6-2000

Sharing Transportation GIS Data

Kenneth Dueker
Portland State University

Paul Bender
Portland State University

Jihong Zhang
Portland State University

SHARING TRANSPORTATION GIS DATA

Kenneth Dueker
Paul Bender
Jihong Zhang

A draft report to the
Oregon Road Base Information Team
Oregon Department of Transportation

June 2000

Center For Urban Studies
Portland State University

INTRODUCTION

Updating and maintaining Geographic Information Systems-Transportation data (GIS-T data) is proving difficult. Different database formats needed to support diverse applications leads to inconsistencies and inaccuracies, and duplication in updating. Dueker and Butler (1998) have proposed an Enterprise GIS-T data model that unbundles the various components of transportation data (network links, cartography, and attributes) to facilitate generating application-specific networks, and which eases updating and maintenance. However, developers of existing application-specific databases that employ integrated data models that bundle the network link with cartography and attributes are reluctant to step back to an intermediate form for managing their data. Consequently, attention is given in this report to the development of a method of incorporating transportation system changes directly to existing application- specific networks.

A clearinghouse approach is recommended in Oregon for the collection and dissemination of **new** transportation features that can be segmented in different ways to meet the needs of various applications and inserted to update existing GIS-T databases. The clearinghouse approach is advantageous in that it is based on collecting data about new or changed transportation features once and uses the data many times to update existing databases.

The next section describes the GIS-T update problem in more detail. It is followed by a description of how other states are addressing the problem of building a complete GIS-T database of streets and highways. Then the update strategies of two nationwide GIS-T databases are described and evaluated. This leads to a description of the data sharing clearinghouse approach for transportation organizations to share data about transportation features. A key feature to the approach is a day-forward implementation of transportation features. This means the clearinghouse will contain data on only new or changed transportation features. Three case studies are proposed to provide proof of concept. One case study tests the state clearinghouse concept, while a second case study tests a delegation of responsibility in some parts of the state to a regional clearinghouse, with flows of data between the two to accommodate organizations that have statewide data collection responsibility or statewide applications. The third case study addresses the issue of developing a new GIS-T database of transportation features for integration with a hydro layer for salmon enhancement planning in the Pacific Northwest. The final section deals with implementing the case studies in an Internet environment to facilitate entry and dissemination of data to and from the clearinghouse.

THE PROBLEM

The problem with sharing and maintaining GIS-T data is the diversity of database formats that lead to inconsistencies, inaccuracies, and duplication. This diversity is due to differences among transportation data models that make it difficult to achieve consistent representations of the transportation system. Yet there are legitimate differences in requirements that lead to application-specific definitions and representations of transportation objects and their geometry. This has resulted in multiple and inconsistent digital representations of various parts of the transportation system.

Currently, we have different networks to support applications, such as vehicle navigation systems, overweight truck routing, facility location and address geocoding, emergency management, or for a reference layer of roads for resource management applications. These applications define roads differently. Some include paths and trails, private streets, alleys, and resource roads and some do not. In addition, the level of detail and spatial accuracy differs. The ***challenge*** is to *establish means of data exchange* among these disparate representations that lead to improvements in accuracy, consistency, and completeness. And more importantly in the long run, is the *need to share updates* to maintain currency in representing the transportation system. At the same time it is important to recognize the legitimacy of specialized representations needed to support different applications.

The current approach to structuring street and road centerline databases bundles the network links, the cartographic linework, and the attributes (name, address range, street type, number of lanes, etc.) into a single database record. However, there are many ways to segment transportation features into network links, different spatial resolutions, and different attributes to maintain and use. No single representation will satisfy all users. Consequently, the Enterprise GIS-T data model by Dueker and Butler is an unbundled approach that stores the data in an intermediate form from which application-specific networks can be generated. The advantage of the intermediate-form approach is consistency of source data to support and update many GIS-T applications.

The following metaphor is offered to make the concepts in this report more understandable:

> Transportation Features (TFs) are like strings of pasta. A bowl of spaghetti contains TFs of all types, freeways, arterials, local roads, alleys, paths and trails, airports, pipelines, and railroads. Users identify the types of TFs they want and select from the bowl those pieces needed for vehicle navigation, emergency dispatch, pizza delivery, walking, or bicycling. Then using a "clean and build" procedure, users can construct application-specific networks.

