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White Paper on Issues and Strategies for Building a State Transportation Framework

Kenneth Dueker
Portland State University

Paul Bender
Portland State University

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Kenneth J. Dueker
Professor of Urban Studies and Planning
duekerk@pdx.edu

Paul Bender
Graduate Research Assistant
benderp@pdx.edu

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Center for Urban Studies
College of Urban and Public Affairs
Portland State University
Portland, OR 97207
http://www.upa.pdx.edu/CUS/

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State Transportation Framework

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Executive Summary

The purpose of this white paper is to systematically re-examine transportation data sharing issues that have been discussed at length, but in a manner to foster final decisions and closure. In some cases, choices among alternatives may require more detailed analysis or pilot studies. The development of this document has benefited from discussion at the Interorganizational Resource Information Coordinating Council (IRICC) Roads Committee, which has led to this consensus document. This sixth and final version serves to draw the process to a close and recommends a twofold approach to the development of a Transportation Framework. It also recommends six pilot studies to examine remaining issues in more detail.

This White Paper posits two purposes for the Transportation Framework. First, the Framework can be considered a set of coordinated map layers comprised of point, line, and area objects representing the location and extent of transportation features that is **complete, consistent, and current**. This part of the Transportation Framework provides a source of "best available" linework that would be updated periodically, probably on an annual basis. This representation would serve **planning business needs** for a limited range of transportation and non-transportation organization stakeholder applications. It may also support a limited number of **operations** type applications, such as pathfinding for rerouting and permitting. Individual users can assess it for fitness to their application. In many instances the Transportation Framework may need augmentation for specific applications. For example, many business needs, such as transportation planning, congestion management, etc., require at least a bi-directional centerline if not dual carriageways or even individual lanes, either in the basic geometry or by attribution. These needs may be too specific or time sensitive to include within general use data for which the Framework is responsible.

The second purpose of the Transportation Framework scope is to facilitate updates. This would entail a **Clearinghouse of new and modified road features** that is collected in the form of transactions. These transactions would be derived from construction projects undertaken by or on behalf of transportation organizations. They are then accumulated in the Clearinghouse and used to update the Transportation Framework's complete, consistent, and current representation of the transportation system. In addition, organizations that maintain their own transportation databases could select updates for transportation features deposited by all transportation organizations for their region of interest.

This twofold approach satisfies the need to facilitate updating the best available data, while at the same time making more detailed data available pertaining to new and modified transportation features. This will support those who need updates of more detailed content and greater spatial and temporal accuracy.

The business needs of GIS applications in the areas of natural resource management, infrastructure management, emergency management, and services management applications were assessed. We conclude that the Transportation Framework should focus on supporting **planning** functions initially, with very limited support for the needs of **operations**. In a longer timeframe, a more robust Transportation Framework, one having greater spatial and temporal accuracy and more detailed attribution, could support more management and operations functions. But initially the requirements and standards for the Transportation Framework are translated to spatial data set and GIS functional requirements that support planning functions. These requirements are both a consistent spatial and temporal accuracy across Framework layers, and a consistent representation of transportation within and across jurisdictions. The initial requirements and standards for the Transportation Framework to support planning functions require coordination and sharing of data resources that extend to other Framework layers and to other jurisdictions.

It is important that all Framework participants acknowledge that the Transportation Framework is not intended to be a replacement for their transportation databases, so it does not have to, nor should it, contain the detail or the robustness to satisfy all their applications. Yet their databases may be derived from the Transportation Framework and should be updated from transactions from the Clearinghouse of new or modified transportation features.

Those organizations that contribute data to the Transportation Framework are assured that other organizations have access to the most current and accurate inter-organizational data. Those organizations that access data from the Transportation Framework are likewise insured that they have access to the most current and accurate inter-organizationally planning data that is available. Similarly, within organizations, there is a need to share data to avoid the problems of stovepipe systems that duplicate basic data and lead to inconsistent representations with varying degrees of spatial and temporal accuracy.

The main objective is to reduce the number of redundant project-level databases that decay over time and substitute a Transportation Framework that is easy to access and can respond to varied planning-level business needs of the numerous organizations with pieces of the transportation puzzle. Consequently, the Transportation Framework fosters use of the best available data, and relies on data sharing mechanisms to maintain its currency.

A tension between simplicity and robustness resulted in the realization that a complete, consistent and current representation of roads is needed, but the Transportation Framework cannot meet all business needs for road data. Yet, the Framework should play a major role in collecting data concerning new or modified roads that will enable updating and improving the complete representation of roads.

This learning process led to the establishment of the following criteria and design principles for the Transportation Framework (Roads):

- Compile "best available" data from existing imagery and GIS resources to create a complete, consistent, and current roadway system. Attribute it minimally to support simple routing applications.

- Enable its gradual improvement in spatial accuracy and correspondence with other layers on an as-needed, ad-hoc basis by means of a check-out/check-in process for regions undergoing detailed study.
- Enable the addition of content detail and spatial accuracy from engineering CADD data and inventory databases. This necessitates that the Transportation Framework includes a roadway identification schema and linear referencing.
- Establish an explicit periodic updating process to keep the complete representation of the road system current.
- Capture data when roads are created or modified. Begin the capture of these data on a **day-forward** basis as *transactions* as the best means to update the complete representation of the road system.
- Create a **clearinghouse** of these transactions from which other road database users can query and select data to maintain and update their own organizations' data.
- Create incentives, mandates, guidance, and technical assistance to transportation organizations to foster the reporting of metadata relating to all of the activities outlined above.

Six pilot studies are identified to address outstanding issues:

1. Pilot Study 1 is being conducted by ODOT. They are building a complete Roads database in Wasco County to demonstrate the feasibility of conflating data.
2. Pilot Study 2 is proposed for a county in Washington State. Pilot Study 2 would test the feasibility of compiling a complete Roads database by a process of handoffs from one organization to another, each adding roads from their GIS database.
3. Pilot Study 3 is proposed for a group of counties in Washington State that do not have complete GIS data and would not be able to participate in a process as proposed in Pilot Study 2. Pilot Study 3 would contract with a roads database vendor to build and maintain the Transportation Framework (Roads).
4. Pilot Study 4 is proposed for a jurisdiction in Washington State interested in moving their Roads data to an enterprise-wide database. Pilot Study 4 would involve not only building a transaction updated Roads database, but would require extracting data in a consistent format from projects, permits, and work orders that build or modify roads and intersections.
5. Pilot Study 5 is proposed to test the Clearinghouse concept. Pilot Study 5 would build a web-based collection of data about new and modified Roads.
6. Pilot Study 6 is a test of withdrawing data from the Clearinghouse and updating Roads databases.

Three options are identified and described. These may be considered as functional "add-ons" to the basic, "best available" roads linework of a Framework that satisfies many GIS needs, including tight integration of the Transportation Framework (Roads) with other NSDI layers. There is great interest and need for integrating hydrography, cadastral, roads, railroads and bridge structures, including culverts, for salmon enhancement planning. In addition, this will include spatial accuracy improvements to the best available linework to support limited vehicle-tracking applications.

Three optional enhancements to the basic linework follow directly from the analysis and identification of business needs:

- Address ranges and street names. Address geocoding functionality is of great interest and importance to emergency dispatch agencies and to many other users of address geocoding.
- Linear Referencing Systems (LRS) to support adding attributes of roads for and infrastructure (IMS) management.
- Network representations of the roadway system to support routing applications, such as disaster and contingency planning. Overweight/oversize truck routing would require additional data of height, weight and turn restrictions.

The three options listed above can be prioritized for phased implementation and to identify stakeholders willing to pay for the enhancement**.** A rough estimate of cost for compiling the basic linework statewide is estimated to be $1,000,000 per state (Washington and Oregon). This estimate does not include administration or management of the compilation process. Nor does it include the time and cost of determining exactly what data should be used, setting up data sharing partnerships, and other aspects of incorporating the concerns of stakeholders. Each additional option is estimated to cost $250,000 per state. The add-on cost of additional enhancements should be the responsibility of stakeholders who would benefit. The White Paper concludes with this identification of options for stakeholders to consider in determining the desired robustness of the Transportation Framework and how to allocate costs.

Uncertainty and risk inhibits buy in by Framework stakeholders. Consequently, reducing uncertainty and risk is a primary challenge. Meeting this challenge with the goal of achieving stakeholder confidence and support will require agreement on:

- A clear articulation of stakeholder business needs and the corresponding Transportation Framework functionality.
- Feasible and achievable cost, time, and overall resource estimates.

Glossary of Acronyms

AHTD	Arkansas Highway and Transportation Department
ArcIMS	ESRI Arc Internet Mapping System
BLM	Bureau of Land Management
BMS	Bridge Management Systems
CADD	Computer Aided Drafting and Design
DLG	Digital Line Graph
DOT	Department of Transportation
DOQQ	Digital Orthophoto Quarter Quads
E911	Emergency Dispatch Organizations
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
FHWA	Federal Highway Administration
GASB	Government Accounting Standards Board Statement
GeoStor	Arkansas GeoSpatial Clearinghouse
GDT	Geographic Data Technology
GIS	Geographic Information Systems
GPS	Global Positioning Systems
IMS	Intermodal Management System
INSAR	Interferometric Synthetic Aperture Radar
IRICC	Interorganizational Resource Information Coordinating Council
ITS	Intelligent Transportation Systems
KDOT	Kansas Department of Transportation
LIDAR	Light Detection and Ranging
Mn/DOT	Minnesota Department of Transportation
NavTech	Navigation Technologies, Inc.
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NSDI	National Spatial Data Infrastructure
ODOT	Oregon Department of Transportation
PMS	Pavement Management Systems
PSRC	Puget Sound Regional Council
PWDs	Public Works Departments
REO	Regional Ecosystem Office
USFS	United States Forest Service
SDS	Spatial Data Standard
StratMap	Texas Strategic Mapping Program
TEA21	Transportation Equity Act for the 21st Century
UNETRANS	Unified Network Transportation
USGS	United States Geological Survey
PSRC	Puget Sound Regional Council
WISLR	Wisconsin Information System for Local Roads
WSDOT	Washington Department of Transportation

Introduction and Purpose

This white paper assesses alternative approaches and data sources for the development of a Transportation Framework for the state of Washington. The white paper includes the development of a scope of work for pilot projects that may be needed to explore and test options for building and maintaining a Transportation Framework.

The purpose of this white paper is to systematically re-examine transportation data sharing issues that have been discussed at length, and in a manner to foster final decisions and closure. In some cases, choices among alternatives may require more detailed analysis or pilot studies. The development of this document has benefited from discussion at the Interorganizational Resource Information Coordinating Council (IRICC) Roads Committee, which has led to a consensus document. This sixth and final version serves to draw the process to a close and recommends a twofold approach to the development of a Transportation Framework. It also recommends six pilot studies to examine remaining issues in more detail.

The development of this paper was guided in part by the Project Charter of the Transportation Framework, State of Washington. The Charter has these key objectives:

> *5.1. Identify and recruit partners to develop, maintain, and distribute the transportation Framework and Framework data that meets a set of business and analytical needs defined by the partners and users.*
> *5.2. Develop a transportation Framework data model and standards based on business and analytical needs for the data, technology available to implement the model, and the ability to provide and maintain the data over time.*
> *5.3. Define and implement institutional arrangements to facilitate data collection and maintenance partnerships, and to make the data accessible at the least cost with the least restrictions on use.*
> *5.4. Implement interactive platform independent software, database, and processes to support integration of data received from data providers, maintenance of data by data stewards, and data accessibility by partners and the general public.*

This paper is supportive primarily of Objectives 5.1 and 5.2, with attention given to approaches to fulfill objectives 5.3 and 5.4. In addition, the Charter identifies critical success factors. This white paper seeks to achieve the commonality called for in factor 8.4:

> *8.4. Define a data model that partners agree meets their needs.*
> *Identify business needs and functional requirements, and define the data needed to support them. Examine existing data models. Seek consensus agreement on the data model. Partners commit to achieving consensus. Provide frequent and on-going communication of progress and decisions to partner organizations.*

The Scope of the Transportation Framework

It is anticipated that the Transportation Framework will have two purposes. First, the Framework can be considered a set of coordinated map layers comprising point, line, and area objects representing the location and extent of transportation features that are **complete, consistent, and current**. This part of the Transportation Framework provides a source of "best available" linework and attribute data that would be updated periodically, probably on an annual basis. This representation would serve ***business needs*** of a **planning** type for a limited range of transportation and non-transportation organization stakeholder applications. It may also support a limited number of **operations** type applications, such as pathfinding for rerouting and permitting. Individual users can assess it for fitness to their application. In many instances the Transportation Framework may need augmentation for specific applications. For example, many business needs, such as transportation planning, congestion management, etc., require at least a bi-directional centerline if not dual carriageways or even individual lanes, either in the basic geometry or by attribution. These needs may be too specific or time sensitive to include within general use data for which the Framework is responsible.

