TRANSPORTATION RESEARCH

CIRCULAR

Number E-C046 October 2002

Using Spatial Data, Tools, and Technologies to Improve Program Delivery

TRB Statewide Transportation Data Committee Peer Exchange

AASHTO Data Task Force of the Standing Committee on Planning

March 23–24, 2002
Charleston, South Carolina

JAMES P. HALL, *Editor*

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSPORTATION RESEARCH *E-CIRCULAR*

Number E-C046, October 2002
ISSN 0097-8515

Using Spatial Data, Tools, and Technologies to Improve Program Delivery

TRB Statewide Transportation Data Committee Peer Exchange

AASHTO Data Task Force of the Standing Committee on Planning

March 23–24, 2002
Charleston, South Carolina

JAMES P. HALL, *Editor*
University of Illinois, Springfield

TRB website:
www.TRB.org

Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001

Contents

Background

SCOPE

New spatial data, tools, and technologies are enhancing and streamlining transportation program delivery activities in many parts of the country. The Transportation Research Board (TRB) Committee on Statewide Data and Information Systems hosted a peer exchange to identify the kinds of spatial data tools and information that are most effective in delivering multimodal transportation programs. The optimum use of these tools in identifying and prioritizing programs and in improving program delivery was also explored. Results of the exchange provided findings and insights into what kinds of spatial data, information, tools, and technologies can yield the most value and benefit in improving transportation planning and program delivery processes for transportation agencies.

SPONSORS

The peer exchange was organized by the Statewide Transportation Data and Information Systems (A1D09) and the Data Task Force of the AASHTO Standing Committee on Planning. The FHWA Office of Planning and Environment provided funding.

PARTICIPANTS

Invitations were extended to members of the TRB Committee on Statewide Data and Information System and others who are involved or interested in implementing spatial data tools and technologies to operate, manage, and improve transportation programs within their agencies and departments. The following is a listing of the peer exchange participants:

- Rob Bostrom, Kentucky Transportation Cabinet;
- Carol Brandt, Bureau of Transportation Statistics (BTS);
- Frank DeSendi, Pennsylvania Department of Transportation;
- Stacy Fehlenberg, Environmental Protection Agency;
- Kim Hajek, Texas Department of Transportation;
- James P. Hall, University of Illinois at Springfield;
- Charlie Howard, Washington State Department of Transportation;
- Pat Hu, Oak Ridge National Laboratory;
- Jonette Kreideweis, Minnesota Department of Transportation;
- Susan Lapham, BTS;
- Ysela Llort, Florida Department of Transportation;
- Jim McQuirt, Ohio Department of Transportation;
- Charles “Chuck” O’Hara, Mississippi State University;
- Tom Palmerlee, TRB;
- Roger Petzold, Office of Intermodal and Statewide Planning, FHWA;
- Freddie Simmons, Florida Department of Transportation;
- Ron Tweedie, Consultant;
- Anita Vandervalk-Ostrander, Cambridge Systematics, Inc.;
- Ron Vibbert, Michigan Department of Transportation;

- Bill Walsek, Maryland State Highway Administration; and
- Daniel Widner, Virginia Department of Transportation.

FORMAT AND TOPICS

The peer exchange program included three opening presentations highlighting the role and value that spatial data, tools, and technologies offer. Subsequent group discussions and brief individual state presentations focused on:

- Specific examples showing how new spatial data, tools, and technologies have led to improved decision making, streamlined program delivery activities, and more comprehensive analysis of modal choices and alternatives;
- Issues associated with the implementation of new spatial data, tools, and technologies, including issues associated with integrating data with different scales and resolutions;
- Effective uses and applications of nationally available data sets; and
- The role of remote sensing and other emerging spatial data technologies.

Results of the peer exchange provided insights into what kinds of spatial data, information, tools, and technologies can yield the most value and benefit in improving transportation program delivery processes for transportation agencies.

The state department of transportation representatives were also requested to answer five questions as part of their presentations. Questions 1 through 3 focused on program development and delivery, because previous committee activities had emphasized the critical impact of spatial technologies on the delivery and use of transportation data for program decision making. The five questions were:

1. What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?
2. How are information and new spatial data, tools, and technologies helping you address the issues and factors?
3. Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?
4. What barriers or constraints have you encountered in gaining support for spatial data, tools, and technologies? How have you been able to secure the resources for these new data, tools, and technologies?
5. What do you believe are the critical pieces that must be in place to ensure success in this area?