Building a Transportation Feature (TF) database from current data resources involves collecting connected links with same name/route into a TF. But most organizations do not want to take this backward step to create an intermediate product. Those with existing GIS-T databases are looking for ways of updating. Consequently, the emphasis of this report is on establishing a means of sharing transportation system updates without having to step backwards to a more fundamental data model. However, custodians of application-specific databases become responsible for incorporating the new or changed TFs into their databases. The problem of updating a diversity of existing GIS-T databses without costly reformatting and restructuring necessitates a new approach. The proposed approach is a clearinghouse concept to capture and disseminate data about new or changes to TFs. The concept concentrates on collecting the data once and making the updates available for many kinds of GIS-T user databases. User organizations are responsible for accessing data for the types of transportation features needed and at the frequency needed for their application. Then they can "slice and dice the transportation features into segments that meet their needs.

We propose three case studies to test a possible method of explicitly addressing the challenges mentioned in brief above. This method consists of creating an Internet Database Clearinghouse using the TF data model and an off-the-shelf software, architecture. Before going into greater detail, it is important to state at the outset that neither the Clearinghouse, nor the three case studies designed to test it, are meant to serve as a new, top-down, centralized, web-based GIS. Quite to the contrary, the TF model and Clearinghouse proposal explicitly recognize the value and need in maintaining distinct, autonomous enterprise GIS.

Having stated this, it is also impossible to overstate the growing need and long-term technical and organizational value in *sharing transportation GIS data.* This need has long been discussed and argued for among both GIS and transportation scholars and practitioners. Now, with ever growing public and business demands on a quality, environmentally sound transportation infrastructure, on one hand, and rapidly expanded technical GIS capability on the other, it is clear that the time is at hand to combine technical and organizational resources to facilitate this data sharing.

Three case studies are proposed to test this approach to sharing of GIS-T data using the Enterprise GIS-T and TF concepts and principles introduced in recent years by Dueker-Butler. We first discuss below the most recent efforts in other states in developing statewide road GIS databases, followed by a description of the innovative GDT public/private partnership called Community Update and the proposal to modernize TIGER. The paper will then go on in greater detail to discuss the need served by each case study proposal, as well as detailed strengths and weaknesses.

LEARNING FROM EXPERIENCE ELSEWHERE

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. They appear to be leading states because they have a head start. They are starting from existing mainframe highway inventory and mapping applications, while enhancing and converting to a GIS application. Also, Minnesota and Wisconsin are motivated by a mandate to administer a state aid to local roads program that requires an inventory of roads and their condition. The motivation for the Arizona DOT to update and further develop the GIS framework database of Arizona's surface transportation network, is to build a partnership among governmental agencies in Arizona.

Arizona DOT completed a road centerline map database in 1975, but it received little maintenance, if any in rural areas, after 1975. The Centerline update project is largely a bulk integration of state highways with data at the county level, county by county. The update process consists of conflating data from various sources and the addition of linear referencing and geocoding procedures. A transactional updating system is envisioned after completion of the project that will rely on segment IDs that are being assigned.

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 current system are being addressed in the redesign and linear referencing is being added. Linear referencing of local roads will employ an intersection offset method since linear referencing has not been supported at the local level. Again, maintenance does not appear to have been systematically addressed.

In Minnesota there are two road centerline efforts. One is centered on the seven county metropolitan area but is expanding to include 22 counties. It is a public-private cooperative effort emphasizing address geocoding applications. It has been built and is being maintained by a private firm for the production of their street atlas products. The Metro Council pays the firm for a portion of the maintenance costs and the firm provides the data to public agencies at no cost, and licenses the data to private users for a cost. Updating is more thorough in populated places and is less systematic in sparsely populated counties. The effort is largely market driven.

Although the State DOT is a participant in the Twin Cities Metro GIS street centerline program, they have embarked on a separate system development to build a digital unified base map of all roads in Minnesota. There is mention of sharing data in the counties of overlap, but it does not appear systematic. Again, the Mn/DOT effort replaces the existing 30-year old mainframe system and it includes railroads, navigable waterways, and airports as well as highways. They have dealt with several difficult issues, such as developing an Anchor Section identification schema, linear referencing, and interchange coding, and forming partnerships. However, there does not appear to have been much attention to update and maintenance. This is a typical flaw, and one of the motivating factors for developing the Clearinghouse approach.

Examination of these efforts is instructive. First, projects to move centerline files to a modern GIS/DBMS platform is made more difficult by a growing list of new requirements. The addition of linearly referenced attribute data, spatially accurate cartography, and topologically correct networks for vehicle routing to serve multiple purposes adds complexity to the conversion task. These requirements all make the construction of top-down, multi-jurisdictional transportation GIS databases less and less practical. This in turn enhances the utility of the Clearinghouse approach.