The second purpose of the Transportation Framework scope is to facilitate updates. This would entail a **Clearinghouse of new or modified road features** that is collected in the form of transactions. These transactions would be derived from construction projects undertaken by or on behalf of transportation organizations. They are then accumulated in the Clearinghouse, and used to update the Transportation Framework's complete, consistent, and current representation of the transportation system. In addition, organizations that maintain their own transportation databases could select updates for transportation features deposited by all transportation organizations for their region of interest.

This twofold approach satisfies the need to facilitate updating the best available data, while at the same time making more detailed data available pertaining to new and modified transportation features. This will support those who need updates of more detailed content and greater spatial and temporal accuracy.

The challenge to this twofold approach is to create incentives and/or mandates to report new and modified transportation feature data to the Clearinghouse on a transactional basis. In part this can be done by providing guidance on the proper form of formatting and reporting of these changes.

State Framework Review

This section reviews other efforts at creating state Transportation Frameworks, some of which are also aimed at adopting and/or testing the Federal Geographic Data Committee (FGDC) transportation identification standard (FGDC, 2000). Two approaches are noted. The first represents state Departments of Transportation (DOTs) which build statewide Geographic Information Systems (GIS) databases of all roads for internal reasons. These can be seen as indirect attempts to create a statewide Transportation Framework. The second approach is to build a comprehensive Transportation Layer within the context of a statewide FGDC-inspired Framework. Both of these efforts are reviewed here.

Several states have embarked on developing statewide GIS databases of all roads. The following summarizes some key points from three states: Minnesota, Wisconsin, and Arizona. These states are leading the way because of their early start in tackling the work. They are starting from existing mainframe highway inventory and mapping applications, while enhancing and converting to a GIS application.

Arizona DOT completed a road centerline map database in 1975. The Centerline update project is largely a bulk integration of highway data, county by county. The update process consists of conflating data from various sources and the addition of linear referencing and addresses. A transactional updating system that will rely on segment IDs that are being assigned is envisioned after completion of the project. The Wisconsin Information System for Local Roads (WISLR) is a redesign of a 25-year-old local roads database used for roadway inventory and payment of general transportation aids to local governments. Limitations of the prior system are being addressed in the redesign and linear referencing is being added. The emphasis is focused on rebuilding the database, and its maintenance still needs to be addressed systematically. Minnesota DOT has embarked on a system development to build a digital unified base map of all roads in Minnesota. The Minnesota DOT effort replaces the existing 30-year-old mainframe system and it includes railroads, navigable waterways, and airports as well as highways. Again, there does not appear to have been much attention to update and maintenance issues and concerns. The Wisconsin and Minnesota efforts are both quite expensive upgrades of mainframe files to GIS applications to support state aid to local road programs.

Texas is developing the Texas Strategic Mapping Program (StratMap) to compile what it terms "mission-critical" GIS Framework data, including transportation, for the entire state. An integral part of the StratMap objective is the "open exchange of information between agencies, open access to non-sensitive government information, and private sector value-added opportunities." Phase 1, the compilation of the initial transportation Framework by vehicle Global Positioning Systems (GPS), was completed in August 2001. Data are being compiled using an object-oriented model, meeting FGDC standards for road identification. The next phase will include "maintenance, production, and enhancement of those data layers… transportation and boundaries will be maintained with current data as it becomes available." The Framework is currently available as an 11-county subset on CD-ROM.

Both Vermont and Montana have made significant progress in testing Framework implementation using FGDC schema for identification. Vermont has recently completed its pilot project. Montana began a similar FGDC Framework review pilot titled "A Collaborative Multi-jurisdictional Approach to Building a Geospatial Ground Transportation Framework Database for Montana."

The Intergraph Corporation conducted a study for the Kansas Department of Transportation (KDOT),"NSDI Transportation Data Model Impacts," completed in

April 2000. This was not an attempt to test or build a Framework, but a test of making the KDOT transportation database compliant with the FGDC model and metadata standards.

A larger number of states now maintain statewide GIS clearinghouses as nodes of the National Spatial Data Infrastructure (NSDI) National Geospatial Data Clearinghouse. These include Alabama, Alaska, Georgia, Iowa and Nebraska.

Arkansas has successfully created GeoStor, "an on-line data delivery system that allows the user seamless access to digital map data (GeoData) of any area in Arkansas with no subscription fee." Efforts are being made to link the GeoStor project with a state Transportation Framework in cooperation with Arkansas Highway and Transportation Department (AHTD). AHTD has begun its own Framework equivalent project, the Arkansas Centerline File project. Information will be captured utilizing GPS techniques, digitizing from second generation Digital Orthophoto Quarter-Quads (DOQQ), and/or warping and attributing AHTD centerline files to match the second generation DOQQs.

Georgia has set out to compile a Transportation Framework to use in constructing the "Georgia Spatial Data Infrastructure" state equivalent of the NSDI. The Framework website reports that the transportation database is complete and accessible, but provides no other documentation.

Kentucky has recently adopted an enterprise architecture perspective and has developed its own spatial data standard, an integrated model of multi-thematic data content standards. The spatial data standard represents an implementation of the Federal Geographic Data Committee geospatial data content standards and meets data sharing requirements of the NSDI. Beyond this, Kentucky DOT is creating a complete street Centerline file using GPS.

Utah has made an effort to develop the Utah Framework Implementation Plan, based on the seven FGDC NSDI Framework layers. The transportation Framework effort is adhering to the FGDC standards and data model. Utah is also involved in a transportation pilot study testing the USGS National Map. The only other transportation pilot study is the Washington-Idaho National Map pilot, which includes Spokane and Pend Oreille counties in Washington, and Kootenai and Bonner counties in Idaho.

The Washington-Idaho National Map pilot will explicitly attempt to build up the Framework map from as many local sources (city, county, state and Forest Service) as possible. Any gaps in available data will be filled in with data purchased from a vendor, GDT. Datasharing partnership agreements and incentives to participate are seen as key organizational elements to be tested. An ArcIMS NSDI clearinghouse node is being considered as the data server for the pilot.

In summary, these state efforts provide guidance on the initial building of a comprehensive and complete statewide transportation layer. They are very expensive to build, but in spite of this, little attention as of yet has been given to complex and costly issues of updating. The second approach, that of attempting to test compiling data from numerous sources following the FGDC Road Identification schema, is moving ahead more slowly, as state GICs work to tackle both technical and organizational issues that so far have hampered Framework construction. From this review we can not yet deem either approach as being successful in meeting objectives.

In addition to the state framework efforts, the U.S. Bureau of the Census MAF/TIGER Modernization Study (Booz, Allen and Hamilton, 2000) proposes a system to update and maintain TIGER, an important source of data for many street and road centerline databases. An objective of the 21st Century MAF/TIGER Enhancements initiative is to correctly locate every street and other map feature in the TIGER, each MAF (Master Address File) address, and implement an effective automated feature change detection methodology. This program will provide a highly accurate and up-to-date resource that will be available to support other core activities that rely on address list information.

Business Needs

Business needs of users of transportation data are examined to determine the content, structure, and spatial and attribute accuracy requirements for the Transportation Framework. The challenge is to determine how many and which needs to accommodate in a single representation of the transportation system. Building a robust multi-purpose representation would be costly and difficult and would demand frequent updates. On the other hand, a simpler representation might not serve enough needs to be justifiable.

The purpose of this assessment of business needs is to determine the content and accuracy requirements of the Transportation Framework. Assuming a common representation cannot meet all business needs, the Transportation Framework needs to include a mechanism to aid and foster updates or data sharing among those who maintain their own transportation databases.

All organizations that have GIS-T applications do so in support of some combination of **planning, management, and operations** needs. Generally, the business needs of planning can usually be met with spatial data of low or medium spatial and temporal accuracy. Another generalization is that the business needs of non-transportation organizations require less accurate spatial and temporal transportation data than do transportation organizations. These conclusions follow from an assessment of the business needs and applications discussed below.

Although the business needs supported by the Transportation Framework should be limited to requirements that are inter-organizational in nature, intra-organizational data sharing may be a stronger motivation than inter-organizational data sharing objectives. Many organizations have internal stovepipe systems that could benefit from better sharing of data. Improving data sharing within the organization would thereby foster inter-organizational data sharing capacity.

A preliminary examination of business needs within WSDOT exemplifies opportunities for data sharing within and outside of the Transportation Framework. The business needs of WSDOT fall in the following categories:

- The need to relate state roadway data to other layers, such as land ownership, local roads, wetlands, streams, land use and land cover, utilities, and sensitive environmental and cultural areas.
- The need for a detailed inventory of infrastructure on state roads.
- The need for a complete GIS representation of all roads in the state in a form to support routing that includes functional and jurisdictional classification, surface type, status, and height, weight, and turn restrictions.

Meeting these internal business needs requires sharing of data within WSDOT and externally with others. Achieving the internal data sharing will make the external data sharing easier and more effective. WSDOT will need to address which business needs can be derived from Framework data, and which will need more detailed content or more frequent updates than can be provided by the Framework, and thereby maintained outside of the Framework.

WSDOT should be able to take advantage of the Framework in satisfying its business needs. They need to relate transportation layers to other Framework layers. They need a comprehensive GIS-based infrastructure inventory system as well as a complete, consistent, and current representation of roads suitable for routing applications.

The requirements of several statewide or regional applications for transportation data are examined to identify common transportation data elements and spatial and temporal requirements to include in the Transportation Framework. These applications are emergency management, infrastructure management, freight mobility, and salmon enhancement. All four are illustrative of the growing and diverse applications of transportation data.

Emergency Management Business Needs

Emergency Management is subdivided into *disaster planning* and *emergency response*. Disaster planning is an important form of contingency planning that deals with evacuation routing and rerouting around closed facilities. Contingency planning does not require a high level of spatial and temporal accuracy. On the other hand, emergency response has a higher need for current data and has a higher need for spatial accuracy to snap GPS-derived positions to the correct piece of road. For emergency response, temporal accuracy is the highest requirement. The most recent streets and corresponding addresses are required for proper emergency call address matching and routing. Spatial accuracy is required for disaster planning, due to the need to assess road and bridge impacts from floods, fires, and earthquakes. The temporal accuracy requirements for contingency planning are low.

Disaster planning makes increasing use of GIS as a means of quickly integrating and sharing data among agencies. Road centerline files help determine evacuation routes and answer spatial questions or queries, such as: What roads are subject to flooding? Which routes are already designated emergency routes (for plowing, etc)? What are evacuation times of main/alternative routes? Where are bridges (possibly impassable) located? What roads are affected by disaster? Are they totally impassable? What alternative routes are available?

This distinction between business needs of planning and operations is crucial. For example, disaster planning is a planning business need of emergency management, while emergency response is an operational business need, and there are distinct differences in their spatial and temporal accuracy requirements. A common Transportation Framework would serve the needs of disaster planning, but the needs of emergency response would require more currency, or temporal accuracy than can be supported by the Transportation Framework.

Homeland security has become a major issue in the arena of emergency management. Homeland security encompasses both disaster planning and emergency response in the event of a disaster or emergency. The emergency response component of homeland security would in all likelihood require a specialized database, to handle specific operational needs of homeland security. The representation in the Transportation Framework used for contingency planning would be a good starting point.

Infrastructure Management Business Needs

The business needs of infrastructure management are complex. Infrastructure management is an organizing concept that pertains to organizations responsible for planning, construction, maintenance, and operation of infrastructure, such as departments of transportation and public works. They tend to require significant levels of inter-organizational coordination, and are thereby candidates for data sharing via the Transportation Framework.

The lifecycle management concept used in infrastructure management consists of the functions of planning, construction, maintenance, and operations. These categories are useful in assessing spatial and temporal accuracy requirements. These can be used to address many applications that fall under the heading of infrastructure management. These are examined in detail: new Government Accounting Standards Board Statement (GASB) 34 reporting requirements for asset management, road pricing, and freight mobility.

