reality.

F) Computer techniques for integration of heterogeneous data is possible

In the short term, a national system should be developed that mosaics the existing state, local and federal data together using a common integration model. While limited, this is possible and, in the past few years, has been used extensively. This process is known as Spatial ETL and involves Extracting, Transforming and Loading of data layers from multiple sources into an

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11.
ISSN: 1578-5157

integrated data base using a common semantic data model. This has been done successfully in various pilot projects under the direction of DHS and NGA. Examples include "Project Homeland" for San Francisco bay area and the state of Colorado, as well as the GIS for the Gulf project for areas affected by Hurricane Katrina (figure 3).

G) Technology

This project should be viewed as an enterprise IT system – not a research project for developing new technologies (i.e., hardware, GIS software, etc.). Whenever possible, the system should be built using proven COTS products. There are now multiple vendors that provide standards-based technology that is designed to solve the problems of building a national GIS.

H) Standards and architecture

Modern GIS server technology together with open standards and Services Oriented Architecture (SOA) can provide enabling components for implementing a national system. This architecture can support an integrated system that distributes the ongoing management of geographic subsets in a distributed network of participating nodes, making it possible for federal, state, and local organizations to collaborate in the maintenance and use of a national geospatial database (figure 4 and figure 5).

At the same time, this type of architecture supports easy integration with other IT systems and crosscutting applications such as those required for responding to national emergencies.

I) What will it take to create a National GIS mandate for the country?

- Leadership (i.e. a person people follow who can implement such a system and that the people will trust, empower, and follow).
- Demonstrated ongoing action as sustainability of data is critical.
- A clear definition and program plan of what a National Map/National GIS must be.
- A mandate supported by leadership (USGS, DOI, OMB, Congress…).
- Improved communication. Effective communication is needed not solely about the system vision, but also the implementation plan, status, and results).
- Collaboration and compromise across all levels of government. These efforts should focus on minimizing duplication of effort where possible, so it is easier to maintain and sustain data.
- Resources (people, fundraising, advocacy and education, etc.).
- An operational organization.
- Funding and simplified procurement process for inter-government collaboration.
- Better understanding by policy makers of the benefits of GIS.

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11.
ISSN: 1578-5157

J) A national GIS system should be collaborative – a network of partners

Clearly, a national system must take advantage of state and local governments, as well as commercial data partner resources (figure 6). In the past, virtually all geographic data used by the federal government was created and maintained within the federal community. Today, for selected data types, state and local government GIS's create significant amounts of geographic data that is as good as and often better than collected by the federal agencies. By developing the right partnerships as well as data standards and integration processes, the federal government could take on a new role of periodically integrating and making this data available as national coverage's for use by everyone. Also, for selected data types (i.e., street centerline data, imagery, etc.) the private sector is now offering reliable high quality data that can be licensed at prices that are considerably less expensive than traditional in-house government processes. These resources should be capitalized on.

K) Federal Government Role

Beyond the development of the overall system, there are two significant roles for the federal government to play. For certain layers, the federal government is the only authoritative source (i.e., geodetic control, hydro, networks, elevation, etc.). These datasets must be maintained on an on-going basis by the federal government.

There is also a need to create, set up and manage an integration process that integrates the data from many sources. The federal government needs to set up a program and system for creating this ongoing integration infrastructure. This will require the right kinds of partnerships related to data sharing and access and also a program for ongoing funding.

Finally, it will be necessary to set up a technology and organizational support infrastructure for hosting the National GIS in a high performance and reliable environment. This infrastructure would not only be the initial data services infrastructure, but also serve as a platform for the wide array of applications supporting the federal government. It would also provide a continual repository where anyone could go to get copies of the data for various uses.

4. Conclusion

The world of geospatial data and applications is progressing rapidly. US federal agencies and other governments around the world are continuing to discover the rich benefits of using GIS as a framework for improving government services. A national approach for improving and integrating geographic data in the US is clearly overdue. Successful application in the fields of public safety, national security, emergency response, water resources, human assets, agriculture and the environment will provide the evidence that a national GIS strategy would bring many benefits. Government agencies must be encouraged to work together to realize this common goal.