None of the efforts have fully addressed the update and maintenance problem as a major design requirement. The efforts are “projects” rather than “programs”. Consequently, maintenance is not given adequate attention early enough in the project to influence design and procedures. As a result of this examination of experience in other states, we recommend that ***maintenance*** be an explicit system design requirement and that a pilot project on update and maintenance be a major task in the implementation project. This requirement is a driving force behind the new GDT Community Update program and the modernization of TIGER, discussed below.

Community Update from GDT

Geographic Data Technology (GDT) has developed, in coordination with Environmental Systems Research Institute (ESRI), the Community Update program, "a public/private partnership for maintaining and distributing street centerline data." The GDT effort will focus on providing the most accurate, complete and up to date street centerline databases by partnering directly with the local government agency. The Community Update program is complementary with our Clearinghouse concept, , but does not substitute for it.

The core of the GDT concept is that local government agencies will submit their incremental centerline updates to GDT. This can be accomplished either by downloading the GDT database and use existing editing tools, or the user may perform the edits on-line, taking advantage of the ArcIMS editing tools. GDT then checks these edits are also routed through its own internal editing process where the information is verified by GDT.

A key feature of the GDT Community Update concept is that GDT owns and maintains the data, a proprietary database. An equally important feature is that the process supports a single representation of this street centerline system. GDT is also geared more specifically toward address matching use and applications. The initial editing will be allowed only for geocoding related attributes such as street names and address ranges. As GDT recognizes however, there are multitudes of local government application needs related toward navigation and routing. These will require attributes such as one-way street designations, turn restrictions and bridge heights, and other representations that are not supported.

Although very similar, the GDT concept should not be seen as a *competing* venue or framework. The TF Clearinghouse concept and GDT's Community Update can work well together, in an integrated fashion. Community Update works well as a vendor access system that is compatible with the TF Clearinghouse proposals. The TF Clearinghouse serves as a broader, more systematic regional model that will ensure equitable database access across a region or a state, for a greater variety of users, each with different representations.

The TF Clearinghouse sits above the Community Update process. The community update incorporates selected transportation features from the clearinghouse into a proprietary database. The Metro Case Study will be the most likely candidate to incorporate and test the GDT program as a component of the broader Internet Clearinghouse concept discussed below.

TIGER Modernization

The U.S. Bureau of the Census MAF/TIGER Modernization Study (http://www.census.gov/geo/mod/maftiger.html) 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 data base, 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.

The modernization study says "more accurate base map will alleviate a publicly perceived problem with census geographic data and also facilitate digital data exchange with federal, tribal, state, local, and private partners. Sharing of geospatial data will improve relationships with partners and ultimately enhance the Bureau's geographic programs."

Like the GDT Community Update Program, the Census Modernization approach assumes partners are content with the format and structures provided by GDT or Census. But they may not be happy with the street segmentation requirements of GDT or TIGER. They may wish to include pedestrian paths not contained in GDT files or may not want to segment at political or statistical area boundaries as in TIGER. These two partnering strategies illustrate the update problem for state and local transportation organizations. Each custodian of a GIS-T database wants local transportation organizations to report the data in their peculiar format. This type of partnering strategy is not a satisfactory solution to the transportation feature update problem. The Clearinghouse approach deals with this problem directly.

DATASHARING CLEARINGHOUSE AND TRANSPORTATION ORGANIZATION USER ACCESS PROTOCOL

GIS clearinghouses serve as repositories of spatial databases. The original GIS clearinghouses existed primarily as repositories of meta-data for various datasets located elsewhere. These have been established at various state and national agencies, including state libraries (NY), universities (Cornell) and national mapping agencies (UK Ordnance Survey). As our case study prototypes can demonstrate, it will not be necessary to limit the clearinghouse function to a single, centralized organization. Rather, it is more important to create an overlapping, purposely redundant hierarchy of linked clearinghouses, including the Community Update described above. In complex urban areas or complex resource counties, regional clearinghouses might be appropriate. These could function as a delegated clearinghouse for their region. In the remainder of the state, ODOT would be the clearinghouse for transportation centerline data. Linkages would have to be developed so that statewide queries, from BLM or a road database vendor could be handled solely by the state clearinghouse.