Asset Management/GASB 34. The recently released GASB 34 requirements reiterate and reinforce the business needs requirements of asset data management. A good working definition comes from the FHWA Asset Management primer: "Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making" (FHWA, 1999). Properly designed and implemented asset management systems can bridge the stovepipe problem of current individual bridge management systems (BMS) and pavement management systems (PMS). This in turn inhibits the sharing of data that the Transportation Framework, and this paper, is attempting to help address.

Underlying the business needs of Asset Management is the "economic assessment of trade-offs between alternative improvements and investment strategies from the ***network-or system-level*** perspective" (FHWA, 1999). Some of the basic business needs identified by the FHWA include: inventory of assets (physical and human resources); valuation of assets; quantitative condition and performance measures; and performance-prediction capabilities. An effective Asset Management system, making use of the Framework, has the potential to strengthen the now-tenuous link between the transportation plan and actual programming and resource allocation decisions.

GASB 34 allows government agencies to get around the depreciation requirement for infrastructure assets if these assets are managed using an asset management system, and if the infrastructure is being preserved at or above a predetermined condition level. According to GASB 34, the asset management system should:

- Have an up-to-date inventory of assets;
- Perform condition assessment of the infrastructure assets at least once every 3 years, and summarize the results using a measurement scale; and
- Estimate the annual amount required to maintain and preserve the infrastructure assets at the condition level originally established for those assets (FHWA 1999).

Asset Management requires an inventory-based GIS where assets are referenced linearly to the transportation system. The detail of assets is beyond the scope of what should be included in the Transportation Framework, but the underlying geometry of the transportation system should come from the Transportation Framework.

Road Pricing. The financing of highways is expected to move from a gas tax-based system to a mileage-based system. A mileage-based system could be extended to differentiate charges by road segment and time of day. However, differential charges by location and time of day would require vehicle-tracking systems that link to digital road map databases that provide segment charge rates. Spatial accuracy sufficient to snap to the correct segment and temporal accuracy to reflect all roads in use would be needed.

The spatial accuracy issue is confounded by two considerations. One is that tracking depends on following a sequence of positions. When one or more GPS data points are wrong due to errors in positioning from passing under overpasses or past high-rise buildings that interrupt signals from satellites, the vehicle appears to leap off one road onto another and back again. Tests of relative distance are needed to determine if a point is too far away from the last position to be possible. The second problem is that the spatial accuracy requirement is dependent on the geography of the road network. In areas of greater density, with roads close together and many intersections, much greater accuracy is needed to place a vehicle on the correct segment. This is a particular problem on important segments such as freeways due to the proximity of frontage roads, ramps, and over- and under-passing streets. Consequently, transponder reader instrumentation of selected facilities, such as major highways where differential charges are imposed, may be preferable to sole reliance on vehicle tracking.

If the above-mentioned problems associated with vehicle tracking are solved, the Transportation Framework, with sufficient spatial and temporal accuracy, could provide the basis for the digital road map database for highway finance systems of the future. In addition, if the Transportation Framework includes attribution of jurisdictional responsibility, the mileage summaries by jurisdiction can be produced.

Freight mobility. Freight mobility has emerged under TEA-21 as a major transportation planning requirement. Safe and speedy transfer and transport of goods is vital to the port-based economies of the Pacific Northwest. Freight is increasingly facing delays as urban roadway congestion increases. Business need attributes include: congestion levels, roadway condition, low clearances, bridge weight restrictions, and lane restrictions. These may require more detail than road centerlines will permit.

The freight sector faces three broad areas of improvement with respect to business needs (Paulson, 2001): institutional development, including developing multi-jurisdictional freight institutional approaches; leveraging information technology to optimize system performance; and infrastructure investment.

A "last mile" syndrome also increasingly hampers freight mobility. Short intermodal connectors that link the National Highway System (NHS) to major intermodal transfer facilities represent this last mile. These predominantly local urban streets are hampered by pavement deficiencies twice the average of other non-NHS roads (Paulson, 2001). Modeling both freight and passenger travel requires these road segments.

An assessment of freight mobility indicates that planning business needs could be accommodated by low- or medium-accuracy spatial and temporal data, but would require augmentation with more attribute accuracy (clearances and restrictions) than would likely be part of a common Transportation Framework. The overweight and oversize permitting (operations) process would likely require more temporal accuracy than would be provided in a common Transportation Framework in terms of restrictions associated with construction or weather. Nevertheless, if a state DOT were to host the Transportation Framework, enhancement and support for overweight and oversized permitting may be desired.

Salmon enhancement Business Needs

Salmon enhancement planning has become one of the pivotal social, economic and environmental issues for the Pacific Northwest region. For the ODOT Salmon Recovery Initiative, ODOT has completed a culvert inventory over two years. Each culvert has been categorized by whether or not it meets fish-passage requirements.

For salmon-enhancement planning the IRICC Roads committee has developed a roads database design in the process of identifying the roads spatial data set business requirements for inclusion in the Regional Ecosystem Office (REO) regional Framework clearinghouse for spatial data set management and coordination. This database design is included in Appendix A. The salmon enhancement planning business requirements include ecosystem assessments that specify road and hydro relations to determine locations and types of bridges and culverts, cuts and fills near streams, and that identify road construction projects that produce sediment to the hydro system. Very high positional or spatial accuracy is needed to properly locate and align the road and hydro layers.

The planning business needs of salmon enhancement can be accommodated by medium accuracy temporal data, but will require a level of spatial accuracy that is consistent with hydro data. Salmon enhancement planning will also require the integration of road and bridge attribute data from a number of transportation organizations.

Table 1 displays the applications discussed above and identifies the spatial and temporal accuracy requirements in general: low, medium and high.

Table 1
Framework Business Needs

Emergency Management

	Planning	***Management***	***Operations***
Business Need	Disaster Planning	Response Coordination & Reporting (C & R)	Emergency Dispatch
Spatial Accuracy	Medium	Low	Med/High House/Highway
Temporal Accuracy	Low	Low	High
Data Model	Boundary, Bi-Directional Flow Network	Thematic Map	Bi-Directional Flow Network
Attributes	Bridge Height & Weight Restrictions	Functional and Jurisdiction Classes	Street Address Ranges

Infrastructure Management

	Planning	***Construction***	***Maintenance***	***Operation***
Business Need	Planning Asset Mgmt (GASB)		Emergency Dispatch	Road Pricing
Spatial Accuracy*	Medium	High (engineering)	Med/High House/Highway	Med/High (Veh on ramp)
Temporal	Low	Medium	High	Medium

Accuracy*				
Data Model	Boundary, Flow Network	Engineering Maps	Flow Network	Flow Network
Attributes	Bridge Height & Weight Restrictions	Owner/Contact for transportation segment	Street Address Ranges on Hwys.	Road Closure; Impedance
File Maintenance	Adding Planned, Retiring Status	Add New Features	Change Attributes	Update Road Closure; Impedances

*See Table 2 for definitions of Low, Medium, and High

Freight Mobility

	Planning	***Management***	***Operations***
Business Need	Intermodal Connections	Intermodal Mgmt System (IMS); C & R	Congestion monitoring; Routing
Spatial Accuracy	Low	Low	Medium
Temporal Accuracy	Medium	Medium	High
Data Model	Flow Network; Multimodal O/Destination	Thematic Map	Flow Network
Attributes	Link, Depot Capacity	Flows and Terminal Activity	Clearances and Restrictions
File Maintenance			

Salmon Enhancement/Fish Passage

	Planning	***Management***	***Operations***
Business Need	Ecosystem Assessments	Interagency coordination	Culvert Replacement
Spatial Accuracy	High	Medium	High
Temporal Accuracy	Low	Low	Low
Data Model	Flow Network;	Thematic Map	Flow Network
Attributes	Bridge/Culvert type	Bridge/Culvert type	Bridge/Culvert type
File Maintenance			

NCHRP Functional Requirements

The functional requirements identified in the National Cooperative Highway Research Program (NCHRP) 20-27(3) project on GIS data models for transportation were also examined. These are the most demanding transportation requirements.

The NCHRP 20-27(3) project is concerned with Intelligent Transportation Systems (ITS) functional requirement needs. Basic ITS requirements include vehicle dispatch, traffic information and management, incident management, and transit fleet management. Functional requirements include spatial/temporal referencing methods and a referencing system/datum. The method would include the use of four-dimensional time-space, and the system itself would need to accommodate a *temporal* datum.

Examination of the NCHRP functional requirements did not prove too helpful as the focus was on temporal issues that are more important to ITS applications than to the first-generation Transportation Framework. The ITS applications have temporal requirements that are beyond those required by most of the agencies involved in constructing the Transportation Framework. It is expected that the temporal requirements for most of these common applications of Transportation Framework data will be less demanding than advanced transportation applications, such as ITS. This exemplifies that update frequency differs among applications, as do spatial accuracy requirements. Consequently, the important issue is to determine the common needs of state Framework stakeholders for transportation data, in terms of data model, attributes, spatial accuracy and update frequency.

The initial Transportation Framework may support only a subset of the identified business needs. Time and cost constraints may preclude building the most robust Transportation Framework. Similarly, timelines to upgrade legacy data files to more recent versions of software and data models, such as ArcGIS and ESRI's object-oriented data model for transportation, UNETRANS, is thought by many as the opportunity to reorganize their transportation data. In the meantime, there may be reason to focus on the implementation of a less robust Transportation Framework. However, ArcGIS and UNETRANS are not providing a clear and unambiguous migration path. For backward compatibility reasons, ArcGIS is still a geometry-centric solution and additional tools are needed to support development of logical systems with multiple cartographic and network representations.

Spatial and Temporal Accuracy

The Transportation Framework must be consistent in spatial and temporal accuracy with other statewide Framework data and FGDC layers (Administrative Boundaries, Hydrography, Cadastral, Ortho imagery, Elevation, and Geodetic Control).

Spatial Accuracy: Spatial Accuracy needs will vary, according to business needs. Although it is desirable to find the least amount of accuracy necessary to the Framework, a flexible model that accepts (and maintains metadata for) ***data of varying accuracy is desired***.

Temporal accuracy and currency: Temporal accuracy in the context of the Transportation Framework deals with the frequency and method of update. Table 2 provides a first approximation of accuracy requirements for the Transportation Framework that takes into consideration consistency with other Framework layers. Differing requirements in urban and rural areas is also recognized in Table 2.

Table 2
Accuracy Requirements

Type of Region	*Metropolitan*			*Non-Metropolitan*		
Accuracy Level	*High*	*Medium*	*Low*	*High*	*Medium*	*Low*
Source Scale	1:1000	1:10,000	1:24,000	1:5000	1:24,000	1:100,000
Positional Accuracy (ft)	1 -5'	20'	40'	10'	40'	100'
Temporal Accuracy (update frequency)	less than 1 minute	1 - 7 days	3 months	1 - 5 minutes	2 -14 days	12 months
Linear Accuracy (ft)	1'	5 - 10'	50'	5 - 10'	50'	250'
Attribute Detail (# of attributes per segment)	100+	10 - 100	1 - 10	100+	10 - 100	1 - 10

Table 3 identifies the source material and the range of spatial accuracy that constitute low, medium, and high spatial accuracy.

Table 3
Spatial Accuracy Requirements Classifications

	Spatial Accuracy	
Classification	*Range of Spatial Accuracy*	*Source Material*
Low	1:24,000-1:100,000	Spatial Imagery USGS
Medium	1:10,000-1:24,000	USGS; High resolution imagery; GPS
High	1:1000- 1:5000	Engineering maps, High resolution imagery, GPS

Conclusions from the Assessment of Business Needs

The business needs of GIS applications in the areas of natural resource management, infrastructure management, emergency management, and services management applications were assessed. We conclude that the Transportation Framework should focus on supporting **planning** functions initially, with very limited support for the needs of **operations**. In a longer timeframe, a more robust Transportation Framework, one having greater spatial and temporal accuracy and more detailed attribution, could support more management and operations functions. But initially the requirements and standards for the Transportation Framework are translated to spatial data set and GIS functional requirements that support planning functions. These requirements are both a consistent spatial and temporal accuracy across Framework layers, and a consistent representation of transportation across organizations. The initial requirements for the Transportation Framework relate to other Framework layers and to other organizations. The requirement of consistency with other statewide Framework layers (Administrative Boundaries, Hydrography, Cadastral, Ortho imagery, Elevation, and Geodetic Control) includes:

- Administrative boundaries that fall on streets should align with the Transportation Framework's representation of those streets.
- Hydrography and Transportation should relate correctly, i.e. the stream on the correct side of the road and the steam crossings at the correct river and road milepoints.
- Centerline representations of transportation features should fall within rights-of-way of Cadastral layers.
- Centerline representations of transportation features should relate correctly to Ortho imagery.
- The elevation attributes of transportation features should be consistent with the Elevation layer and topographic maps generated from it.
- The temporal currency of transportation features should be as or more current than the other FGDC layers.
- The Transportation Framework should support routing applications for contingency planning.

