Implementation of *The National Map* Road Database

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Abstract

The National Map is the U.S. Geological Survey's (USGS) next-generation topographic mapping product. This concept aims to achieve a more effective and regenerative public mapping program through local participation, inter-agency data sharing, and integration. This ambitious endeavor faces many significant challenges to its implementation, however.

The Federal Geographic Data Committee (FGDC) was established by the Office of Management and Budget (OMB) Circular A-16 to establish a coordinated approach to establishing a National Spatial Data Infrastructure (NSDI). However, numerous federal initiatives attempting to consolidate spatial information continue to proceed with fairly poor interagency coordination. Such programs include the Census TIGER enhancement project, *The National Map*, and Geo-Spatial One Stop (GOS). This paper assesses the changing role of federal level mapping organizations and recommends the operational establishment of an overarching authority that can effectively manage *The National Map* and other components of NSDI.

The successful development of *The National Map* will rely on sound management that considers the geographic information systems (GIS) requirements and capabilities across all levels of government. Merging a number of consolidation efforts under one umbrella authority will greatly increase the odds of successful implementation of the NSDI initiative. Integrating public road GIS data and systems is a daunting goal that is a cost prohibitive endeavor to undertake for any single agency. Collectively, however, it is in the best interest of the nation and should be pursued by the administration in the spirit of responsible governance.

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Introduction

Technological and economic barriers to geographic information systems (GIS) implementation are quickly dissipating. This has led more and more organizations to adopt GIS as a spatial data management tool. Rapid adoption of GIS technology has not come without cost. Many organizations employing GIS have developed and maintained spatial databases mostly independent of other organizations using GIS. This is apparent across all levels of government. One example of this problem is the existence of multiple transportation databases among government agencies - each one designed to fulfill a particular agency mission. The Topologically Integrated Geographic Encoding and Referencing system (TIGER) data support the Bureau of the Census mission; Digital Line Graphs support the basic topographic mapping mission of the United States Geological Survey (USGS); while the Bureau of Transportation Statistics maintains the National Transportation Atlas Database. Further, many states and counties have transportation networks that they maintain autonomously. These datasets cover many of the same geographic extents and real-world features, but have been designed and maintained disparately within distinct fiscal budgets. The result is not only redundancy but also diminished data quality. Moreover, with budget constraints commonplace, it is very difficult for any one agency to maintain a current spatial dataset for geographies of significant extent. This has been particularly true of the USGS and Census transportation database activities. The USGS states openly that, on average, its topographic maps are 25 years of age (USGS, 2001).

Along with many professionals within the geospatial community, the Office of Management and Budget recognized this operational redundancy in 1990 and released Circular No.A-16 (OMB 2002). This circular, revised in 2002, called for the establishment of the Federal Geographic Data Committee (FGDC) with the purpose of coordinating various spatial data activities among federal agencies. In 1993, the National Performance Review further recognized the importance of spatial information and reported the need to establish a National Spatial Data Infrastructure (NSDI). The vision of NSDI is to create spatial data partnerships across government functions and political levels (Guptill, 1994). The FGDC was placed in charge of developing the NSDI.

Inspired by NSDI, and the feasibility (or lack thereof) of the current USGS topographic mapping process, the USGS created a vision founded in local to national spatial data management collaboration. This vision is encompassed in *The National Map*. It aims to provide the public with basic geographic data across the entire nation through the linking of existing spatial databases at the federal, state, local levels and privately licensed data where feasible. Within the context of this vision, the USGS (USGS, 2001) will claim responsibility for:

1. guaranteeing national data completeness
2. marketing the availability, and utility of *The National Map*
3. creating and stimulating partnerships
4. integrating, certifying, and quality assurance of data from all participants
5. owning and producing content for *The National Map* where no other suitable and verifiable source exists
6. leading the development and implementation of national geospatial data standards.

The stated content goal of *The National Map* is to provide nationally consistent and integrated topographic map information useful for any arbitrarily defined geographic area. Thematically, content is to include orthophoto imagery, elevation data, hydrography, transportation, structures, government and administrative boundaries, geographic names, and land cover information. The target level of cartographic detail to be achieved is equivalent to or greater than the detail of the USGS standard topographic products. The vision of *The National Map* is made available by the USGS (http://www.nationalmap.usgs.gov/nmreports.html). Therefore, no attempt is made here to further describe the ultimate goal and vision of *The National Map*.