The transportation feature clearinghouses and user access protocol we have outlined below will allow the users to find and obtain road centerline data quickly and efficiently. The clearinghouse serves this function by not only being the physical location of the internet server, but by providing the "conceptual framework and operational platform for a fully functioning data cooperative." The organization of this clearinghouse data cooperative is diagrammed below. Through this clearinghouse protocol, agencies will be able to input and access transportation feature database updates.

The protocol is outlined below as two separate flows for clarity. Input occurs from local government agencies (city/county) to a regional clearinghouse or directly to the state clearinghouse, depending on location. Federal agencies (BLM and FS) will contribute directly to the state. The regional clearinghouse will input data to the state, while at the same time receiving updates of relevant data from the federal level agencies through the state clearinghouse.

Similarly, the retrieval access protocol demonstrates the flow of information *from* the clearinghouses to end users, represented as ovals. It is important, to note here that we have included end users such as emergency management systems (EMS) and national road database vendors. These are users for whom the clearinghouse protocol will have the greatest benefit. Here, the state serves as the primary source for all agencies seeking statewide coverage, while EMS organizations and other local government users will have need to access updates from the regional clearinghouse that covers their complete jurisdiction.

These Internet-based prototype spatial data clearinghouses will contain meta-data and search capability. This clearinghouse goes well beyond the exiting model of simply providing meta-data and information on how to obtain the data. The initial program will provide centerline data on all <u>new</u> streets and roads. Subsequently, the clearinghouse can be accessed for the complete system of street and road centerline data.

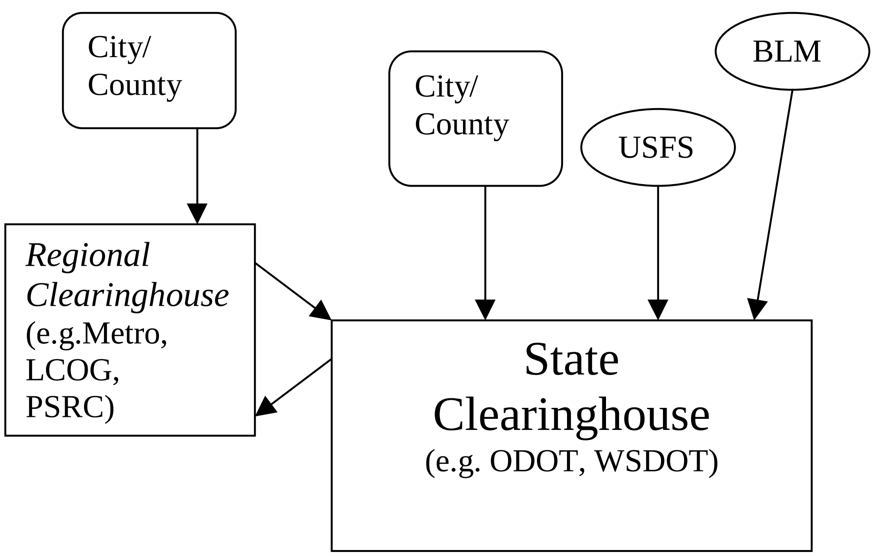
DAY-FORWARD IMPLEMENTATION/CASE STUDY RATIONALE

"Day-forward" is the implementation strategy that will be tested by the case studies 1 and 2 detailed below. Day-forward implementation occurs when the participating agencies submit on a regular interval data about changes to or new transportation features. This implementation strategy will be of great interest to vendors and application developers (refer to Community Update above) and for user organizations of road centerline vector and attribute data who need to have the most up-to date information. Currently, this updating occurs infrequently, or on an as-needed basis, and when it does occur, is costly.

Day-forward updating can take place at varying intervals/frequencies. This will depend on the level of road building and reconstruction activity, as well as the size and resources of the submitting agencies. Counties, with relatively few growing non-city areas will be able to submit on a monthly basis. A fast growing suburban Portland city, such as Wilsonville or Sherwood, would be encouraged/required to submit on a weekly basis. These areas will have the greatest number of new and altered transportation features. Within these constraints of input frequency, user organizations can update their databases on a frequent or infrequent basis, depending on their need for currency. They merely select transportation features for data that have been added since their last update.