INTRODUCTORY REMARKS

Ron Tweedie, facilitator of the peer exchange and past chair of the TRB Committee on Statewide Transportation Data and Information Systems, welcomed the participants. He reiterated that the purpose of the peer exchange was to identify optimum use of spatial data, tools, and information to facilitate decision making and to deliver multimodal transportation programs. Key groups represented at the peer exchange were the AASTHO Geographic

Information Systems (GIS) for Transportation Task Force, the AASHTO Standing Committee on Highways Spatial Information Task Force, and the Standing Committee of Planning Data Task Force.

The peer exchange started with presentations by upper-level administrators who directly manage program development activities. Subsequently, representatives from state departments of transportation presented synopses of their spatial analysis activities.

Florida Department of Transportation Perspective

FREDDIE SIMMONS
Florida Department of Transportation

YSELA LLORT
Florida Department of Transportation

Freddie Simmons, State Highway Engineer, and Ysela Llort, State Transportation Planner, for Florida DOT, presented their perspectives as upper-level administrators on the use of spatial analysis tools in program delivery.

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

- Reduction in resources,
- High number of assets,
- Escalating preliminary engineering cost,
- Delays caused by scope creep,
- Changes in technology,
- Need for coordinated data programs,
- Variety of databases,
- Redundant data throughout business areas,
- Various skill levels of users,
- Data integrity,
- Independent client "island" applications,
- Consistency in data reporting,
- Need for access for multiple users,
- Need for up-to-date data, and
- Data storage concerns.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

FDOT is primarily using two new tools: Geo-Referenced Information Portal (GRIP) and Florida Geographic Data Library (FGDL). These tools provide solutions to most of the key issues addressed in Question 1. They are breaking down integration barriers, facilitating dissemination of data to multiple users, and providing necessary management tools for all phases of project development, delivery, and operations.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

GRIP provides such data on a corridor as work program information, pavement conditions, video logs, crash data, traffic counts, aerial photography, contour maps, structure information, and many other types of information.

FGDL provides hundreds of data layers gathered from many state, federal, and local agencies. These include elements such as tax maps, aerial photos, wetlands data, census information, endangered species locations, vegetation types, historical sites, airports, rail corridors, traffic data, hospitals, flood plains, and hundreds more.

Both of these tools are now used by FDOT as planning and project development tools and in work program development.

What barriers or constraints have you encountered in gaining support for spatial data, tools, and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

Barriers and constraints for gaining support include

- Funding,
- Executive and user buy-in,
- Difficulties in quantifying the benefit–cost ratio,
- Maintaining focus,
- Resistance to change, and
- Coordination.

Methods used to secure resources include

- Determining user needs and gaining user support,
- Promoting needs to managers,
- Securing budget issues from legislature,
- Continual updates to management of progress, and
- Getting user support as development progresses.

What do you believe are the critical pieces that must be in place to ensure success in this area?

- New processes to provide a coordinated approach to collection and use of data,
- Better understanding of data needs for accuracy,
- Agreement on best method for obtaining data,
- Data availability to all offices,
- Determination of actual benefits,
- Cost savings,
- Improvement in data collection and utility,
- More efficient use of data,
- Improved safety in data collection,

- Maintaining executive buy-in,
- Securing continual funding,
- Education and training of users,
- Careful planning, cooperation, and coordination, and
- Aggressive implementation.

Washington State Department of Transportation Perspective

CHARLIE HOWARD
Northwest Washington Division
Washington State Department of Transportation

Charlie Howard, Division Director of the Planning and Policy Office for the Washington State Department of Transportation (Washington State DOT) presented a comprehensive overview of the implementation aspects of effectively incorporating spatial analysis technologies.