Realizing the demands of *The National Map* is a challenging task by any measure. But the most critical initial step in implementation is the development of a strategy that considers the true scope and complexity of the mission. This paper attempts to shed light on how the inherent organizational and technical challenges presented by *The National Map* may best direct the federal government in its implementation.

Paper Objectives

The aim here is to improve understanding in geographic information sharing practices that require both horizontal and vertical political cooperation. Currently, there seems to be a lack of recognition of the complexity of local/regional partnering and integration covering a national extent. As mentioned above, there are redundant federal efforts which are aimed at improving governmental efficiency of GIS road data maintenance. The first goal of this paper is to provide policy makers with a tool that will enable relative comparison of cost among various data and systems integration designs. The second goal is to provide policy makers with a reasoned plan for reducing redundancy in the quest for national mapping efficiency. In achieving this goal, three specific objectives will be met. These three objectives are:

1. To suggest a strategy on how best to organize bureaucracies for interagency spatial data collaboration.
2. To present a recommended approach to *The National Map* road data implementation.

It is hypothesized that the existing political level and management structure of *The National Map* is insufficient for effective project implementation. The project management structure should reside with a political body that is able to authoritatively coordinate integration efforts at an interagency level. A second hypothesis is that the current partnership strategy of *The National Map* is underbound regarding its participant strategy. This will likely make The National Map a cost prohibitive endeavor.

Research Methods

Several different methods were used to fulfill the objectives of this review. The author first needed to more completely understand the argument for developing *The National Map*. Initially, this included review of the published and unpublished documents dealing with *The National Map* as well as conversations with USGS employees. Independent evaluations regarding *The National Map* implementation offered external perspectives on how the USGS may contribute to the NSDI (NRC, 2003; URISA, 2003; USGS, 2001b). Beyond specific program evaluations, it was also necessary to attempt to understand the project requirements of *The National Map*. To complete this mission, several sources were referenced, including the Homeland Security Infrastructure Program publication (NIMA, 2003)[1] and various transportation standard documents.

Review of data sharing literature

Various articles and books were referenced in relating *The National Map* to similar, albeit smaller scale, spatial data collaborations. An attempt was made to tie the theory learned from spatial data sharing projects to *The National Map* initiative. Literature of published geographic information sharing, partnering, standards and spatial data integration topics formed the foundation of the implementation strategies presented in this report.

Data evaluation

The content evaluation of potential National Map partnership data was evaluated. Primarily state, local and commercial transportation data sets were compared in the St. Louis and Atlanta metropolitan areas in conjunction with a larger USGS research project (Usery et al. 2003). The networks were visually evaluated relative to each other and against recent orthophotos. The orthophotos were the assumed ground truth in this analysis due to their high spatial and temporal accuracy and precision. Recommendations for *The National Map*'s inclusion of any transportation dataset, however, are not based solely on the analysis of these small samples. Rather, the data source recommendations within this report are born from years of experience working with various transportation networks as well as consideration for the organizational and data integration challenges described below.

Understanding GIS Data Sharing Issues

The arguments for inter-organizational sharing of spatial data are strong. Dueker and Vrana (1995) suggest three classifications of potential improvements from shared GIS initiatives. Although they focus on intra-organizational collaborations, the same potential benefits apply to inter-organizational initiatives such as *The National Map*:

1. Efficiency – pool efforts and allow for data maintenance at a lower per-unit cost,
2. Effectiveness – new and higher quality products, services and analysis and decision making,
3. Enterprise benefits – improved communication and shared knowledge across the expanded community, providing opportunities for further integration and collaboration.

Conversely, the absence of sharing impedes technological advances and the social adoption of GIS (Pinto and Onsrud, 1995). The lack of data sharing forces organizations to

[1] As of August 2003, the Homeland Security Infrastructure Program document was classified For Official Use Only.

expend more resources on data collection and maintenance as opposed to developing analytical applications and results. Further, applications for spatial data analysis, once developed, are not easily distributable within GIS communities having extensive system heterogeneity.