Some may perceive that the reason a National GIS program has not gone forward in the US is because critical research or technology elements are missing. This is not the case. There are

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11.
ISSN: 1578-5157

many large, successful operational GIS systems that have been implemented and are working quite well. There are countless examples of successful operational systems at all levels of government as well as in the private sector.

Today, the critical issues involve organizational mandates, leadership, and financial resources. The development of such a system is complex and will require good design, a strong leader, and organization with ongoing funding to make it viable.

FIGURES

Figure 1.

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11. ISSN: 1578-5157

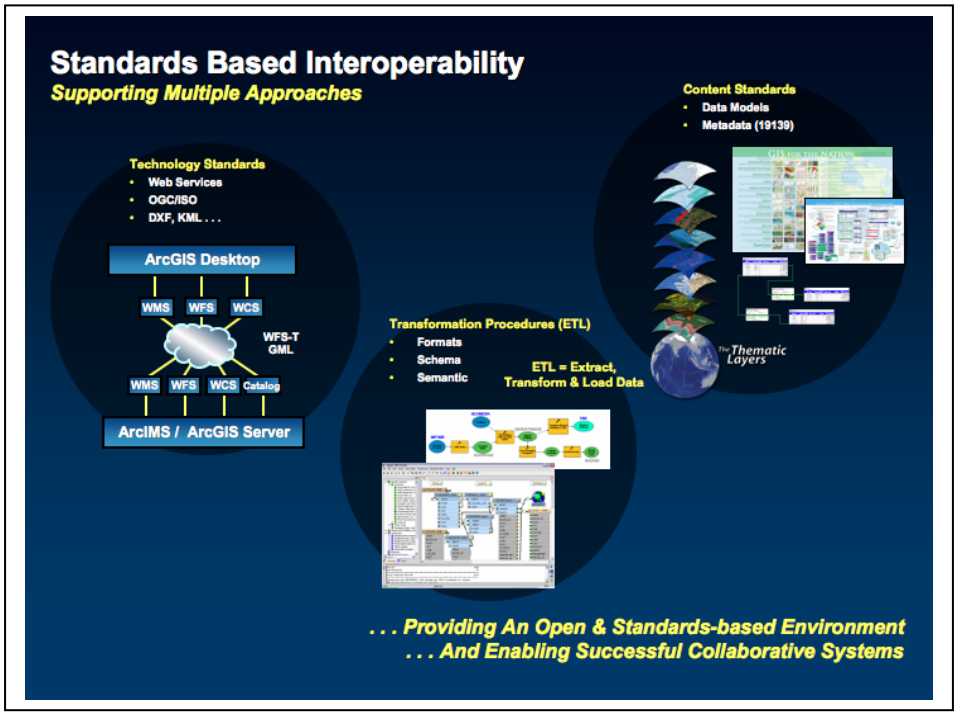

Figure 2.