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

Key issues are

1. Lack of funding, which is tied to public perception of our effectiveness, efficiency and accountability, and our ability to convey our needs in a way that appeals to the public; and
2. The length and lack of certainty in environmental review processes.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

1. GIS and spatial data provide a means of creating a graphical representation of our program. Maps combined with images help us make our case for doing the right things, by showing where new funding will be applied to meet program needs. This has proven to be an effective means of communicating to the legislature and citizens on complex programs.
2. Maps generated from spatial data are included in web-based project summaries as a communication tool with the public. The map plays a key role in public perception that funding is being put to good use, as they can see what we are doing and where (http://www.wsdot.wa.gov/eesc/environmental/programs/envinfo/envinfo.htm and http://www.wsdot.wa.gov/projects/, and navigate to specific project pages from there).
3. Spatial data and GIS tools provide a means of helping us do the right things through planning and project scoping. Complex combinations of data from disparate sources can be integrated into the GIS environment to assist analysis of needs and scoping of solutions. The result is better decisions, because data relationships are more apparent in the graphical view.
4. GIS and remote-sensing-based information and technologies are increasingly available and used by our consultants in doing Environmental Impact Statements (EIS) for transportation projects. This has allowed better information to come to the project planning process earlier in the design.
5. Web-based GIS is being used to encourage and identify mitigation partnerships where beneficial environmental work has been defined. The Uniform Environmental Project Reporting System shows Washington State DOT project locations and environmental restoration, cleanup, protection, or enhancement projects that have either been funded or are proposed for funding. This can be used by transportation projects to find locations for mitigation that have been defined

and have existing support so mitigation negotiations and site design go better and faster (www.ueprs.wa.gov).

6. We are investigating the application of satellite imagery and remote sensing technologies such as light detecting and ranging (LIDAR) to environmental assessment. A pilot project has begun on I 405 through a U.S. DOT grant. The project will evaluate the quality of data and cost benefit of remotely sensed data in comparison with data traditionally used in National Environmental Policy Act of 1969 (NEPA) analysis.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

1. Maps prepared using spatial data and tools have been effective in communicating with the governor, legislature, and the public. These communication tools have helped in developing the consensus that we are doing the right things.
2. Spatial data and tools have been applied in the corridor planning process to overlay design elements on digital orthophotos. These are used to clarify the feasibility of alternative solutions and to display the results with a real-world reference. We have a specific example from the SR104 EIS in which these tools helped the project stay on schedule.
3. The Priority Array Tracking System GIS (PATS/GIS) provides a means of analyzing system needs in a spatial environment.
4. Maintenance has created spatial inventories of work items for managing operations. Polygons identify landscape maintenance needs, such as mowing and spraying. Point events identify catch basin locations. These inventories are used to identify resource needs for maintaining level of service and managing operations.
5. Intelligent transportation system (ITS) web applications such as the Washington State Ferry Vessel Tracking System and Traffic and Weather pages use spatial data representations to provide information to travelers and assist travelers in finding information about a given location. The Washington State DOT web site provides information on ferry locations, traffic surveillance cameras, weather conditions, and road conditions through map interfaces (http://www.wsdot.wa.gov/ ferries/commuter_updates/vesselwatch/).
6. The Monuments database is a web-based application to provide access to the Washington State DOT survey control network. Washington State DOT, local agencies, and private surveyors heavily use this database. The net result, while incremental, shows improvement in coordination between agencies achieved through common survey control (http://www.wsdot.wa.gov/monument/).
7. Environmental review summaries, as part of project summary, are supported by a custom GIS application that facilitates access to more than 70 GIS and remote sensing-based information themes collected from federal, state, tribal, and local organizations. The availability of this information and tool has improved the time it takes to complete a project summary, because the application reduces research time and targets field time. Although the time required naturally varies by the nature and location of the project, it was shown that using this spatial technology tool to complete an environmental review summary reduced the time required by up to 6 h. Additionally, the tool has promoted the statewide consistency and completeness of these reviews, generally improving project definition, cost, and schedules (http://www.wsdot.wa.gov/eesc/environmental/programs/envinfo/EGWbHome.htm).