The requirement of a consistent representation of the Transportation Layer across organizations requires that organizations agree on fundamental elements of transportation in order to exchange data. This consists of the following:

- Criteria for segmenting and identifying roads, i.e. the need to define a transportation feature to facilitate inclusion, identification and exchange of data.
- Consensus on treating transportation features and their intersections as logical objects that can be represented at larger scales as divided roadways with details of ramps and lanes.
- Consensus on some minimum level of network topology and link and node attribution of restrictions for simple routing.
- Consensus on the frequency of updating the Transportation Framework.
- Consensus on methods of identifying additions, changes, and deletions of transportation features and sharing updates.
- Consensus on the linear referencing methods to locate attributes along transportation features.
- Consensus on selected attributes of transportation features that are needed by most organizations.

It is important that all Framework participants acknowledge that the Transportation Framework is not intended to be a replacement for their transportation databases, so it does not have to, nor should it, contain the detail or the robustness to satisfy all their applications. Yet their databases may be derived from the Transportation Framework and should be updated from transactions from the Clearinghouse of new or modified transportation features.

The Transportation Framework intends to provide a **single** and **consistent** representation of the transportation system that is both **complete** and **current**. **Single** means a common definition of features in the Transportation Framework and a core set of attributes about the features. **Consistent** means a known level of spatial and temporal accuracy with proven updating mechanisms. The result is consistency in spatial representation and temporal currency. Organizations who share data via the Transportation Framework help assure consistency of representation and accuracy.

Those organizations that contribute data to the Transportation Framework are assured that other organizations have access to the most current and accurate inter-organizational data. Those organizations that access data from the Transportation Framework are likewise assured that they have access to the most current and accurate inter-organizationally planning data that is available. Similarly, within organizations, there is a need to share data to avoid the problems of stovepipe systems that duplicate basic data and lead to inconsistent representations with varying degrees of spatial and temporal accuracy.

The main objective is to reduce the number of redundant project-level databases that decay over time and quickly lose value. This is accomplished by substituting a Transportation Framework that is easy to access and is responsive to the varied planning-level business needs of the numerous organizations with pieces of the transportation puzzle. Consequently, the Transportation Framework fosters use of the best available data, and relies on data sharing mechanisms to maintain its currency.

A Transportation Framework incorporating all modes may be difficult to compile. Existing statewide digital representations of rail, pipeline, waterway, airports, and public transportation systems are likely to exist at small scales only (1:24,000 or 1:100,000), that would not spatially register with the more detailed roads layer. They would have to be horizontally integrated, and the lack of temporal consistency would create a new problem. Consequently, creating a ***separate roads layer*** is the advisable direction, while developing separate layers for other-modes at a smaller scale. The ***other-modes layers*** would include the systems mentioned above: rail, pipeline, waterway, airports and public transportation systems**.** Separate modal layers will require modal transfer points on each to relate them. This is an interim solution before attempting development of an integrated all-modes Transportation Framework that would be spatially and temporally consistent.

Treating the ***other-modes*** as separate layers relieves the Transportation Framework of being held initially to an overly high or robust standard.. These other layers would conceivably handle most anticipated routine applications. One application that may not be handled well, however, would be salmon enhancement, in which case recompilation may be needed to handle rail and water intersections in salmon enhancement study areas. Consequently, it may be desirable to integrate roads and rail modes at the outset to handle rail-crossing applications and to ensure correct topology and spatial registration.

We are unable to conclude which is the preferred method of compiling the complete, consistent and current representation of the Transportation Framework (Roads)[1]. Three pilot studies are proposed to assess the different methods of compiling the Transportation Framework (Roads). One way is to have a single contractor or agency compile it. Another way is have each transportation organization add and fit their data. The third way is to hire a road database vendor to abstract or enhance their product to meet Transportation Framework requirements, and to maintain it.

Regardless of which approach is chosen (commercial or primary sources) the road vector data will need to be displayed on digital orthophoto imagery for validation. Validating means a comparison of the road vector data to the image for completeness (exists in both) and spatial registration (moving the vector data to match the orthophoto image, or "ground truth"). This should be done preferably at 1:12,000 scale, using the most recent ortho-rectified imagery available. The increasing availability of high-resolution, remotely sensed topography using Light Detection and Ranging (LIDAR) and/or INSAR technologies is also useful (see www.pugetsoundlidar.org for examples).

Rationale for Transportation Framework (Roads)

The process for deciding on the structure, content, and detail of the Transportation Framework has been long and arduous. There has been constant tension between keeping the Framework basic or making it more robust. The argument for simplicity is driven by natural resource applications that merely need "best available" linework for roads to serve as reference data. Yet, when the business needs of user organizations are examined more closely, they often need more robust, intelligent road data to handle routing questions, road ownership or responsibility, surface type, status (planned, under construction, open/closed, retired), bridge/culvert structures, etc. Incorporating these attributes into the roads database increases the importance of updating the data. Consequently, it is difficult to keep the Framework basic.

Meeting the more demanding business needs of transportation organizations (agencies that own and maintain roads, such as departments of transportation, public works, and U.S. Forest service and timber companies) requires even more data. The routing of overweight/oversize vehicles requires weight/height restrictions, and road maintenance requires a detailed inventory of roadway infrastructure.

This tension between simplicity and robustness resulted in the realization that a complete, consistent and current representation of roads is needed, but the Transportation Framework cannot meet all business needs for road data. Yet, the Framework should play a major role in collecting data concerning new or modified roads that will enable updating and improving the complete representation of roads. This led to the notion of a clearinghouse for data on new and modified roads that would serve to update and improve the "best available" data on roads, and to serve as a resource to others who maintain their own roads database.

[1] The remainder of the report addresses Roads only.

This learning process led to the establishment of the following criteria and design principles for the Transportation Framework (Roads):

- Compile "best available" data from existing imagery and GIS resources to create a complete, consistent, and current roadway system. Attribute it minimally to support simple routing applications.
- Enable its gradual improvement in spatial accuracy and correspondence with other layers on an as-needed, ad-hoc basis by means of a check-out/check-in process for regions undergoing detailed study.
- Enable the addition of content detail and spatial accuracy from engineering CADD data and inventory databases. This requires that the Transportation Framework includes a roadway identification schema and linear referencing.
- Establish an explicit periodic updating process to keep the complete representation of the road system current.
- Capture data when roads are created or modified. Begin the capture of these data on a **day-forward** basis as **transactions** as the best means to update the complete representation of the road system.
- Create a **clearinghouse** of these transactions from which other road database users can query and select data to maintain and update their own organizations' data.
- Create incentives, mandates, guidance, and technical assistance to transportation organizations to foster the reporting of metadata relating to all of the activities outlined above.

The Transportation Framework Concept

Figure 1 is an illustration of the component parts of the Transportation Framework (Roads) and its inputs and outputs. There are two major components of the Transportation Framework (Roads). The first, labeled A, is a complete, consistent, and current representation of Roads, and the second, labeled B, is a Clearinghouse of new or changed Roads. The diagram illustrates the compiling or building from GIS source material to create the initial Roads database. After this initial build process, the database would be updated periodically from the data collected in the interim by the Clearinghouse of new transportation features. In addition, there would be checkout procedures for more extensive and complete upgrading for selected regions as warranted. This complete representation of the Road system would be of use for GIS analysis by organizations who wish to use road data, but who do not want to maintain a roads database. On the other hand, there are organizations that need to maintain one or more roads databases for their region of interest, but who find it difficult to obtain current data from other organizations that are responsible for maintaining roads within the same region. After implementation of this Transportation Framework concept, these organizations would query the Clearinghouse for jurisdictions within their region of interest, for Transportation Feature types of interest, and for a time period of interest. This more direct way of obtaining data on roads that are new or have undergone change would increase efficiency and effectiveness.

Because consensus must first be reached on assigning identifiers (NSDI framework transportation identification standard (FGDC, 1999)), updating of the "A" or "best available" data will at first occur using the industry-standard "shapefile" format developed by ESRI. This is a widely used and exchanged format across multiple GIS platforms, and hence will facilitate the initial periods of updating. These files are routinely exported and can be exchanged over the Internet as zipped files and fairly easily opened and integrated using standard GIS tools. This is meant as an interim measure awaiting the adoption of identifiers and transaction updating methods. This will meet the need for "simplicity" and ease in the initial maintenance of the Framework and the use of a Clearinghouse. (See Dueker and Butler, 2000 for a discussion of issues of definition and identification of transportation features). Also, Figure 1 illustrates an evolutionary process that starts with a project (PJ) that utilizes the Transportation Framework (A) and then evolves to a separate roads database to support an on-going operational program (PG) whose database needs more frequent updating. This program roads database then draws updates from the Clearinghouse (B). Alternatively, improved project database could be used in a check-out/check-in process to upgrade the Transportation Framework (Roads). This is represented by the arrow from PJ to the Check-out/Check-in Upgrade box in Figure 1. The diagram shows how transportation organizations input to the Clearinghouse for data about new or modified roads for which they are responsible. At the same time they are users of the Clearinghouse for data about new or modified roads that are maintained by others within their region of interest. Figure 2 illustrates this exchange of data among transportation organizations more clearly.

Figure 1. Building and Maintaining the Transportation Framework (Roads)