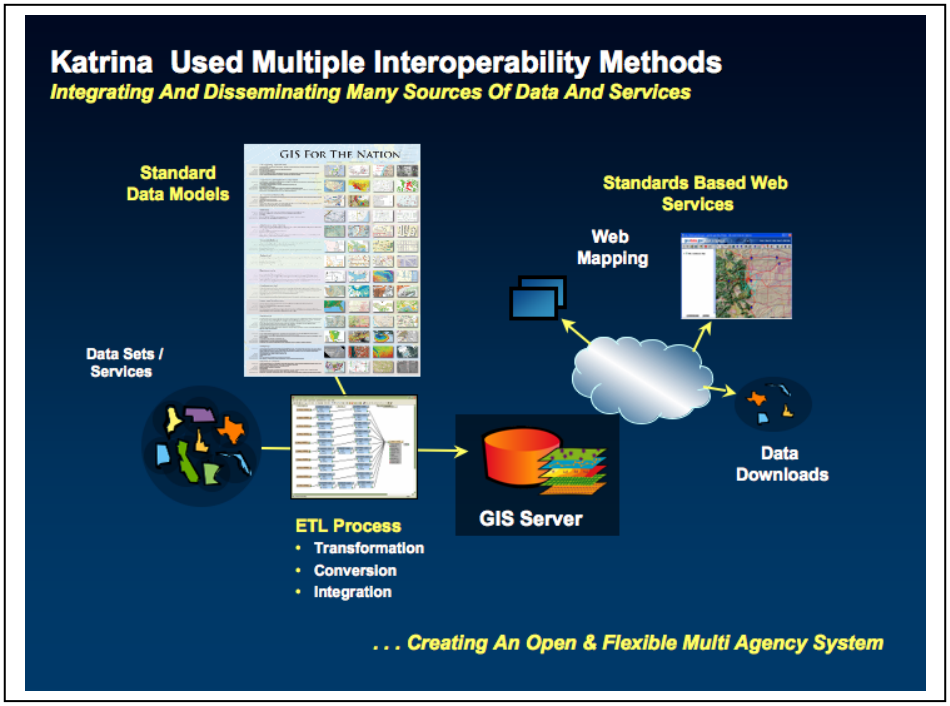

Figure 3.

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11. ISSN: 1578-5157

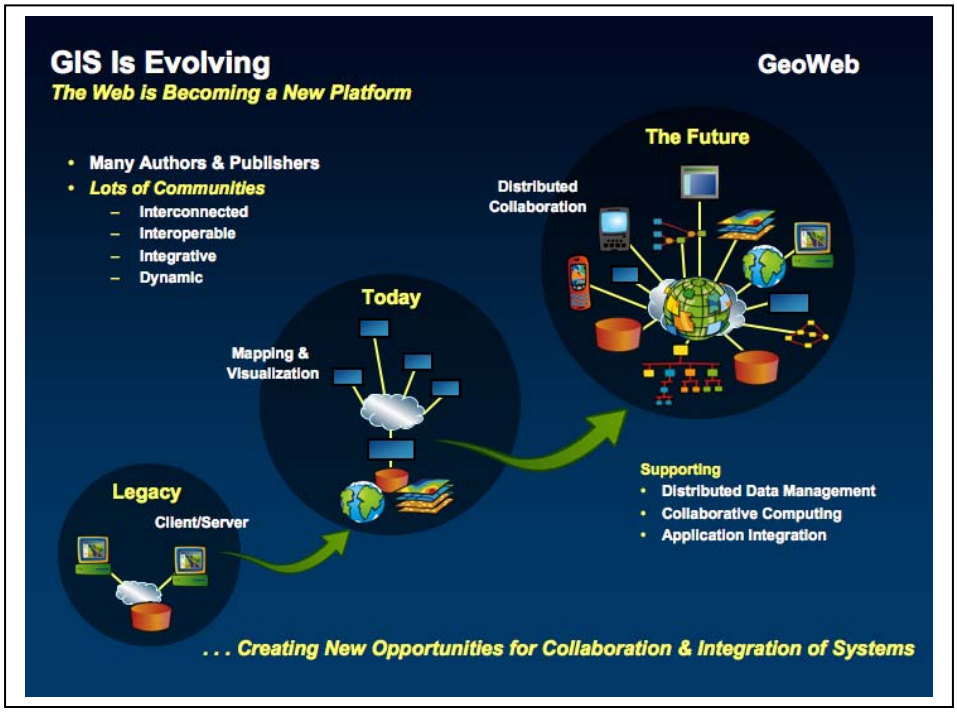

Figure 4.