What barriers or constraints have you encountered in gaining support for spatial data, tools, and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

1. Training and implementation. It is hard to keep staff up to date and interested in learning to use the technology, especially when technology is changing at the pace it does. For example, both GIS and computer-aided design (CAD) data can be viewed with either technology, but many users have not had time to learn that this is now fairly easy if certain standards are used.
2. User-friendly applications. Technology solutions that are easy to use and do just what you need are time-consuming and expensive to put into place on an enterprise scale. Some limited success has been achieved for targeted applications, such as for the Environmental Review studies. The cost and limited application have us looking at more general solutions that provide the same user-friendly characteristics.
3. Funding for data development. The funding to collect and build geospatial data, such as orthophotography, needs to be available during the earliest phases of project design.
4. Interagency coordination. Interagency coordination, cooperation, and funding for geospatial base data and to integrate data across agencies are challenging. Cooperative funding efforts often go awry when competing with individual agency priorities. This is sometimes overcome when the data logically supports a statewide or national governmental issue such as salmon recovery or homeland security.
5. Business relevance. The best way to get resources for any technology effort is to prove to key beneficiaries that the product will improve their ability to do their job and meet their goals. Too often databases are built without the end user in mind. As technologies evolve, such as remote sensing and GIS, it is unclear how they relate to transportation and so we wait. Demonstration projects are needed to add value for the transportation community.
6. Comfort with existing tools. DOTs have historically met their business needs using CAD and computer-aided software engineering (CASE). As we redefine the policies for transportation and integrate issues such as context sensitive design, congestion relief, and watershed approaches, the need for data on the larger landscape becomes more relevant. However, a barrier between software users still exists.

What do you believe are the critical pieces that must be in place to ensure success in this area?

1. Easy access to base data. Accessibility involves access to the software and data, tools to facilitate use of the software and data, training, and technical support. Accessibility is facilitated by standard location references that permit the pulling together of data from many sources. Keys to successful data accessibility include training in the use of standard location references, identification of data stewards with assigned responsibility for maintaining location references, policy that demands adherence to location standards, and enforcement of the policies.
2. Data clearinghouse. A collection of base data—including geo-referenced imagery, base maps, needs inventory, facilities inventory, together with metadata that describe it—is needed.
3. Interagency cooperation. Cooperative partnerships between agencies to pool resources enable development of better, more accurate data than can be done individually.

Washington state is pursuing this through the National Spatial Data Initiative framework data theme development. Development is under way for Cadastral, hydrography, transportation, and geo-referenced imagery. A committee of executives is forming to facilitate implementation of cost-effective, collaboratively developed spatial data management solutions.

4. System hardware. Adequate information technology (IT) infrastructure is needed to support spatial data tools. This includes standards for software, standards to define access to software and data, and network and server resources to handle large-volume spatial databases, especially images.

5. Regulatory applicability. It is unclear whether regulatory and funding agencies accept the resolution and accuracy for funding and permitting decisions. Further clarification could facilitate additional willingness to fund and support spatial data applications and technologies.

6. Funding. Federal and state agencies need to clarify when, where, and how it is appropriate to fund data and application development. Should specific spatial technologies be identified through reauthorization? Should IT funding be specifically identified?

7. Pilot projects. We continue to support the National Consortium on Remote Sensing in Transportation. These pilot projects are instrumental in helping the transportation community continue to evaluate the use of new and emerging technologies. We are starting to see the analysis and cost–benefit assessment from these projects.

Overview of Trends on the Value of Data

STACY FEHLENBERG
Environmental Protection Agency

Stacy Fehlenberg presented a description of the interagency efforts to streamline the NEPA process regarding the I-69 project. I-69 is an Interstate highway that was written into the Transportation Equity Act for the 21st Century (TEA-21) to connect the major U.S. centers, leading economic border crossings, largest seaports, and the growing air freight corridor from Canada to Mexico. She focused on the impetus for the effort, how the efforts were accomplished using spatial analysis, and how the participants are measuring success.

Key issues affecting the NEPA process were lack of early communication and coordination between the transportation and resource agencies. This lack of communication stems from the traditional method of planning transportation projects in which vast amounts of time and energy were invested in developing proposed alignments before consideration of environmental impact. By the time resource agencies saw the Draft Environmental Impact Statement (DEIS), no matter what concerns they might have had and however accommodating the DOT may have wanted to be, it was often simply too late to make major adjustments.