Most would agree that there exists a reasonably strong argument for developing a consolidated national mapping program (OMB, 2002; NAPA, 1999; Jensen et al. 1998). There is a great deal of public money to be saved and benefits to be realized in doing so. However, most also realize that there are many obstacles to overcome before *The National Map* vision comes to fruition (NRC, 2003). What are the major hurdles to successful implementation of *The National Map*? Nedvodic-Bodic et. al. (1999) suggest that two major areas of difficulty inherent to the implementation of spatial data partnership programs: organizational constraints, such as institutional inertia; and technical constraints, such as data heterogeneity. The former set of constraints, she suggests, is significantly more challenging to overcome than the later.

While it is commonly recognized that both technical and organizational impediments to spatial data sharing and integration exist, much research suggests that the organizational obstacles are more difficult to overcome (Croswell, 1991; Masser et al 1995; Nedvodic-Budic et al. 1998). Masser and Campbell (1995) highlight some key obstacles to GIS sharing:

1. variation in participant priorities,
2. variation in GIS experience and technical ability,
3. differences in spatial data handling skills,
4. disagreement among participants regarding data openness, leadership, data standards, equipment and training.

Given the complexity of a national spatial data integration program, these issues are very difficult to surmount. Meredith (1995) shows that the greater the number of participants in a data sharing program, the greater the organizational complexity. In addition, an inverse relationship between the interdependency of sharing organizations and the likelihood of project success has also been noted (Azad et al. 1995).

Perhaps, recognition by the USGS of these organizational impediments to data sharing constitutes their argument for the need of a zero-mandate policy with state and local governments. Such an under-bound network of partners may produce a *National Map* product of such low quality that its cost may not be justified, however. Nonetheless, the above organizational impediments, when considered with *The National Map* and NSDI visions, present some fundamental project realizations:

1. The cost of spatial data sharing is significant.
2. Successful development of *The National Map* is dependent upon an up front understanding of *The National Map* stakeholder community needs and capabilities.
3. Long-term implementation must find a balance between mandated compliance with standards for participants and local control of data management.

The causal mechanism behind many of the inter-agency challenges is the same mechanism that allows each agency to function efficiently. In other words, the forces working against successful implementation of *The National Map* are inherent in institutional bureaucracies. Longstanding institutions have developed and used GIS data for many years to fulfill their own missions and find it difficult to adapt to supporting a broader mission despite acknowledgement of such a need. Daft (1989) demonstrated that bureaucracies are more efficient than open and flexible. Within governmental entities, major changes must typically be initiated with a political mandate before requisite attention and inter-agency cooperation is achieved (Craig, 1995). *The National Map* is an initiative internal to USGS but its requested participant list reaches far beyond the Department of Interior to other federal departments and to state and local agencies.

The National Map, therefore, should not be viewed as an extension of an existing program or the evolution of an existing governmental entity. Rather, it promises to be a collaborative effort among several governmental and private entities that spans various political and geographic scales. The complexity inherent in such a network mandates the implementation of a thoughtful project design and data integration strategy. The first set of challenges, previously reviewed, involves organizational constraints that face *The National Map*. The second set of challenges is technical in nature and addresses the problem of integrating spatial information from different organizations with varying data characteristics and structures. Both organizational development and data integration issues are pertinent across all spatial data themes for *The National Map*. Although many implementation strategies resulting from this work may be applied project wide, the scope of this study, particularly regarding data integration, will be limited to *The National Map* road data.

Combining spatial data from various, disparate sources presents many potential data integrity problems. Spatial data are not represented consistently among organizations with regard to schema, attribution, or geometry. For transportation networks, there may be significant overlap in geographic extent between neighboring partners with many of the same road segment features represented differently. Geometric inconsistencies across datasets also lead to topological accuracy issues when multiple data themes from multiple sources form a composite map for a particular geography. Unifying the existing data sources that will comprise a single framework is the process of data integration (Devogele et al. 1998). Developing processes for successful integration in the midst of such heterogeneity is the second major challenge of *The National Map*.

So how can the USGS, or the federal government more broadly, apply the lessons of past and existing spatial data partnerships in selecting a strategy for *The National Map* that offers the most promise? First, the basic bottom-up framework the USGS is attempting to implement for The National Map information is presented and criticized. Then a recommended conceptual data flow for transportation data is presented.