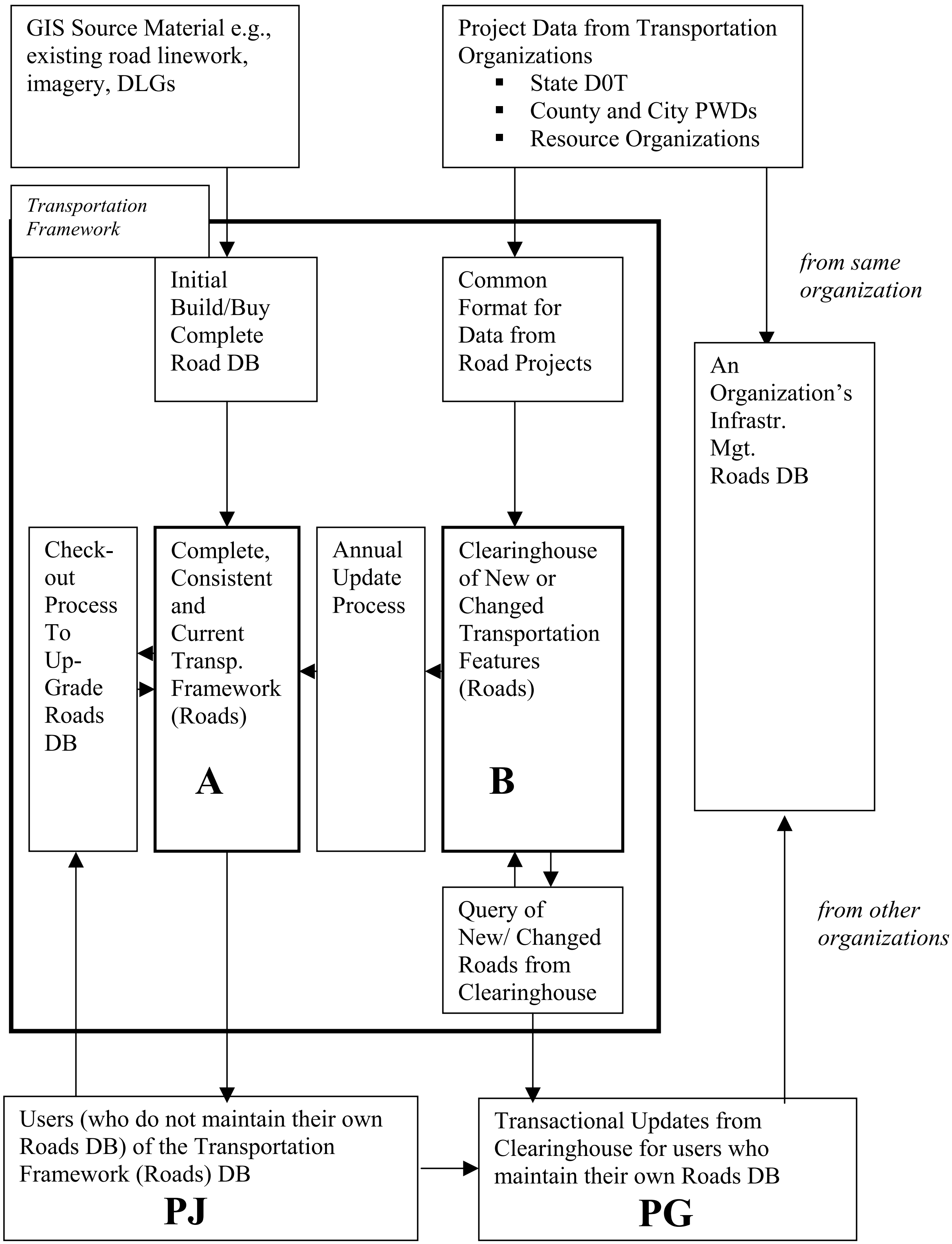


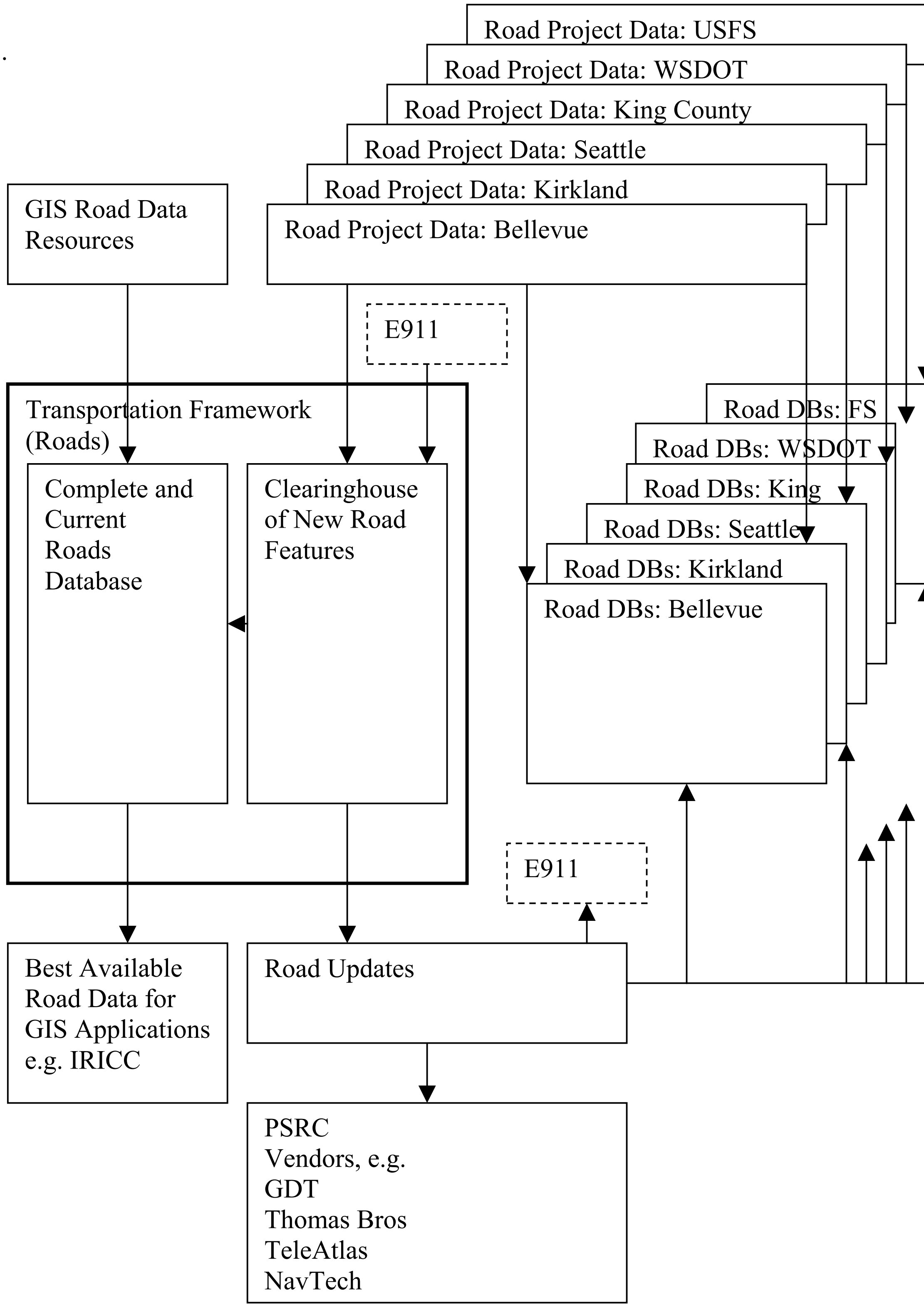
Figure 2 illustrates the user community for the Transportation Framework (Roads) by means of an example for King County, WA. Some of the organizations within King County that own and maintain roads are listed. Under the Transportation Framework concept they would provide data to the Clearinghouse and to other parts of their own organization on roads they have built or changed by means of projects, work orders, or permits. In addition, they withdraw data from the Clearinghouse for roads within their area of interest that have been built or changed by actions of other road organizations. Similarly, there are organizations such as Puget Sound Regional Council (PSRC), and private road database vendors, such as GDT and Thomas Bros., who maintain road databases, but who do not maintain roads. Also, there are organizations who maintain neither roads nor road databases, but who need a roads database for GIS analyses. IRICC falls into this category. Emergency dispatch organizations (E911) are a special case. If road updates from the Clearinghouse are timely enough to meet their needs they could be a potential user of the clearinghouse. If not, E911 organizations might be a contributor of data for new roads, particularly if the reporting of road data from transportation organizations is not well recorded or reported.

Not all Transportation Framework (Roads) implementation issues can be fully anticipated. Remaining issues need to be explored in more detail. Pilot studies are proposed to address these concerns. Figure 3 is a copy of Figure 1 on which pilot studies are identified. The following pilot studies are proposed:

1. Pilot Study 1 is being conducted by ODOT. They are building a complete Roads database in Wasco County to demonstrate the feasibility of conflating data from BLM, Wasco County, ODOT, and DOQQ's. Pilot Study 1 will provide cost experience and technical issues relying on a single contractor to build a Transportation Framework by conflating data from several sources. This pilot is being extended to additional counties. In addition it should be extended to include insertion of annual updates from local governments, and the development of a check out process by which whole regions can be upgraded as better resolution data becomes available

Figure 2. Transportation Organizations Contribute and Withdraw Data from the Transportation Framework **(Roads)**

1.



2. Pilot Study 2 is proposed for a county in Washington State. Pilot Study 2 would test the feasibility of compiling a complete Roads database by a process of handoffs from one organization to another, each adding roads from their GIS database. Pilot Study 2 would test the feasibility of a decentralized approach wherein several GIS organizations within a county adds their own data to the compilation of the Transportation Framework (Roads). This pilot will determine the extent to which GIS organizations are able and willing to participate in the effort. This pilot will also help determine whether proprietary data are significant barriers to sharing data.

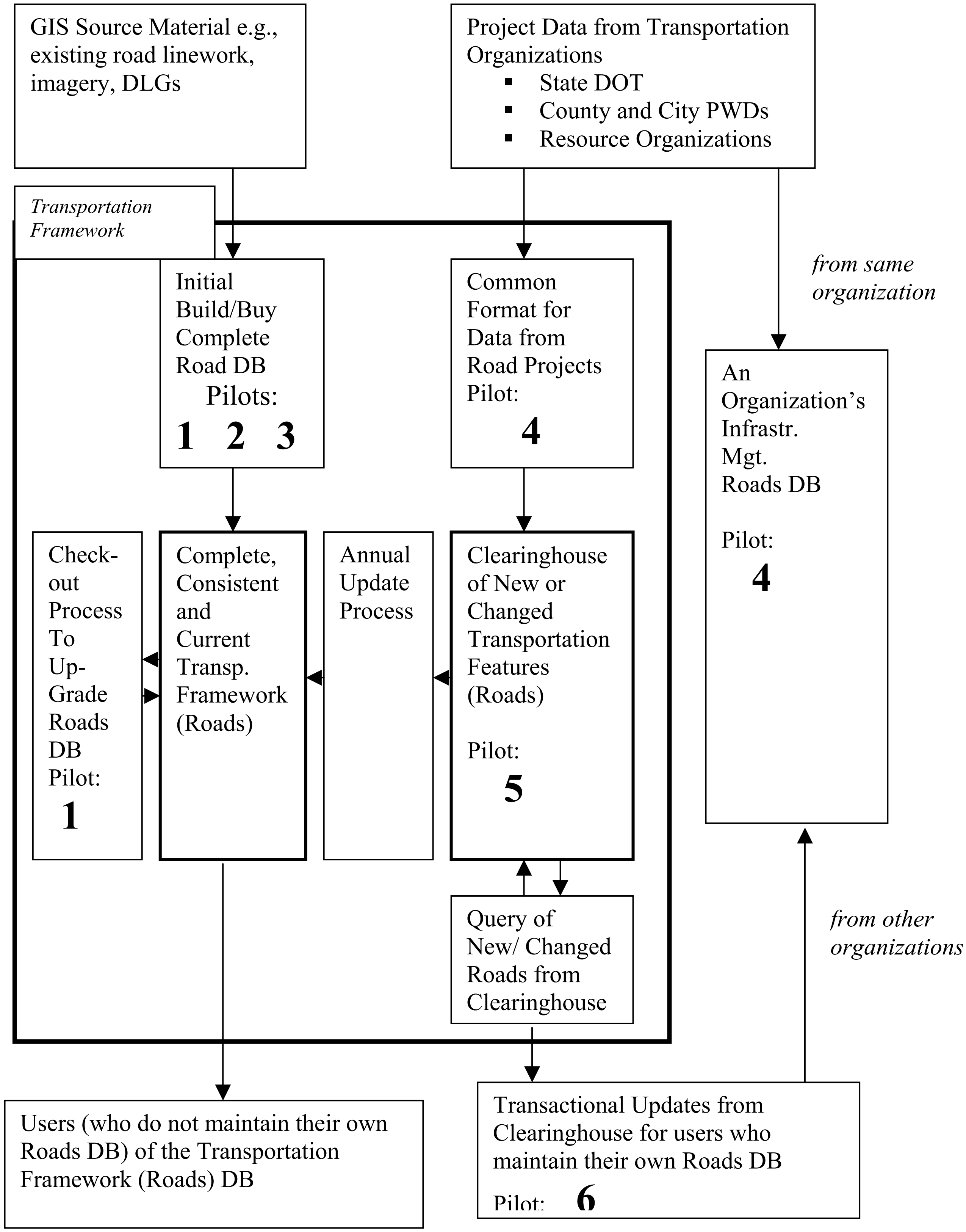
3. Pilot Study 3 is proposed for a group of counties in Washington State that do not have complete GIS data and would not be able to participate in a process as proposed in Pilot Study 2. Pilot Study 3 would contract with a vendor, GDT for example, to build and maintain the Transportation Framework (Roads). Pilot Study 3 will involve negotiations with vendors to determine costs of one-time purchase versus continued maintenance, a cost comparison of the most current data versus year old data, and dissemination constraints.

4. Pilot Study 4 is proposed for a jurisdiction in Washington State, e.g. Bellevue, who is interested in moving their Roads data to an enterprise-wide database. Pilot Study 4 would involve not only building a transaction updated Roads database, but would require extracting data in a consistent format from projects, permits, and work orders that build or modify roads and intersections. Pilot Study 4 would provide insight as to the feasibility of collecting data in a common format about new roads and changes to existing roads from the units of government that are responsible for them.

5. Pilot Study 5 is proposed to test the Clearinghouse concept. Pilot Study 5 would build a web-based collection of data about new and modified Roads. PSU has begun this Pilot Study with a prototype Internet application but it only contains mock data. Pilot Study 5 would test the Clearinghouse concept with real data.

6. Pilot Study 6 is a test of withdrawing data from the Clearinghouse and updating Roads databases. PSRC could take the lead in this by extracting data from Bellevue for updating their address geocoding database, their assignment network, and their ITS network. Pilot Study 6 would help determine the feasibility of transaction updating of application-specific road databases.

Figure 3. Building and Maintaining the Transportation Framework (Roads)



Scope of Pilot Studies

The six pilot studies outlined and discussed below are intended to test several key and interrelated concepts and procedures in building and maintaining the Transportation Framework (Roads). The location of each pilot study and its role in the Transportation Framework is shown in Figure 3.