By sharing information on ecological issues during the preplanning phases, both types of agencies had the opportunity to coordinate their priorities while there was still time to affect them. This gave the resource agencies the chance to present their concerns to the DOTs while there was still time to consider them, and it also afforded the DOTs a chance to know the resource agencies' concerns before investing heavily in a plan that would be objectionable to the resource agencies later. This process streamlines the NEPA process so there are fewer surprises for the resource agencies during NEPA review, and hence less time and money spent by the DOTs trying to accommodate to their concerns. This saves both types of agencies time and money.

It was decided that this information sharing would be done via a GIS database. A spatial database could best compile, analyze, and present multiple agencies' data in a single, meaningful, interpretable database. The greatest constraint to this effort was lack of consistent, quality data in digital format. Another constraint could have been time to develop a methodology to analyze all the data, but fortunately, an appropriate one had just been developed. Also lucky was the availability of a GIS lab and the human resources needed to conduct such a large-scale analysis.

The critical components to make this effort work are avocation from top management on both sides, specific action plans, and the designation of a single agency and single person responsible for the production of the product. There were some steps that could have been taken to further secure the project, and lessons learned as well as successes.

One example of the success of this project is the routing around the Tahomey National Wildlife Refuge (NWR) in northwest Mississippi. The maintenance of a wildlife corridor between the refuges was considered vital by all resource agencies that worked in the Delta, and its disturbance would have raised considerable objection from the reviewing and commenting agencies. By sharing the areas of ecological concern with the DOTs and their contractors early on, the agencies avoided the bisecting of the Tahomey from the White River NWR.

Highlights of the State Summary from the AASHTO GIS-T Conference

ROGER PETZOLD
Office of Intermodal and Statewide Planning, FHWA

Roger Petzold provided the following summary of the results of the 2002 survey of state DOTs for the Geographic Information Systems in Transportation (GIS-T) conference.

- Most state DOTs utilize a Windows NT base operating system.
- There has been some movement to Oracle for the database management system (DBMS).
- Most have fully operational systems.
- Staff level and user support for GIS vary.
- Location of the GIS unit is split between planning and information services.
- It is difficult to retain staff with GIS skills.
- Most states use a 1:24,000 scale base road coverage.
- A major trend is emerging toward development of web-based GIS applications.

The 2002 GIS-T conference in Atlanta had 45 vendors and 400 to 500 participants, including state and local agency representatives. The theme of the 2002 conference is “Melting Down the Stovepipes.” Areas of focus for FHWA include safety, congestion, mitigation, and environmental streamlining.

Texas Department of Transportation Perspective

Kim Hajek
Texas Department of Transportation

Kim Hajek presented Texas Department of Transportation's (Texas DOT's) perspective on the use on spatial tools in program delivery. Currently, Texas DOT annually submits the Unified Transportation Plan (UTP) to the Texas Transportation Commission. The UTP includes projects scheduled for the current calendar year and an additional 3 years. The current value of the UTP is $12 billion, approximately $3 billion a year over 4 years.

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

- Addressing the current backlog, now more than 30 years;
- Need for accurate data linked to a linear referencing system (LRS);
- Locating gaps in the program (projects let and not let);
- Addressing project priority shifts to
  – Governor,
  – Legislature,
  – Transportation Commission, and
  – Public;
- Addressing known environmental issues such as
  – Burial grounds,
  – Historic artifacts,
  – Animals or plants on the endangered species list, and
  – A contingency plan to address unknown events;
- Reducing confusion among cities, counties, and metropolitan planning organizations (MPOs) on program delivery; and
- Maximizing available funding for building projects.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

- Addressing current backlog,
- Producing accurate data with LRS,
- Locating gaps in the program,
- Shifting project priority,
- Addressing environmental issues,
- Reducing confusion in the public,
- Maximizing funding,
- Redesigning the program using GIS to shift focus to corridor-based development,

- Reducing the number of UTP categories from 34 to 12 and providing clear rules about categories to facilitate planning (environmental, right-of-way, use of maps to locate projects), development, and construction of the program,
- Redesign of data entry screen to include the LRS component,
- Determining what projects exist within a given corridor and which ones have been let or not let,
- Use of project sequencing within corridor segments to obtain better financing with FHWA and bids from contractors, and
- Identifying known environmentally sensitive areas.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

The Trans Texas Corridor is a project to advance Texas on a new multi-use statewide transportation corridor that moves people safely, efficiently, and more reliably, and improves our quality of life. Its features are

- Up to 4,000 mi of new road with a 1,000-ft corridor width,
- Rail corridors,
- Public utilities,
- Cost of $175 billion, over 30 years, and
- Financing from tolls on cars and trucks and fees for freight and passenger trains and electric, gas, oil, and telecommunication lines.