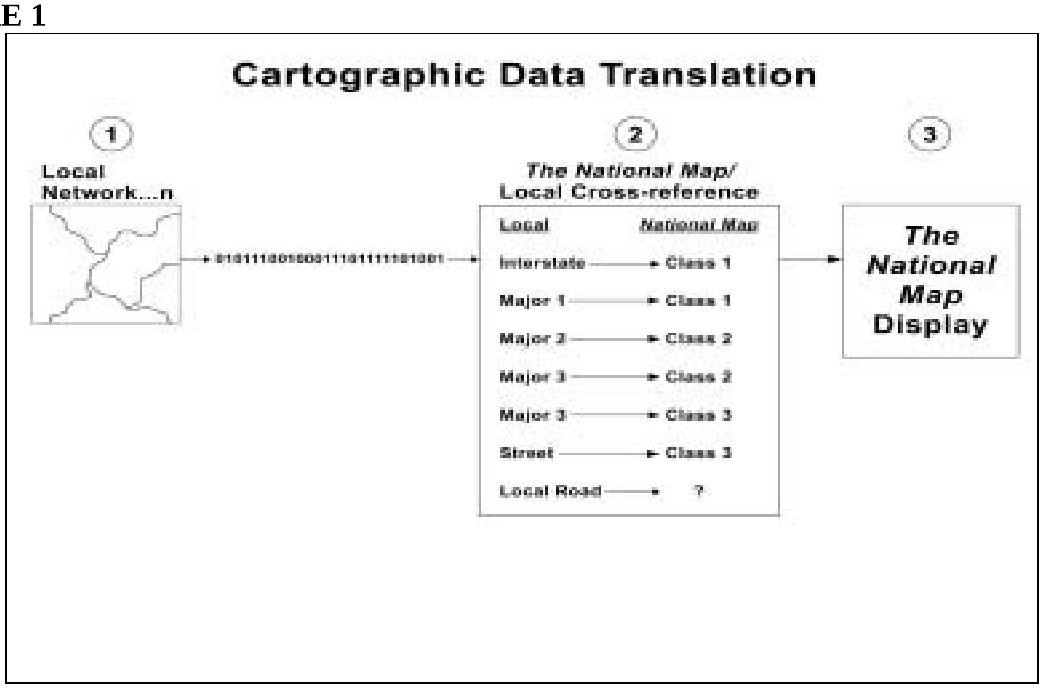
Current USGS Approach to Content Supply

There exist three main strategies for accomplishing spatial data interoperability offered by Devogelle et al. (1998). The *first* approach is to integrate the data manually, specifying the data from participating databases that is to be merged with the global application. Global application processes receive the component data and synthesize the information to meet the global application requirements. A *second* approach to interoperability is through the application of standards. Standardization can be applied to both data models and schemas. Essentially, standards facilitate data exchange among systems. With a wealth of valuable information already existing, however, the problem of converting present, unstandardized, data to a standard format remains a problem with this approach. The *third* strategy for achieving interoperability is to develop a software system that ties together existing data model and schema designs. This is referred to as a federated database system (FDB) approach. It requires that all local schema differences be resolved via a global, virtual schema (Devogele et al. 1998, 336). This would be a daunting task for *The National Map* considering the number of participants. A federated system may be developed with either a bottom-up (local translated to global schema) or a top-down (global schema mandated to local) approach (Laurini, 1998).

What strategy is currently proposed for achieving data interoperability for *The National Map*? As briefly described in section 3.1, *The National Map* currently relies on a bottom-up strategy for data integration that is most closely related to a FDB approach. The current strategy for dealing with horizontal integration of transportation is to develop automated and semi-automated techniques for linear feature edge-matching. From a data attribution perspective, USGS staff will translate local schema designs to *The National Map* global schema via maintenance of a cross-reference table. The benefits of this strategy include limited disturbance of local participants' existing processes. Any standards that are applied with this approach are applied at the overarching level. This translates into less of a need for USGS to incentive local participation, monetary or otherwise.

There are many disadvantages to the current USGS integration approach, however. A bottom-up approach is much more complex than a top-down approach due to the heterogeneity of existing spatial databases (Laurini, 1998). Responsibility for tying together partner data is left to the overarching authority, along with the cost for doing so. Of primary concern is that this process does not address the problems of inconsistency among the various jurisdictions. An enormous amount of work is left up to the organizing entity, i.e. the USGS with some major issues left unresolved. Figure 1 illustrates the basic philosophy of this mapping service structure and some of its limitations.