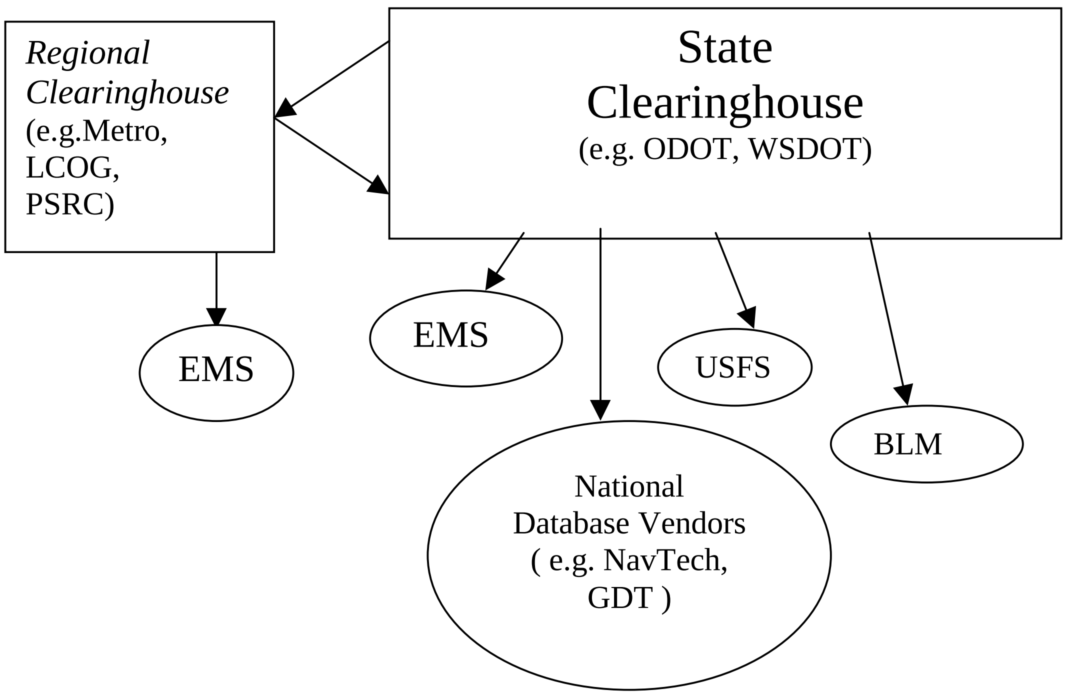
The day-forward implementation will take place using different clearinghouse concepts, which are diagrammed below:

Transportation Organization Input Protocol



The data retrieval process is diagrammed below:

Transportation Organization User Retrieval Access Protocol



Case studies 1 and 2 will fully demonstrate the day-forwarding implementation strategy at the state and regional levels, respectively. Case Study 3 calls for the creation of a road layer for salmon enhancement planning in a two-county, bi-state region as a pilot study for the Interagency Resource Information Coordinating Council (IRICC).

Case Study 1 calls for a day-forward implementation of new transportation features (TFs) in the three western Oregon counties of Marion, Polk, and Tillamook, and /or the three eastern Oregon counties of Wasco, Sherman and Gilliam. Transportation organizations within the counties will submit data to the state-level clearinghouse at ODOT.

Case Study 2 will feature a greater variety of agencies "day-forwarding" their data in the Portland metropolitan region. Many of these agencies already have GIS-T databases. Also, there is already an existing program of updating a regional Enhanced TIGER street centerline database. One objective of this case study is to improve that process. Another is to incorporate the GDT Community Update process into the implementation of the clearinghouse concept. The case study will also have to deal with a significant jurisdictional geographical overlap, as well as some TF overlap for major features such as Willamette River bridges serving city streets and state highways. As described above, agencies will be submitting updated data on different, but regular intervals.

In this case, Portland Metro will be the regional clearinghouse. Metro's Data Resource Center (DRC), has already established and maintains a Regional Land Information System (RLIS). Local agencies will jointly determine through working groups/technical advisory committees the level of voluntary and mandatory day forward updating. Transportation organizations that have statewide facilities, such as USFS and BLM, would submit their changes directly to the state clearinghouse, which in turn would disseminate the relevant data to regional clearinghouses. Similarly, national data users would turn to the state clearinghouse, and not have to go to each regional clearinghouse. The state clearinghouse would access relevant data from regional clearinghouses.

Local government agencies, such as Portland's Office of Transportation, will participate in the data sharing through the day-forward process. They are important contributors of data, as they are closest to the small, detailed changes occurring daily in the transportation system.