Advantages resulting from the Trans Texas Corridor are

- Relocation of flow of hazardous material away from urban areas,
- Reducing the number of cars and trucks on the highways,
- Addressing air quality standards, and
- Support for economic growth.

What barriers or constraints have you encountered in gaining support for spatial data, tools, and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

- Determining the base-map level of accuracy,
- Determining the hardware and software environment for Texas DOT architecture (Environmental Systems Research Institute), and
- Identifying the relational database—“islands” of GIS data.

What do you believe are the critical pieces that must be in place to ensure success in this area?

- Education of administration and commissioners on benefits of GIS;
- Communication and coordination between divisions, districts, administration, transportation commission, legislature, and governor;
- Use of common hardware and software by all entities (state DOT, MPOs, cities, and counties);
- Linking of UTP projects in a GIS format (like corridors) using relational databases and GIS maps; and
- Delivery of the program to the public via the World Wide Web and regional public meetings.

Further information is available on the Texas DOT web site: www.dot.state.tx.us. The Trans Texas Corridor link provides information on the Trans-Texas Corridor, and the Revenues and Expenditures link provides details on the UTP.

Kentucky Transportation Cabinet Perspective

ROB BOSTROM
Kentucky Transportation Cabinet

Rob Bostrom's presentation focused on the organizational aspects regarding the application of GIS technologies.

KENTUCKY PERSPECTIVE

This perspective includes (1) some background on Kentucky's organizational approach to GIS and spatial data and (2) a response to the five questions identified by TRB for the Peer Exchange. Responses to questions are from three different groups: the Division of Information Technology, the Programming Branch, and the Division of Planning. The source of the responses is shown in parentheses after the paragraphs below.

KENTUCKY GIS ORGANIZATION

- GIS Office. This group works out of the Governor's Office of Technology (GOT). See web site at http://ogis.state.ky.us/.
- Transportation Cabinet, Division of Information Technology. This group of three people is in charge of software, documentation, supporting files, and training for GIS. They are also in charge of the Highway Information System (HIS), the Oracle database for data going into GIS. It includes more than 300 attributes and will go to EXOR this fall. The user manual describes the system in great detail.
- Transportation Cabinet, Division of Planning. This division is in charge of creating the GIS base maps. The base maps are 1-m accurate based on Global Positioning System (GPS) work done by the local area development districts. This division is in charge of HIS data collection and GPS data collection and is responsible for quality control (QC). Guidelines for GPS data collection are attached.
- Transportation Cabinet, Division of Programming. This division is in charge of the cabinet's 6-Year Plan, which is the "bible" for scheduling and tracking projects. This division has an Oracle database that is used heavily for GIS inputs. It has been a leader in GIS applications for the cabinet.

There are approximately 140 GIS users in the cabinet, and every division now uses spatial data. The district offices are also starting to use GIS. The cabinet's consultants make heavy use of GIS.

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

The key issue affecting program delivery is delays in project schedules. These delays are due to a number of factors, including overly optimistic original project schedules, delays caused by environmental issues, and shifting of personnel to higher priority projects.

Inefficient distribution of information is still a problem. For example, design changes are made in a road alignment. This adjustment moves the alignment outside of the areas evaluated for environmental impact. Without effective information flow back to the Environmental Division, the project is stopped for reevaluation later when the realignment is discovered. A centralized method of sharing spatial information (GIS) would mitigate this factor.

Lack of complete statewide information remains an issue.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

We are bringing more and more information into GIS so that people can quickly evaluate information and make more informed decisions. For example, the archaeologists now have GIS tools so they are saving between one half and two days' work in preparation for projects as compared to the past.

The use of GIS can quickly identify where data gaps occur.

We have GIS capabilities to link real-time data from the Oracle Preconstruction Project Status System, and this information is used for management reports, public presentations, and internal project tracking.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

The high profile corridor project I-66 has used GIS heavily (see report on web at http://www.kytc.state.ky.us/planning/I-66%20report/I-66er.htm). GIS was used to help build mapping to facilitate public meetings and discussion.