FIGURE 1



The above figure illustrates some classic complicating factors with the bottom-up federated approach. First, a partnership is established with a local authority. Second, each stream of information from the partner's WMS needs to be interpreted and cross-referenced to *The National Map* schema before it can be displayed. A complete integration of schemas, where local schema discrepancies are resolved, will be forgone in *The National Map* due to the volume of participants. The cross-reference table above shows how the local semantics will rarely match the global semantics. There will rarely be a 1:1 match of feature classes between the local and global data structures. Further, the data layer containing major roads for any one local participant is most likely unique from all other participants when considering the various systems, cartographic representations, and definitions for a major road. With the number of partners envisioned coupled with the heterogeneity of mapping schemas and systems, maintaining thousands of partnerships will be awfully burdensome.

Beyond the classic schematic integration issues, discrepancies specific to geographic information presents further challenge to a distributed database design. The typology of spatial database issues below is based on a list of issues presented by Laurini (1998, 380).

1. Diversity in spatial representations,
2. Diversity in global projections,
3. Diversity in values for the same items located at different sites,
4. Diversity of spatio-temporal sampling,
5. Variability of definitions over time and space,
6. Discrepancies in coordinate values,
7. Discrepancies in boundary alignment (zonal fragmentation),
8. Variability in content quality,
9. Variability in data maintenance procedures,
10. Discrepancies in spatial metadata

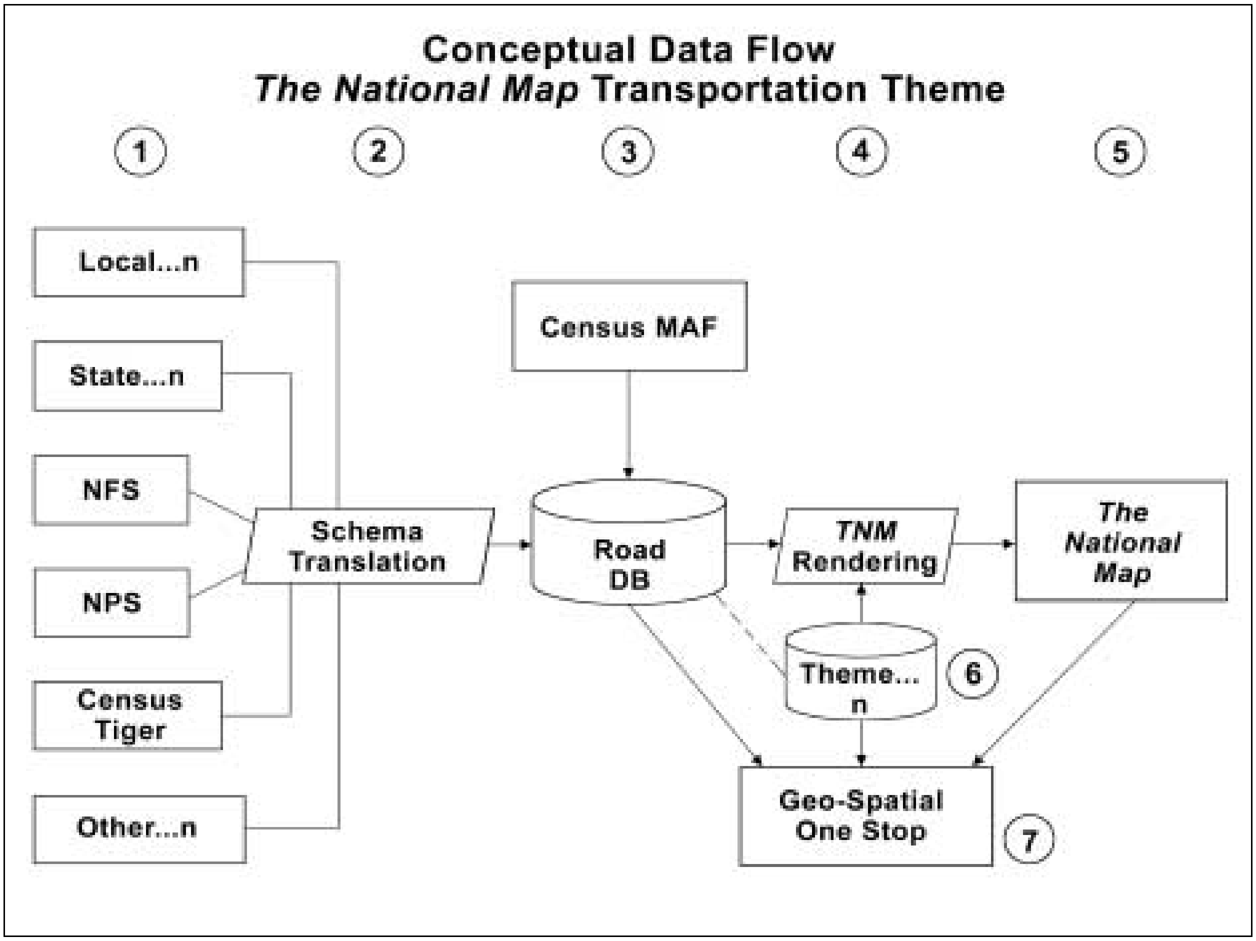
Given the complexity of integration issues, it is difficult to envision how the current strategy can be employed over the entire nation and meet the transportation theme requirements of *The National Map* and NSDI stakeholders. A successful program will require some cooperation and standardization at the local, data maintenance level. A conceptual data flow is presented below. The following model illustrates how limited, centralized data standards might enable a more complete, consistent federated dataset for transportation.