Case Study 3 will not be a day-forward implementation. Instead, the lead agencies will construct a comprehensive database from scratch, integrating data from various sources. The need in this case alone is to build a road database that relates bridges and culverts to their hydro and road features. The key point here is that design of this complete coverage of roads will be informed by the companion case studies on updating and maintenance. The day-forward strategy tested in case studies 1 and 2 will therefore be quite applicable to the IRICC study.

In addition, the case studies will test the approach of establishing a schema for Transportation Features and their identifiers, the common data model that holds the TF as the object of interest. Attributes of TFs are represented as linear and point events, and are located along a TF using linear referencing.

Each case study demonstrates different aspects of these important data sharing principles. Case Study 1 will demonstrate the statewide clearinghouse for the collection and dissemination of new transportation features. Case study 2 will demonstrate the delegation of this clearinghouse function in metropolitan areas, while at the same time allowing statewide users to access the data from the state clearinghouse. Case Study 3 will demonstrate the principle of enlisting state and local cooperators to construct TFs by registration and possible conflation of existing transportation vector data to USGS digital orthophoto quarter-quadrangles.

CASE STUDY ISSUES : LEAD AGENCIES AND STRATEGIES

There are currently three logical lead agencies for the case studies. The Oregon Department of Transportation will perform the clearinghouse function for Case Study 1. ODOT will work with local governments to collect new Transportation Features (TFs) in Marion, Polk and Tillamook Counties. Similarly, Portland Metro will perform the clearinghouse function for Case Study 2, also involving the implementation of new Transportation Features (TFs) in the Portland metropolitan region as a more systematic approach to updating and improving the Enhanced TIGER street centerline file. Finally, Case Study 3 will address an immediate need for an IRICC Pilot Study to assemble all transportation features for two counties straddling the Columbia River, Klickitat Co. in Washington & Hood River Co. in Oregon.

The three studies will test strategies for GIS-T data sharing. The Strengths, Weaknesses, Organization and Inter-Organizational Cooperation of each case study will be discussed below, along with a discussion of the model used for each.

Strengths

The ODOT CaseStudy 1:

This would be a day-forward implementation to collect and distribute features from three Mid Valley counties. Day-forward allows implementation of a case study to “hit the ground running”; there is no need to rebuild or worry about previous, existing data. User organizations are responsible for cutting the TFs into links or segments suitable for inclusion in their application-specific databases. This ODOT administered case study also allows for the most complete test of the crucial ***ID assignment procedure***, which is the basis for a workable TF model.

Metro Case Study 2:

This study will also take advantage of a day-forward implementation. In addition, it provides the key test of acceptance of data from various sources, and allows dissemination to various Enterprise GIS, and to the state clearinghouse for GIS-T data. The urban road data in this study will be very diverse and extensive, and of high value to potential commercial venders road databases to produce temporally and spatially accurate and up to date products for address geocoding, vehicle navigation, emergency dispatch, and location analysis.

IRICC Case Study 3:

Finally, the IRICC Bi-State study includes multiple, overlapping natural resource-based counties. In this case two neighboring states are intertwined in regional salmon Endangered Species Act (ESA) listings issues. This is a highly visible and important issue. The salmon ESA listing is driving the need for road database information and "smart" maps. Current watershed/riparian mappings have a "dumb" roads infrastructure layer, whereas the need is for a more accurate and updateable representation of roads to relate to the existing hydro layer to assess road and stream relations, particularly at crossings.

Weaknesses

ODOT Case Study 1:
This is obviously *Not* Bi-State. Since one of the full tests of the TF concept is complete data-sharing among very "strong" agencies, this is at this time a drawback of using this study. Additionally, it is limited in geographic scope and is limited to new transportation features and thereby does not yield a complete database.

Metro Case Study 2:
The counties in this study area already have a procedure for updating their Enhanced TIGER file. The proposed approach may not be a major improvement. There is also some question as to a potential overlap of the proposed case study and the GDT Community Update program.

IRICC Pilot Study 3:
Unfortunately, for this case study, the Federated, Day-Forward Transactional Update model doesn't work. The entire database from shared and combined data needs to be complete and accurate in an end-state. There is thus a need to build a complete database from available data from various sources, but at the same time there is a need to fully anticipate update and maintenance requirements.

In addition, the counties are very rural, with no "critical mass" of road-feature rich urban/suburban areas to test "knotty", or potentially difficult TF issues. These may include complex freeway interchanges or "lollipop" suburban road characteristics. However, it does contain the full range of resource road issues. This case study will also address differences in data resources in the states of Washington and Oregon.