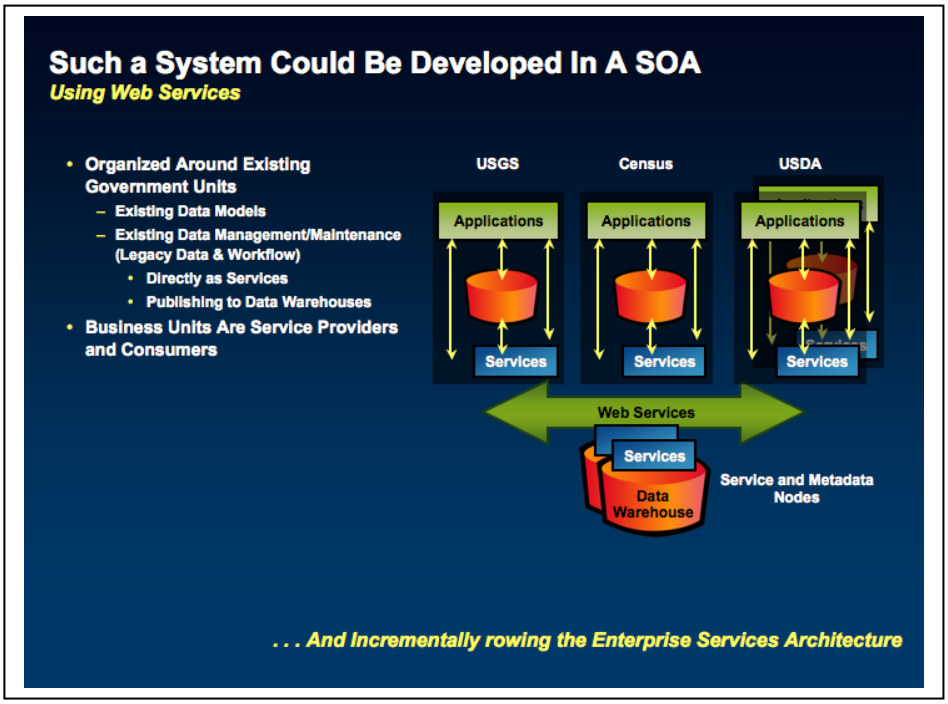

Figure 5.

Dangermond, J. (2008): "A vision for a national geographic information system", GeoFocus (Editorial), nº 8, p. 1-11. ISSN: 1578-5157

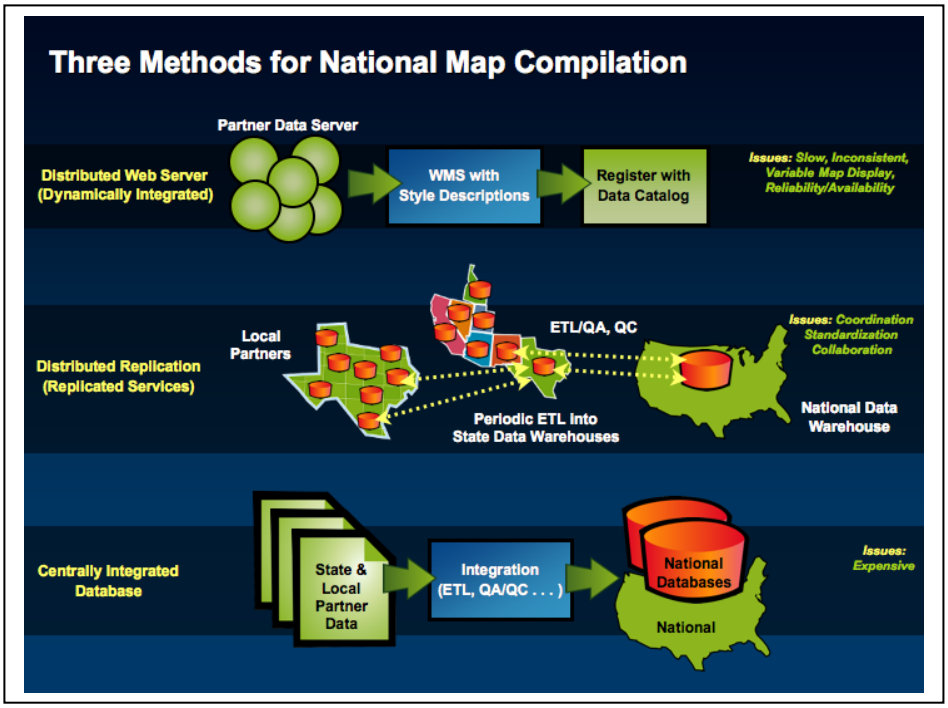

Figure 6.