A Recommended Transportation Web Service

The long-term solution to integrating national street centerline data is to develop a distributed database of national extent that meets the scale requirements of local governments. Jensen et al. (1998) calls for the need to establish a centerline database accessible to all levels of government. Such a database could be maintained at the local level with no duplication of effort at the federal level. Centralized control of standards, informed by all stakeholders, would constitute the mechanism for information exchange and interoperability.

Figure 2 illustrates the suggested, long-term web mapping service for *The National Map* Transportation. Although such a program cannot be implemented immediately, the overarching authority of NSDI needs to develop a plan for achieving such a distributed non-redundant data maintenance program.

FIGURE 2



The schematic is detailed by stage number labeled on the data flow diagram. Generally, the flow of information is from left to right. Participating data contributors maintain data on the left, committing it to a centralized road data repository via a translation process, and a cartographic template application for *The National Map* rendering on the right of the diagram.

Stage 1: Data Partners

The first stage of the data flow recognizes the participating data providers to *The National Map* transportation theme. Under this design, each participating agency will have a menu of local system-schema designs to migrate their data too. The menu will be a list of systems and schemas derived from the phase 1 requirements study, identifying the most common data structures among the data providers. Data will reside locally with each participating organization. Eventually, the majority of transportation data content within *The National Map* primary network will come from local organizations. And minimum content standards and capture conditions must be adhered to by all data providers.

Census TIGER files, it is recommended, should provide the base network for transportation. Many local government transportation networks are based on TIGER files. Therefore, many local GIS agencies are familiar with the format and history of TIGER data. In addition, the TIGER Enhancement project is actively soliciting local participation in improving the spatial accuracy of its network. Although no network maintenance plan beyond the 2010 Census has been publicly discussed, it is recommended that a decentralized, ongoing data development effort be initiated.

The U.S. Forest Service (USFS), the Bureau of Land Management (BLM), and the National Park Service (NPS) represent other federal agencies that have unique road network requirements. The Forest and Park Services need forest fire roads mapped. Since this demand is unique to them at the federal level, perhaps they will then maintain public land fire road geometry and attribution. *The objective is to have each agency fund the data development effort proportionate to their respective data use*. Data flows from each distributed database through a translation process and to a national Road DB. Local reference to neighboring partner data for edge-matching may be accomplished through a view of the Road DB.

Stage 2: Schema Translation

With each participant storing transportation data within a known (via metadata) system and schema, automated data translation procedures may be developed for importing all participant data to a centralized data base. Data from each provider will be committed periodically, based on demand for each partner's data, the frequency of network change, and schematic translation processing capacity constraints.

Stage 3: Central Transportation Database

The Road DB will hold all geometry, primary key assignments for road segments and nodes, as well as minimal attribution for cartographic display. However, the majority of the network attribution will remain distributed. Each partner will be periodically provided with available primary key sequencing files, allowing for complete functional autonomy from the Road DB during database maintenance. Therefore, all data committed into the Road DB will already have had primary key assignments for nodes and road segments. The Census Master Address File will be related to the Road DB similar to the manner in which it is currently related to the TIGER files. Network continuity validations, nation-wide quality assurance, or other analytical procedures may be developed and applied to the Road DB by USGS researchers or other agencies interested in the continuity of the national Road DB.