The six pilot studies are meant to address issues that have been discussed and debated in previous versions of this White Paper but which need further study. As the diagram indicates, more than one study will be used to test a single concept or procedure (e.g., Pilots 1,2,3 test the compilation step), and one will test more than one procedure (e.g., Pilot Study 4 is used to test common format and transaction updating).

These pilot studies will provide empirical and qualitative evidence of what works and what does not in a variety of situations. Cost data and public domain issues that arise will be especially valuable, as these relate to two of the primary objectives of the Framework effort.

Five pilot studies are proposed for jurisdictions in Washington State, while the sixth is already underway in Wasco Co., Oregon. The results should be of use by both Washington and Oregon Transportation Framework initiatives, as well as by local jurisdictions, and by the IRICC Roads committee.

The first three pilot projects will serve to compare the integration of separate spatial data sets of transportation organizations to an already integrated road spatial data set. Table 4 presents a framework for thinking about the first three pilot studies. It displays different approaches for building a Transportation Framework (conflation versus enriching an already integrated database), whether it is developed in a centralized or decentralized environment, and includes both development and maintenance issues. Pilot Study 2 is a decentralized approach that enriches TIGER with GIS roads data from various organizations, while Pilot Studies 1 and 2 test the two centralized approaches.

Table 4
Framework for Pilot Studies

	Conflation Approaches		Enrichment Approaches	
Control	Centralized	Decentralized	Decentralized	Centralized
Example of starting point	Geometry-centric BLM GTRN	Data-centric IRICC Roads	TIGER	GDT
Construction process	Conflation of linework from various sources	Conflation of linework to develop roads DB	Enhance TIGER with attributes	Contract for enhancement with locally provided attributes
Transportation Framework Clearinghouse	State DOT as producer, steward and maintainer	Decentralized producers, State DOT steward and maintainer	Decentralized enhancement, State DOT steward and maintainer	Contracted products for state and local use
Maintenance	Annual recompilation	Transaction updating	Recompilation or transaction updating	Contracted transaction updating
Clearinghouse of changes		New or changed roads		Provide new or changed roads to contractor
Pilot Study	1	2	2	3

Scope for Pilot Studies 1 and 2

Pilot studies 1 and 2 will directly test the integration of federal, state and local road centerline files. Pilot Study 1 is already underway in Wasco County and partially completed by a University of Oregon research team for ODOT. The study is comparing and conflating road linework and attributes from BLM, Wasco County and ODOT, representing the centralized approach by a single contractor. This study does *not* include data from commercial vendors, and so sheds no light on the use of a commercially available database as the basis for the Transportation Framework. It will, however, provide previously unavailable cost and experience data that will allow an estimate of the cost of similar work.

In addition, the twofold concept can be tested by extending the study to several adjacent counties, and by including insertion of annual updates from local governments. The study should also include development of a check-out and check-in process by which whole regions can be upgraded as better resolution data becomes available.

The second pilot will also be a test of “stitching” or compiling together linework and data from several agencies. This is a decentralized approach that has long been discussed and debated by the Washington and Oregon transportation framework groups. The test unit would in this case be a county in Washington state, replicating but extending the work already underway in the Wasco County Pilot discussed, but where the work would be performed by these organizations having GIS road databases. The steps of the production plan are specified below:

Steps in Building the Transportation Framework

Step 1: State adopts Modernized TIGER or GDT as the integrated seamless base file of the roadway universe.

Step 2: State DOT adds Anchor Points to state system at major intersections and county boundaries and assign IDs to these segments of roadways between Anchor Points. Relate these segments to the TIGER or GDT shape files. Sort by County and distribute to County Producers. Relate state system shape files (arcs) and attribute/inventory database records to these segments.

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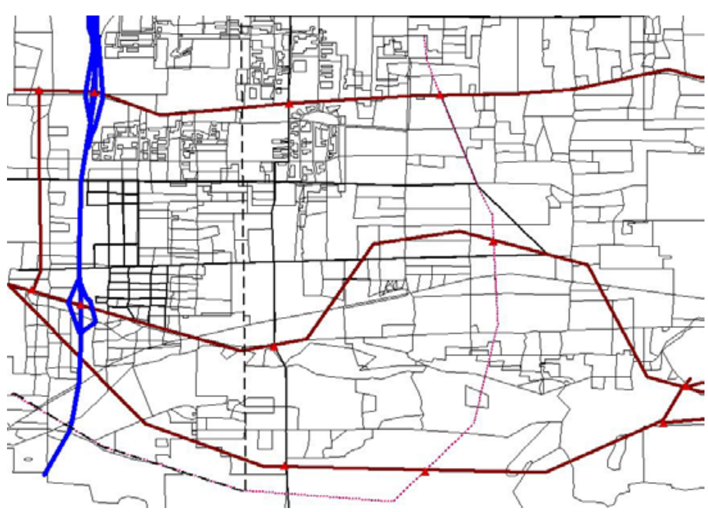
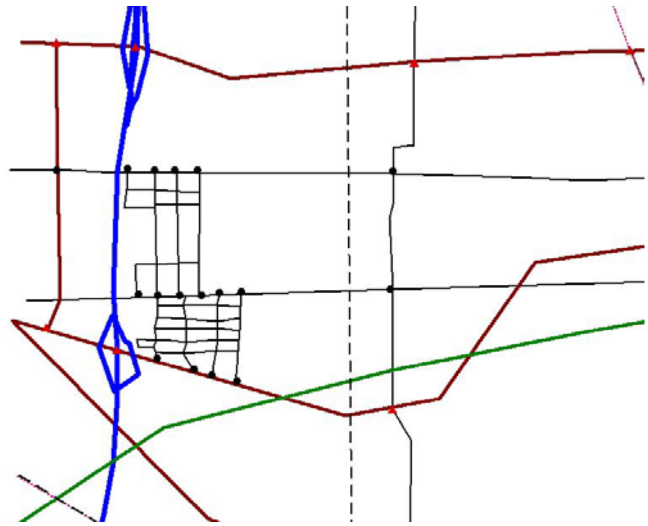


Step 3: Start with files from State DOT. County Producers add Anchor Points to City and County local roads to roadway beginning points, to intersections with

arterials, and to arterial roads at intersections with arterials of equal or higher rank, and assign IDs to these segments of roadway between Anchor Points. Relate County shape files (arcs) to these segments. Distribute to other road organizations in County, such as county and city public works departments, U.S. Forest Service, National Park Service, timber companies.



Step 4: Start with county files. Other transportation organizations may densify the Anchor Points, if needed. Each transportation organization shall relate their shape files and assign IDs to these segments of roadway between Anchor Points, and relate their attribute/inventory database records to these segments.

Step 5: State DOT incorporates all additions and maintains the Transportation Framework in a form that can be accessed in part or whole by users.

Contracting Out: Pilot Study 3

Pilot Study 3 will address another approach discussed in previous versions of this White Paper and among committee members, contracting out the development of the Transportation Framework (Roads) to a commercial vendor such as GDT. This pilot will address the needs of counties that do not have comprehensive GIS data and who therefore cannot or choose not to use the Pilot Study 2 approach.

The main concern of this pilot involves cost and public domain or dissemination issues. Costs will be determined along two dimensions or factors: one-time purchase of data with subsequent state and local maintenance, versus contracting out for data and maintenance. In both cases there are questions of public access to proprietary data. What limitations on dissemination or public access will the contractor impose? Or, at what price will those limitations be removed? We have been unable to answer these questions in a hypothetical context. They will have to be answered in the context of negotiating an actual contract for purchase. This pilot will negotiate these issues toward the development of a successful private-public partnership.

Another objective of Pilot Study 3 is to explore possible cost savings associated with the vendor's use of updates from the Clearinghouse. One purpose of the Clearinghouse is to facilitate updating road databases by any and all potential users. Consolidation of changes to the transportation system should reduce the cost of the database.

Transactional Updating: Pilot Study 4

Pilot Study 4 will address two issues related to the Transportation Framework: capturing and formatting new or modified road features, and a clearinghouse for depositing and accessing the data on new or modified roads. Pilot Study 4 consists of developing procedures for collecting, submitting, and retrieving data from all transportation organizations or jurisdictions concerning road-related projects, permits and work orders.

Pilot Study 4 will address two data sharing issues: sharing data inter-organizationally and intra-organizationally. Submitting data to the proposed Clearinghouse will enable one organization to know of changes made by another organization in common areas of overlapping concern or jurisdiction. Similarly, sharing of data among units within the same organization related to new or modified roads is needed. For instance, a change in signal timing may affect intersection capacity, which is of concern to the transportation planning group within the same unit of government. This type of intra-jurisdictional data sharing among stovepipe GIS systems will improve consistency and currency of data and reduce unnecessary data duplication. This pilot is proposed for a city, such as Bellevue, WA, or similar locale, that is in the process of adopting an enterprise-wide Roads database.

The purpose of Pilot Study 4 is to address the thorny and little discussed issue of maintenance of the Transportation Framework. Pilot Study 4 attempts to develop procedures for collecting and reporting data on new or modified roads that will serve the needs of the Transportation Framework and internal data sharing business needs of transportation organizations.

An important aspect of this Pilot Study is the institution of reporting requirements in the form of inducements or mandates to report changes to the roadway system. The major compliance tool would be to tie state-aid road funding to the reporting of changes.

The formatting of changes to road features is illustrated below. The first illustration is for a change in surface type and the second if a change in number of lanes by the addition of a turning lane. Only the attribute changed is reported, along with the date of change, the status (planned, under construction, open, closed, retired), the Transportation Feature ID, and the location along the feature measured by linear referencing. The data for a new road would have to include all attributes.

Change in surface type

Date:
Status from: open
Status to: open
Transportation Feature ID:
From MP:
To MP:
From Surf type: unimproved
To Surf type: asphalt

Change in number of lanes

Date:
Status from: open
Status to: construction
Transportation Feature ID:
From MP:
To MP:
From Number of Lanes Add Direc: 2
To Number of Lanes Add Direc: 3
Description: right turn lane
From coord. string:
To coord. string:

Clearinghouse of Transportation Feature Updates: Pilot Study 5

The purpose of Pilot Study 5 is to test, by means of prototyping with real data, the Clearinghouse concept. The Clearinghouse is a depository of new or modified road features coming directly from transportation organizations responsible for building or modifying roads, submitted to the Clearinghouse as transactions.

Pilot Study 5 will extend the Clearinghouse prototype that has been developed by (PSU). The PSU prototype is an ArcIMS application that demonstrates the input, query, and display from a database of new, retired, or changed Transportation Features using mock data. The Pilot Study 5 prototype Internet application needs to deal with real data from a representative county, or group of counties, to test submission procedures and the utility of data extracted from the Clearinghouse.

An important aspect of Pilot Study 5 is the visualization in the form of maps of Transportation Features selected as a result of a query. Thus persons selecting data would get visual feedback from their query of features, by type, date or location.

The final objective of Pilot Study 5 is to simulate the update process by inserting selected changes into a Roads database. This update will require matching on the Transportation Feature ID and using dynamic segmentation to locate along the feature, or using coordinates to find matching roads.

Using Data from the Clearinghouse for Updating Application-Specific Databases: Pilot Study 6

Regional GIS Clearinghouses can serve as repositories of more localized spatial databases. They can function in conjunction with State Clearinghouses for maintaining the Transportation Framework (Roads). As discussed in Dueker, Butler, Bender and Zhang (2001) they can be related to a statewide clearinghouse. Both state and regional clearinghouses would share relevant changes. In the Portland metropolitan region, Metro's Data Resource Center (DRC) already performs many functions of a regional transportation clearinghouse nature as part of its maintenance of the Regional Land Information System (RLIS) database.

In the Puget Sound area, this regional clearinghouse function could be taken on by the Seattle Metro or PSRC. In this pilot, either Seattle Metro or PSRC institute a day-forward, transaction-based approach to facilitate and disseminate updates, placing this approach in a regional context, and would require local jurisdictions to adopt a uniform update reporting format similar to that described above, placing in essence a top-down mandate for these individual jurisdictions to eventually adopt an Enterprise GIS.

Pilot Study 6 will test the "final step" of the updating of Roads databases maintained by others using data selected from the Clearinghouse. This is of concern to users who maintain their own Roads databases, but who do not maintain roads, such as the Puget Sound Regional Council (PSRC) and private Roads database vendors, such as GDT, Navtech and Thomas Brothers. In addition, transportation organizations who maintain roads and their own application-specific Roads databases will need to draw data from the Clearinghouse concerning roads in their jurisdiction that are owned and maintained by other transportation organizations.