Organizations/ Inter-Organizational Cooperation

Each case study has a different set of participating organizations and inter-organizational cooperative arrangements. These are key variables that may ultimately effect the successful implementation of a case study

ODOT Case Study 1: This study will involve ODOT and the GIS departments of the participating cities and counties, and federal agencies. ODOT will perform the role and duties of the central lead agency, with some clearinghouse functions dealing with transportation organizations of various levels of GIS sophistication.

Metro Case Study 2: Metro and the cities and counties of Multnomah, Washington and Clackamas will be the participatory agencies. Metro Data Resource Center (DRC) is the lead, with local agencies forming Technical Advisory Committees (TAC) or working groups similar to IRICC/ORBITS. This will be a test of converting from an approach of constructing a new "edition" of the database to updating with a transactional approach.

IRICC Case Study 3: This pilot includes the states of Oregon and Washington, the regional offices of BLM, USFS, USGS, and Klickitat and Hood River Counties. The nature of the pilot, building a road database using the Enterprise GIS-T model, will require one dedicated lead agency, and the cooperation of subordinate agencies. Then an application-specific database will be constructed.

Model

The Enterprise GIS-T data model (Dueker & Butler, 1998) has been identified as a promising approach for update and maintenance of GIS-T databases (Dueker & Butler, 1999). This is a solution that these case studies should allow us to demonstrate in a "day forward" implementation by submitting data about new or changes to transportation features.

With this model in mind, what follows is a brief summary of the sharing and update web-based server architecture.

ODOT: The ODOT study will use a "federated" approach; county GIS data will be shared. The study will use the transactional day-forward update system using Common Object Request Broker Architecture (CORBA) and the linear locational referencing system (LRS) datum.

Metro: Similarly, this study will use a federated client-server transactional day-forward updating model, with CORBA and the linear LRS datum.

IRICC: The major difference is with the IRICC Pilot. Due to the nature of the database issues, the federated model described above will not work. The salmon habitat analysis requires reconstructing/ building complete database; a workable Format is still being developed.

The three case studies outlined above with their key features offer dynamic and exciting potential for the implementation of sharable data out new transportation features in an update GIS-T-based application that can serve the diverse needs of transportation organizations and users of transportation centerline data.

CONCLUSION

To restate: The ***challenge*** is to <u>*establish means of data exchange*</u> among these disparate representations that lead to improvements in accuracy, consistency, and completeness.

And more importantly in the long run, is the *need to share updates* to maintain currency in representing the transportation system. At the same time it is important to recognize the legitimacy of specialized representations needed to support different applications.

As our case study prototypes can demonstrate, it will not be necessary to limit the clearinghouse function to a single, centralized organization. Rather, it is more important to create an overlapping, purposely redundant hierarchy of linked clearinghouses. In complex urban areas or complex resource counties, regional clearinghouses might be appropriate. These could function as a delegated clearinghouse for their region. In the remainder of the state, ODOT would be the clearinghouse for transportation centerline data. Linkages would have to be developed so that statewide queries, say from BLM or a road database vendor could be handled solely by the state clearinghouse.

Implementation of three case studies will allow the testing of the efficiency, effectiveness and equity of the database clearinghouse concept.

Efficiency: Efficiency will be greatly enhanced with the day-forward concept. Users will have the *choice* of how often they would like to "dip in" to the clearinghouse database. Increased completeness, accuracy and timeliness of data leads to and promotes efficiency gains to participants.

Effectiveness: Seamless, integrated databases. Increased effectiveness also implies being able to go *beyond* existing tasks and functionality, to performing tasks and analysis not yet being performed or yet possible! Case Study 3 will demonstrate the effectiveness of the shared database at aiding the salmon habitat quality assessment mandated by the ESA listing.

Enterprise Equity: There is growing concern over the proper use and sharing of public, or government-maintained GIS. The case studies will demonstrate a model for allowing both public and private access to these clearinghouse data. A premium can be charged for more frequent access to the clearinghouse databases.

PROPOSED ARCHITECTURE FOR THE TRANSPORTATION DATA CLEARINGHOUSE

It should be restated here that the purpose and functioning of the Clearinghouse is *not to* serve as a GIS in itself. While there is growing interest and use of internet-distributed GIS, and the Clearinghouse architecture would ultimately support such GIS functionality, for now the GIS will continue to reside with local user agencies. The Clearinghouse will utilize mapping as user-friendly interface tool, not as an actual GIS functionality. All responsibility and control of the databases will remain with their original contributors.