Stage 4: Cartographic Rendering

A default cartographic template will be maintained by the USGS or government contractors for the purpose of displaying the Road DB via *The National Map*. Custom templates may be developed for various purposes by any interested party. The template will also incorporate other data sets to be displayed on *The National Map*, including NSDI themes that are not common to *The National Map* and views for restricted (non-public) access data. Maintaining the cartographic template, and WMS more broadly, may be a function the federal government should consider outsourcing to the private sector. There is a wealth of WMS experience and success in private industry that should be tapped.

Stage 5: The National Map Product

The National Map will provide the cartographic window to the Nation's transportation data providers. Ultimately, all national map data will be viewed through this WMS. Again, a commercial applications service provider may be contracted to host *The National Map* site.

Thus far, only the primary, public transportation data has been recognized within this data flow. However, *The National Map* will have multiple access levels, from unrestricted (public) to classified levels for national security and emergency management access only. There will undoubtedly be a need for other, more robust, transportation networks to support sophisticated routing applications. Although recent discussion within an inter-agency transportation theme team recommended that TIGER have routing attributes added to it by any agency that is interested in routing on *The National Map* data (Canfield, 2003 pers.com.), the reality is that such an effort would be cost prohibitive. A network that supports routing applications not only requires attributes such as direction but also requires topological design considerations that are beyond the framework of the TIGER data model.

The public sector would be wise to leave routing database development to commercial data providers. Organizations may be granted various levels of access to these networks via a *National Map* subscriber service. Of course, the commercial data venders such as NavTech, GDT, or TeleAtlas would receive royalties for the use of their data. Government should be able to take advantage of private routing and geocoding software that has been developed around the commercial networks. Applications relating event locations on the Road DB to a commercial network, such as NavTech, can be developed by utilizing the comparable spatial precision and addressing attribution of the two road networks.

Stage 6: Other Data Theme Relations

Other data themes or data sets may be explicitly or implicitly related to the Road DB. The dotted line in figure 2 signifies that other data sets may have foreign keys to the Road DB or visa versa. Records within the Structures model, for instance, may require a foreign key to a road segment identifier. Explicit linkages across themes must be considered in the design of *The National Map* as a whole. This stresses further the importance of a coordinating standards development effort among data themes. As discussed above, other transportation data may be indirectly related to the Road DB via network conflation applications. Spatial data sets should be available for view within a *National Map* access layer (public or restricted) and should also be registered with the Geo-Spatial One Stop portal (GOS).

Stage 7: Geospatial One-Stop Relation

It is recommended that *The National Map* be coupled with GOS via a shared gazetteer. *The National Map* would serve as the data view of information within GOS. Of course, the core data themes within The National Map are expected to be nationally seamless and compliant with explicitly defined standards, whereas the GOS information serves as a clearinghouse with relatively few participatory demands. But users should have the option of identifying participant data sets for download via *The National Map* interface or, conversely, by directly selecting the data sets listed within GOS for view in *The National Map*. This allows users to relatively quickly assess the usability of a GOS listed dataset with the national base map (*The National Map*). And, secondly, it allows further opportunity to highlight inconsistency in entity representations between datasets.

The alternative described in the seven stages above should be considered by *The National Map* transportation team. It is unlikely, however, that this approach would be adopted without political elevation of *The National Map*. That said, many shortcomings of the present USGS approach are addressed with the conceptual approach described above. Some of the benefits of this web service approach are listed below:

1. Primary key attribution of road segments is resolved with the above approach. Unique identification of road segments and nodes within a data structure will be a requirement of American National Standards Institute's (ANSI) transportation standard (FGDC, 2003).
2. Maintenance of a global schema is greatly simplified when a moderate level of schematic standardization is applied to the participant network. There is no longer a need to constantly monitor each participant's data for changes in schema design or capture conditions. With the present USGS approach, the technical data structure may stay the same, however the local data capture conditions may change. Without a communication mechanism to *The National Map*, such a change would go unnoticed. For example, a local government may decide to no longer map alleys, driveways, and unpaved roads due to local budgetary constraints. The database structure may remain the same but the maintenance procedures that dramatically affect content would change. Such procedural changes may be invisible to the USGS without a coordinating effort from the local data provider. This report recommends that minimal schematic design and capture conditions be adhered to by all participants, allowing for both a temporally and spatially consistent Road DB.
3. Inconsistent, unstandardized content may require customized and rapidly evolving integration procedures for various partners. Unless data is edge-matched in the road data bases, as recommended, integration procedures must be applied with each data update.
4. Partnership interoperability development will not be inhibited by the Road DB design. Whereas the heterogeneity of current systems, capture conditions, content quality may make it difficult to perform spatial or network analysis across partnership datasets. Existing software for TIGER and commercial datasets will be utilized with this suggested strategy, for instance. This effectively decreases the potential benefits of a national road data layer. With some level of standardization, however, applications developed by one municipality could be more easily marketed to other municipalities – considerably decreasing the total public cost of system development.
5. The proposed strategy establishes neither an overbound or underbound network organization (Golembieski, 2003 pers. com.). Without any standards being established at the participant level, massive confusion and inconsistent quality will characterize *The National Map* implementation. At the same time, it is recognized that too much top down control will increase the participatory cost of local governments, perpetuating redundant, public GIS development. The standards development process must recognize the diversity of local data management systems and refrain from mandating how to maintain spatial data. Rather, standards should be data focused, merely addressing basic schema design and minimum database content.

Conclusion

Paramount to *The National Map* implementation is an administration level recognition of the need for an overarching authority for consolidating the Nation's geospatial data. The vision of a national base map offered by the USGS merits the full attention of the geospatial community. However, the successful implementation of this national mapping program is beyond the control of the USGS. Procuring data, developing appropriate data maintenance strategies, and coordinating geographic information sharing partnerships encompasses more than twelve federal agencies (USGS, 2001), forty federal functions (NAPA, 1999), and countless state, local and private organizations. Further, *The National Map* vision is very closely related to other federal geospatial consolidation programs, such as Geo-Spatial One Stop. A viable long-term approach to *The National Map* development will require the direction of an objective, accountable, overarching body that will establish geospatial product requirements and develop a national geospatial consolidation plan.

Current project management structure in the research and development of *The National Map* is lacking within the USGS. Premature activity regarding system design and development is abound as *The National Map* vision has begun large implementation efforts prior to developing a sound implementation plan. A requirements assessment for *The National Map* stakeholders is far from complete and with no apparent beginning. Overall, there is a lack of adequate formal project structure within USGS for the roll-out of such a complex initiative. This is partially due to institutional inertia among the stakeholder community, a lack of congressional mandate for *The National Map*, and no clear interagency authority.

The long term issues of integration and interoperability must be addressed at the outset of *The National Map* development. With data requirements as a guide for implementation, an overarching authority must consider the costs and benefits of various alternatives to road data strategies. A heuristic integration complexity model is recommended to assist in the cost assessment of each strategy. The total estimated cost of each strategy should be weighed against the benefits of their respective results.

It is further suggested that a viable, long-term approach to *The National Map* road data includes the development of a distributed road database. Such a database would be maintained by a combination of local and national data contributors. Each contributor should be responsible for maintaining road data within its geographic jurisdiction while conforming to minimal standards that provide for national base data consistency. A phased approach to implementation is suggested, with resources focused solely on the development of a sustainable, long-term system.

The National Map can be implemented successfully with more thoughtful consideration of the broad geospatial community. Careful attention must be paid to public spatial data demands across governing levels, not merely among federal agencies. Its place within the NSDI must be clearly defined and managed at the appropriate executive level. If properly implemented, *The National Map* will serve The Nation well through more effective governance, higher data quality, and an unprecedented window to the world for the public.

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Biography

Bryan Weaver is a second year Masters of Science student in Geography at the University of Georgia. His thesis focus is on *The National Map* and he is attempting to estimate the relative difficulty of integrating data at various political scales. From May to August of 2003, Bryan was employed by the USGS via the University of Georgia. During this time, he researched geospatial data sharing programs and *The National Map* effort.

Prior to entering graduate school, Bryan worked for more than five years with Rand McNally & Co. He worked as a Cartographer, GIS Specialist and GIS Project Manager with the map making company. He graduated *summa cum laude* from Ohio University in 1996 with a Bachelor of Science degree, having majored in Environmental Geography and minored in Economics.

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