It is proposed that PSRC undertake Pilot Study 6 and use data from the Clearinghouse to update the three different road databases they maintain: 1) address geocoding database, 2) traffic assignment network, and 3) ITS network. The important issue to be examined in this pilot is whether the transactions to record changes to roads can be made sufficiently robust to update databases of different types and detail. For this reason Pilot Studies 4 and 6 are inter-related and should be performed in a common study area, such as eastern King County, WA, including the City of Bellevue.

Options and Directions

This section provides some specific, but still tentative, cost options to help frame the discussion of how much robustness or functionality to build into the Washington State Transportation Framework (Roads). The White Paper has identified several Framework constituencies, each with slightly different priorities or business needs. How many of these business needs will be supported by the initial Transportation Framework (Roads)? The answer, in part, depends on: 1) willingness to provide funding, staff or database resources, needed to add functionality to meet specific business needs, and 2) the extent to which those business needs are common to several stakeholders. For example, address geocoding is a business need common to several stakeholders, but unnecessary to others.

In addition, these choices of options enable the development of a *phased* approach to building the Framework, based on identifying and ranking business need priorities. The White Paper, along with further analysis of business needs, will assist in distilling these priorities and basic needs for the Framework.

Three options are identified and described below. These may be considered as functional "add-ons" to the basic, "best available" roads linework of a Framework that satisfies many GIS needs, including tight integration of the Transportation Framework (Roads) with other NSDI layers. There is great interest and need for integrating hydrography, cadastral, roads, railroads and bridge structures, including culverts, for salmon enhancement planning. In addition, this will include spatial accuracy improvements to the best available linework to support limited vehicle-tracking applications. Three optional enhancements to the basic linework follow directly from the analysis and identification of business needs:

- Address ranges and street names. Address geocoding functionality is of great interest and importance to emergency dispatch agencies and to many other users of address geocoding.
- Linear Referencing Systems (LRS) to support adding attributes of roads for and infrastructure (IMS) management.
- Network representations of the roadway system to support routing applications, such as disaster and contingency planning. Overweight/oversize truck routing would require additional data of height, weight and turn restrictions.

The three options listed above can be prioritized for phased implementation and to identify stakeholders willing to pay for the enhancement. A rough estimate of cost for compiling the basic linework statewide is estimated to be one million dollars per state (Washington and Oregon). This estimate does not include administration or management of the compilation process. Nor does it include the time and cost of determining exactly what data should be used, setting up data sharing partnerships, and other aspects of incorporating the concerns or stakeholders. Each additional option is estimated to cost $250,000 per state. The add-on cost of additional enhancements should be the responsibility of stakeholders who would benefit.

The White Paper concludes with this identification of options for stakeholders to consider in determining the desired robustness of the Transportation Framework and methods of allocating costs. Regardless of which combination of the three "add-ons" is selected instituting an update and maintenance process, such as the *transaction update* approach for new and modified transportation features is crucial to ongoing maintenance of the Framework. However, the cost estimates for the basic best available linework and the above listed add-on options do not include maintenance costs associated with building and operating the Clearinghouse of new and modified transportation features.

The priority of business needs drives not only the choice among options for functionality, it drives the way in which the Transportation Framework is built, structured, and maintained. The following scenarios illustrate the inter-relatedness of business needs, functional options, compilation method, data model, and maintenance method:

- If emergency dispatch is the highest priority, street addressing and relating wireless phone positions to the nearest street becomes the most important functionality of the Transportation Framework. This suggests starting with an existing integrated database, such as GDT or TIGER. Contracting database maintenance to a single contractor, GDT would provide for a more centralized process that enables use of a highly structured and detailed data model. On the other hand, a decentralized maintenance process would have to be supported by a more generalized data model that all participants could use.
- Giving salmon enhancement planning the highest priority requires a process of stitching together the best available linework with route identifiers and linear referencing to facilitate accessing bridge and culvert attributes from infrastructure management organizations (e.g. city, county, and state DOTs, FS, BLM).
- Ranking both needs equally may lead to consideration of ***two separate*** frameworks. These individual frameworks would serve to better handle contrasting and competing needs, balancing desired redundancy and unnecessary duplication. Use of common Anchor Points and Anchor Segments for these frameworks would allow for subsequent registration and integration with one another. The Transportation Framework Project Steering Committees for each individual framework could achieve stronger internal consensus and agreement, while maintaining external informal coordination with each other. This approach would be more costly, but would provide for better control by stakeholders with common needs.

These scenarios serve to illustrate that the possible ***choice set*** is large. The options are not mutually exclusive. Stakeholders will have to mix and match among options and combinations to decide how to best accommodate their business needs to take advantage of a cooperative effort to share costs of while at the same time minimizing the loss of control associated with a multi-participant effort. In other word, will the increases in spatial and temporal accuracy of the proposed Transportation Framework outweigh the risks of a multi-participant effort? As this discussion implies, uncertainty and risk inhibits buy in by Framework stakeholders. Consequently, reducing uncertainty and risk is a primary challenge. Meeting this challenge with the goal of achieving stakeholder confidence and support will require agreement on:

- A clear articulation of stakeholder business needs and the corresponding Transportation Framework functionality.
- Feasible and achievable cost, time, and overall resource estimates.

There are a number of institutional and technical barriers to achieving this consensus. Surmounting them can be difficult. These institutional and technical barriers to address are:

- Integration and conflation of transportation data from different sources and systems with different operational definitions of what a road is, different segmentation criteria, and different spatial and temporal accuracy.
- The need for Framework data to interface with specialized applications with proprietary formats (e.g., infrastructure management, address geocoding, and routing systems)
- Building consensus as to the content of a common framework layer in a multi-participant setting.
- Ever-changing and evolving conditions, expectations, and needs of Framework stakeholders.
- Resource and funding requirements and uncertainties in relation to control and time issues of managing a multi-participant effort.

Although the White Paper addresses these issues and advances the consensus–seeking process, it is now time for stakeholders to participate in the decision and development process towards a multi-purpose Transportation Framework. The problems of continuing along separate paths are growing.

Conclusions

This White Paper provides synthesis of issues and alternatives in the development of a Transportation Framework for Washington. The recommended two-part approach to the Transportation Framework will accommodate pressing applications, such as the need for a roads spatial data set for salmon enhancement planning. At the same time, the Clearinghouse concept to start collecting more detailed data on new or modified roads will enable gradual upgrading to a more robust Transportation Framework. In addition, the more detailed data on new roads will provide others with resources to update their own Roads database.

The White Paper serves the Transportation Framework initiatives in both Washington and Oregon in support of a broad range of applications in resource management, emergency management, infrastructure management, and services management. The White Paper defines the purposes of pilot projects needed to test some of the assumptions and issues that are still outstanding. The completion of these pilot studies will help to determine if the proposed two-part approach to the Transportation Framework is workable and feasible.

Sources Cited

Breyer, J. (2000). “GIS partnership for a composite roadway framework.” Presentation at
GIS-T 2000 Symposium, Minneapolis. Accessed 3/02
http://www.gisworks.com/paperGIST2000(postprint).pdf.

Booz, Allen and Hamilton. (2000). “Master Address File (MAF)/TIGER Modernization Study. For the Geography Division, US Bureau of the Census. Accessed 3/02
http://www.census.gov/geo/mod/booze_allen.pdf.

Butler, J.A. (2001). "How to Get There from Here - Building Network Systems Using ArcGIS and the Geodatabase." Lafayette, CO: Campbell & Bromberg, Inc..

Engelmann, M., Carpentier, G., & Meacham, J. (2001). ODOT County GIS Mapping Wasco County Pilot Project webpage. Accessed 9/01
ftp://ftp.odot.state.or.us/tdb/trandata/maps/Framework_layers/Wasco_Report.pdf.

Dueker, K., Butler, A., Bender, P., & J. Zhang. (2001). “A Clearinghouse Approach to Sharing Transportation GIS Data,” *Transportation Research Record*, *1768*, 203-209.

DuChateau, J. (2000). An enterprise linear referencing system for the Wisconsin information system for local roads (WISLR) project. Presentation at GIS-T 2000
Symposium, Minneapolis. Abstract Available and Accessed 3/02,
http://www.bts.gov/gis/reference/GIS_T2000/gistabs.htm#1.1.2.

Federal Geographic Database Committee. (2000). NSDI Framework Transportation Identification Standard (Public Review Draft). Accessed 3/02
http://www.bts.gov/gis/fgdc/web_intr.html.

Federal Highway Administration. (1999). “Asset Management Primer.”
http://www.fhwa.dot.gov/infrastructure/asstmgmt/amprimer.pdf.

Federal Highway Administration. (2000). “Primer: GASB 34.”
http://isddc.dot.gov/OLPFiles/FHWA/010019.pdf.

Maxwell, J. (2000). Implementing a successful regional road transportation network in a
cooperative multi-jurisdictional environment. Presentation at GIS-T 2000 Symposium, Minneapolis. Abstract Available and Accessed 3/02,
http://www.gis-t.org/abstracts.htm.

Paulson, L. (2001). "Giving Freight a Voice." Accessed 9/01, http://www.tfhrc.gov/pubrds/marapr01/freight.htm.

Puget Sound LIDAR Consortium. (2001). "Examples of LIDAR data." Accessed 2/02, http://www.pugetsoundlidar.org/.

Regional Ecosystem Office. 2001 "Draft Concept, Roles and Responsibilities for Seamless Regional Framework Clearinghouse." Chapter III Hydrography, Spatial Data Set Management and Coordination, July 25, 2001. Accessed 11/01, http://www.sscgis.state.or.us/coord/FrameLayers/hydro_roles-resp7-25-01.pdf.

Ross, D. & Brott, D. (2000). Developing a unified intelligent statewide transportation GIS database. Presentation at GIS-T 2000 Symposium, Minneapolis. Abstract available and Accessed 3/02, http://www.gis-t.org/abstracts.htm.

State GIS-T/Clearinghouse References

Alaska State Geospatial Data Clearinghouse. (2002). Alaska NSDI Geospatial Data Clearinghouse Node. Accessed 2/02, http://www.asgdc.state.ak.us.

Geological Survey of Alabama (GSA). (2002) . Alabama NSDI Geospatial Data Clearinghouse Node. Accessed 2/02, http://www.gsa.state.al.us/gsa/GIS/clearinghouse.html.

Georgia GIS Data Clearinghouse. (2002). Georgia NSDI Geospatial Data Clearinghouse Node. Accessed 2/02, http://www.gis.state.ga.us/Clearinghouse/clearinghouse.html.

GeoStor. (2002). GeoStor Database. Accessed 2/02, http://www.cast.uark.edu/cast/geostor/.

Kentucky Transportation Cabinet. (2001). "Standards for Road Data Collection Using Global Positioning System Techniques"- Kentucky Transportation Cabinet, Division of Planning Report, Accessed 3/02, http://www.kytc.state.ky.us/planning/gisourky/Documents/Standardsall.pdf.

State of Nebraska. (2002). Nebraska Geospatial Data Clearinghouse Gateway. Accessed 2/02, http://www.nol.org/Isite/GEOgateway.html.

Montana Transportation Working Group. (2002). "A Collaborative Multi-jurisdictional Approach to Building a Geospatial Ground Transportation Framework Database for Montana" Accessed 2/02 http://mtgeo.org/itwg/framework/Transportation/Grant/app04182000.htm.

Texas Strategic Mapping Program. (2002). Texas Strategic Mapping Program webpage, includes overview of "StratMap" Accessed 2/02, http://www.tnris.state.tx.us/stratmap/overview.htm.

United States Geological Survey. (2001). "*The National Map* - Washington-Idaho Pilot." Project Accessed 2/02, http://mac.usgs.gov/mac/isb/pubs/factsheets/fs11401.html.

Utah Information Technology Services. (2002). Utah Framework Implementation Plan Accessed 2/02, http://agrc.its.state.ut.us/i_team/iteam_final.htm.

Vermont Center for Geographic Information, 2002. "NSDI Framework Transportation Identification Standard Vermont Pilot Project." Accessed 2/02, http://geo-vt.uvm.edu/cfdev2/VCGI/proj/bts.cfm.

Appendix A

IRICC Transportation Framework
Route Core Data

DRAFT 9/19/2000

D. Guenther, REO. Core_Data

The following lists the agreed upon set of core data necessary for the Transportation Framework project. All data is linked to spatial information, which defines a route. A route is a user defined section of road. This document will focus on describing the core data attributes only. For Framework spatial requirements please refer to the Transportation Spatial Requirements document. For Framework data standards for transportation structures, refer to the Framework Structures Core Data document.