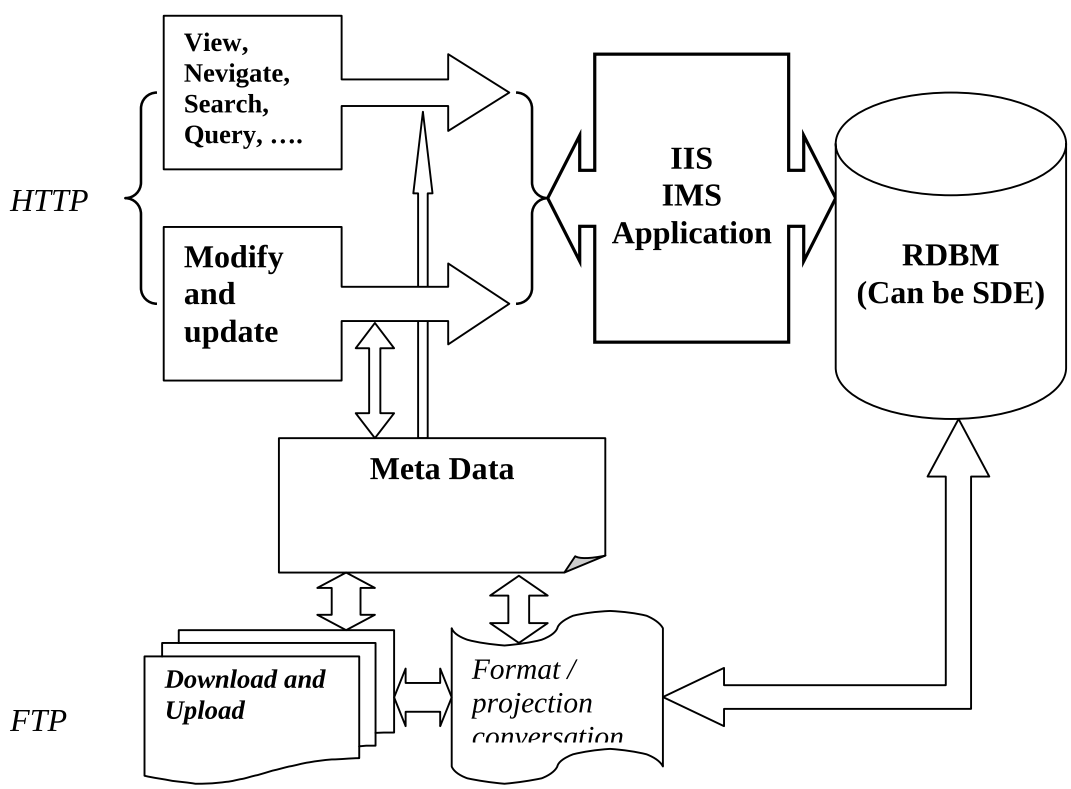
System Architecture Requirements

The major functionalities of the GIS-T Clearinghouse application should include but not be limited to the following:

- View and navigate the data, including the standard functions such as query, search;
- On-line submission of data;
- Data format and projection conversion;
- Data upload and download;
- Meta data.

With the view function, user should be able to navigate the data, view the data and see whether it is the data they want. "What you see is what you get" is the principle of viewing data function. With on-line modification and update function, users should be able to modify the data, correct the errors, and update their data. Data format conversion and representation functions will provide for translating the data into new formats. All the above functions are based on http protocol. The data download and upload functions will employ the ftp protocol. The meta data tracking the data history and recording the access to the data will be generated for user reference.

Users should be able to access clearing house by any commonly used Internet browsers. The Internet Mapping Server (IMS) is the core of clearing house application. Any of the ArcView MapCafe, MapObjects IMS (MO IMS), and ArcIMS can be used as the developing tool for these prototype case study applications.



The general architecture for our Clearinghouse case study transportation data clearinghouse is illustrated as the following figure.

- Users and providers interact with map server through the interface created by MO application (through WebLink class).
- A requests from an EMS clearinghouse user is passed into IMS through the application.
- IMS handles the requests and generates the appropriate commands that are passed to and carried through MO application. The result of the MO application is then posted to browser.
- Relational Database Management System (RDBMS), which could be the Spatial Data Engine (SDE), provides necessary data for the application.
- HTTP protocol is used for Clearinghouse data transaction while FTP protocol is be used to up/download the transportation data.

Clearinghouse Architecture