These elements were developed consensus from the partners. Core data is data common to all participating agency datasets. Core data may not include all common data, but relative to broad scale needs.

Data Elements:

1. File Header Information: **Required values are in bold type.**
This information pertains to all information being submitted. It describes a file transfer event, describing all data submitted.

> **Origination Date** - Date the file or information is submitted.
> Field Name: ORIGINATION_DATE Type: Date.
> **Validation Date** - Date the data is current.
> Field Name: VALIDATION_DATE Type: Date.
> **Projection** - The name of the projection which the line work was developed in.
> Field Name: PROJECTION**.** Type: Alpha. Size: 50.
> **Coordinate System** - The coordinate system the line work was developed in.
> Field Name: COORDINATE_SYSTEM Type: Alpha. Size: 50.
> **Datum** - The geographic Datum the line work was developed in.
> Field Name: DATUM. Type: Alpha. Size: 50.

2. Feature Attributes:
This information pertains to a specific data element or record being submitted. Each record will have a different set of data.

> *Road Location Information*
> Framework Unique Identifier - A system generated unique permanent identifier. As records are submitted to the Framework Clearinghouse each record will be assigned a unique ID. This ID may then be used and tracked by participants in sharing data across ownerships.
> Field Name: FRAMEWORK_ID. Type: Integer. Size: 7.

Agency Unique Identifier - The unique ID which the contributing agency has assigned to the feature.
Field Name: LOCAL_ID. Type: Alpha. Size: 50.

State - Code for State where the road is located. FIPS codes will be used.
Field Name: STATE. Type: Alpha. Size: 2.

County - County FIPS code for feature location. FIPS codes will be used.
Field Name: COUNTY. Type: Alpha. Size: 3.

Metadata Information

Feature Source Type - The compilation map or image source used when adding or updating transportation data.

These codes can be found in the associated lookup table listed in Section 4 - Appendix.
Field Name: FEATURE_SOURCE_TYPE. Type: Alpha. Size: 25.

Feature Source Date - The compilation map or image source date used for the addition or update of transportation data.

Example: 19990515 (CCYYMMDD = May 15, 1999)
Field Name: FEATURE_SOURCE_DATE. Type: Date. Size: Date.

Feature Source Scale Number - Describes the scale denominator of the map or image source for the transportation data additions or updates in the database. Exact scale can be input. The density of transportation features displayed will vary by the base map scale.

Example: 24000
Field Name: FEATURE_SOURCE_SCALE_NUMBER. Type: Alpha. Size: 6.

Feature Accuracy Type - Describes the positional accuracy of the transportation data being added or updated in the database. Describes the correctness of the measurement. Use actual value e.g. .001; 3; 100. All units are entered in meters.
Field Name: FEATURE_ACCURACY_TYPE. Type: Alpha. Size: 4.

Road Specific Attributes

Road Name - Road name(s) which have been assigned. Note: either NAME or Road_Number is required. If unknown then OWNER must be filled in as unknown.
Field Name: NAME. Type: Alpha. Size: 35.

Alternate Road Name - List of all other known names.
Field Name: ALTERNATE _NAME Type: Alpha. Size: 35.

Direction Prefix - Directional indication code (i.e. NE).
Field Name: PREFIX. Type: Alpha. Size: 2.

Direction Suffix - Directional indication code (i.e. NE).

Field Name: SUFFIX. Type: Alpha. Size: 2.

Road Number - Road numbers(s) which have been assigned. Note: either NAME or Road_NUMBER is required. If unknown then OWNER must be filled in as unknown.
Field Name: ROAD_NUMBER. Type: Alpha. Size: 15.

Alternate Road Number - List of all other known road numbers.
Field Name: ALTERNATE_ROAD_NUMBER. Type: Alpha. Size: 15.

Measure Method - Date and comment type description of how the FROM and TO measures were generated (ex. Odometer).
Field Name: MEASURE_METHOD. Type: Alpha. Size: 50.

From Milepost - The 'FROM' milepost where the road segment value starts.
Field Name: FROM_MP. Type: Real. Size: 999.99

To Milepost - The 'TO' milepost where the road segment value ends.
Field Name: TO_MP. Type: Real. Size: 999.99

From_ARM - The 'FROM' milepost where the field measured Accumulated Route Mile (ARM) value starts.
Field Name: FROM_ARM. Type: Real. Size: 999.99

To ARM - The 'TO' milepost where the field measured Accumulated Route Mile (ARM) value ends. Field Name: TO_ARM Field Name: Type: Real. Size: 999.99

Inventory Direction - The direction of the inventory (increasing or decreasing) for dual lane roads.
Field Name: DIRECTION.   Type: Alpha. Size: 10.

Right Side Address Low - Lowest street address on the right side in direction of increasing addresses.
Field Name: RT_FROM_ADD. Type: Alpha. Size: 6.

Left Side Address Low - Lowest street address on the left side in direction of increasing addresses.
Field Name: LF_FROM_ADD.   Type: Alpha. Size: 6.

Right Address High - Highest street address on the right side in direction of increasing addresses.
Field Name: RT_TO_ADD. Type: Alpha. Size: 6.

Left Address High - Highest street address on the left side in direction of increasing addresses.
Field Name: LF_TO_ADD. Type: Alpha. Size: 6.

Left Zip - Postal zip code on left side of feature in direction of increasing addresses.
Field Name: LZIP_TYPE. Type: Alpha. Size: 10.

Right Zip - Postal zip code on Right side of feature in direction of increasing addresses.
Field Name: RZIP_TYPE. Type: Alpha. Size: 10.

Owner Level - Jurisdictional level of owner of facility (see code list) (i.e. Federal).
Field Name: OWNED**.** Type: Alpha. Size: 1

Owner Name - Jurisdictional classification or name of facility owner (see code list) (i.e. Forest Service).
Field Name: OWNER**.** Type: Alpha. Size: 35.

Manager Level - Jurisdictional level of manager of facility (see code list) (i.e. Federal).
Field Name: MANAGED**.** Type: Alpha. Size: 1

Manager Name - Jurisdictional classification or name of facility manager (see code list) (i.e. Forest Service). Field Name: **MANAGER.** Type: Alpha. Size: 35.

Functional Classification - Functional classification (i.e. Interstate). This includes railroad and utility pipelines.
Field Name: **FUNCCLS.** Type: Alpha. Size: 35.

Functional Type - Functional type (i.e. U=Urban).
Field Name: FUNCTYP**.** Type: Alpha. Size: 1.

SOURCE - Jurisdictional level at which data originates (see code list) (i.e. Federal).
Field Name: SOURCE. Type: Alpha. Size: 1

Source Agency - Jurisdictional classification or name of agency that submits the data (see code list) (i.e. Forest Service).
Field Name: SOURCE_AG**.** Type: Alpha. Size: 35.

Road Status - Code for the management of the road. (Ex. R=Retired, O=Operating, P=Proposed).
Field Name: STATUS. Type: Alpha. Size: 1

Surface Type - The code showing surface type of the feature. (Ex. H=Hard Surface, G=Gravel, D=Dirt).
Field Name: SURFACE_TYPE. Type: Alpha. Size: 1.

IRICC Transportation Framework
Structures Core Data

8/16/2000

D. Guenther, REO. Structure_Core_Data

The following lists the agreed upon set of core data necessary for the Transportation Framework project. All data is linked to spatial information, which defines a route. A route is a user defined section of road. This document will focus on describing the core data attributes only. For Framework spatial requirements please refer to the Transportation Spatial Requirements document. For Framework data standards for transportation structures, refer to the Framework Structures Core Data document.

These elements were developed consensus from the partners. Core data is data common to all participating agency datasets. Core data may not include all common data, but relative to broad scale needs.

Fields in **bold** are required for the Framework Clearinghouse.

Data Elements:

1. File Header Information:
This information pertains to all information being submitted. This describes a file transfer event, describing all data submitted.

Note: Location coordinates will refer to the center point of the structure. Fields in bold are required for the Framework Clearinghouse.

Framework Structure ID – To uniquely identify each structure. Source: Generated by Clearinghouse.
Field Name: STRUCTURE_ID. Type: Integer. Size: 15

Agency Structure ID – Unique ID from data source agency. Used to link framework data to agency data.
Field Name: LOCAL_STRUCTURE_ID. Type: Character. Size: 35

Latitude - The Latitude for the structure.
Field Name: X. Type: Integer. Size: 7.

Longitude - The Longitude for the structure.
Field Name: Y. Type: Integer. Size: 7.

Elevation - The elevation above mean sea level for the structure.
Field Name: Elevation. Type: Integer. Size: 4.

Source Information- General information as to the source of the data.
Field Name: SOURCE_INFORMATION. Type: Alpha. Size: 240 characters.

Route Framework ID- To designate which route a structure is on. Route_Framework_ID is a system generated unique permanent identifier. As records are submitted to the Framework Clearinghouse a lookup based on supplied Local_Route_ID and Source will provide the unique ID. This ID may then be used by participants in sharing data across ownerships.
Field Name: ROUTE_FRAMEWORK_ID. Type: Integer. Size: 7 characters.

Local Route ID - The unique ID which the contributing agency has assigned to the route.
Field Name: LOCAL_ROUTE_ID. Type: Alpha. Size: 50 characters.

Accumulated Route Measurement - The milepost where the structure is located on the route. Route mile accumulated from the beginning of a route in the direction of a roadway.
Field Name: ARM. Type: Real. Size: 999.99 (Where does this start?).

Structure Class - Designation for the general type of structure (Valid: culvert, bridge, ford or road blockage).
Field Name: STRUCTURE_CLASS. Type: Alpha. Size: 25.

Owner Level - Jurisdictional level of owner of facility (see code list) (i.e. Federal).
Field Name: OWNED. Type: Alpha. Size: 1

Owner Name - Jurisdictional classification or name of facility owner (see code list) (i.e. Forest Service).
Field Name: OWNER. Type: Alpha. Size: 35 characters.

Owner Level - Jurisdictional level of manager of facility (see code list) (i.e. Federal).
Field Name: MANAGED. Type: Alpha. Size: 1

Manager Name - Jurisdictional classification or name of facility manager (see code list) (i.e. Forest Service).
Field Name: **MANAGER**. Type: Alpha. Size: 35 characters.

Feature Source Type - The compilation map or image source used when adding or updating transportation data.

These codes can be found in the associated lookup table listed in Section 4 - Appendix.
Field Name: FEATURE_SOURCE_TYPE. Type: Alpha. Size: 25.

Feature Source Date - The compilation map or image source date used for the addition or update of transportation data.

Example: 19990515 (CCYYMMDD = May 15, 1999)

Field Name: FEATURE_SOURCE_DATE. Type: Date. Size: Date.

Feature Source Scale Number - Describes the scale denominator of the map or image source for the transportation data additions or updates in the database. Exact scale can be input. The density of transportation features displayed will vary by the base map scale.

Example: 24000

Field Name: FEATURE_SOURCE_SCALE_NUMBER. Type: Alpha. Size: 6.

Feature Accuracy Type - Describes the positional accuracy of the transportation data being added or updated in the database. Describes the correctness of the measurement. Use actual value, e.g., .001; 3; 100. All units are entered in meters.
Field Name: FEATURE_ACCURACY_TYPE. Type: Alpha. Size: 4.

Note: States and federal agencies do not seem to be tracking anchor points, but looking at reasons for relevance and importance. Are they necessary for sharing transportation data, or linking transportation framework to hydrography.

Culverts: In addition to the above attributes, culvert core data will include the following.   (Note: when fish and hydro data needs are known they will be included):

Culvert Type- The shape and material for the culvert. (E.g. Ellipse, concrete).
Field Name: TYPE. Type: Alpha. Size: 25.

Culvert Size - The diameter or area of the culvert.
Field Name: SIZE. Type: integer. Size: 2.

Culvert Length - The length of the structure.
Field Name: LENGTH. Type: integer. Size: 3.

Bridges: In addition to the above attributes, bridge core data will also include the following:

NBI - The code assigned to all bridges and dams under the National Bridge Inventory.
Field Name: **NBI**. Type: Integer. Size: 5

Fish passage and hydrography attributes: In addition to the location information above, these structures will include fisheries and hydrography information as determined by the agency specialists. This section is a place holder for this information to be attached to the transportation framework information set. This information will then be linked to the hydrography framework as well.

Example:
Fish_Passage – A Y/N field describing whether fish can pass this barrier.
Fish_Species – The species related to fish passage. Code value based on scientific name.