Planning has also moved to GIS-based mapping (http://www.kytc.state.ky.us/planning/gisourky/index.html), and this is greatly increasing efficiency in map productions and shortening the cycle between major mappings of information.

Program Management is also using GIS to help build the 6-Year Plan. See web at http://oraweb.kytc.state.ky.us/sypbook/owa/swb$.startup.

Planning has used GIS successfully for the long-range (20-year) plan. See web at http://www.kytc.state.ky.us/planning/STP.htm.

The use of new technologies provides the means for preparing several preliminary alternate alignments for projects, which can be quickly analyzed to determine relationships to environmental concerns and preliminary roadway quantities. This provides the capability to review more alignments and help identify major concerns earlier in the planning phase.

Other examples of GIS usage include traffic models using TransCAD, Census Support/TAZUP using Maptitude, corridor studies, and map display, such as count maps that are copied from GIS to PDF (e.g., see http://www.kytc.state.ky.us/planning/Count_Maps/count_maps.htm).

What barriers or constraints have you encountered in gaining support for spatial data, tools, and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

The biggest challenge is cultural. Many people fear change. If you can show the users how their jobs will be easier or better, then most will accept it. The cabinet has a clear commitment to capturing spatial data. The real challenge is in building it so that it can be shared enterprisewide.

There is also a high learning curve associated with these technologies. We have to help guide and train the users so that the technology can be more easily incorporated into their work processes.

Our constraints have not been from lack of new resources and technologies but have come from the lack of buy-in from project managers in keeping project information updated in our Oracle Preconstruction Status System. Having the GIS capabilities has helped convince the project managers to keep data updated, because they are seeing exhibit maps and reports being provided to management personnel.

What do you believe are the critical pieces that must be in place to ensure success in this area?

The individual agencies need to be better informed about the "big picture." We are constantly making decisions to create a "quick-fix" that ends up creating more work in the long run than if we had taken more of an enterprise approach.

We must ensure that our employees stay current on new technologies, by providing required training and new software and hardware. We must let our employees think outside the box, so they will develop new and better ways of doing their work, which will help us in the overall project and program delivery.

MANAGEMENT SUPPORT

Historically, data collection has been viewed as a necessary task, but as a less important, sideline activity that can be done by underutilized, undertrained staff who are also perceived as less than important. This has changed in recent years as a result of the cabinet's putting a higher priority on data collection, GIS, GPS, and other related activities.

RESISTANCE TO CHANGE OR BUILD SHARED SYSTEMS

In the past, data collectors themselves have been reluctant to implement new techniques or technology. "We've always done it this way" is still heard. Ownership has been fragmented because each of the 12 districts has a unique way of viewing or addressing data needs. This mindset has been eroding over the past few years. Middle and upper management understand the need for data for accountability, for gauging the performance of the highway system, and ultimately for improving the highway programming process (planning).

Maryland State Highway Administration Perspective

BILL WALSEK
Maryland State Highway Administration

Bill Walsek presented Maryland's perspective on the application of spatial technologies and on developing an agencywide spatial resource.

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

Highway projects are increasingly being evaluated from multiple perspectives. Although providing additional highway capacity to handle the growth of travel is still the major driving force that spawns the idea for a project, other criteria frequently play a significant role in determining what will be built. Highway projects are being evaluated not only on the basis of their potential to move people but also on their societal impacts.

In examining a project's impact, emphasis is placed upon notifying the potentially affected public and soliciting comments on the project. Additionally, assessments of the project's impact on the environment and nearby historical and archeological resources are important determinants of the final scope of the project.

Maryland's attempt to manage and limit suburban sprawl has resulted in the enactment of legislation collectively referred to as Smart Growth. The central idea behind Smart Growth is that the state and local governments cooperatively identify boundary areas in which there are existing sizable development and supporting infrastructure. These geographies are called Priority Funding Areas. Development growth is encouraged to stay within these defined limits by the state's refusal (with limited exceptions) to fund highway projects outside of these boundaries.

Lastly, the Maryland State Highway Administration is increasingly viewed as having not only a role in building and maintaining highways but also in managing the operation of its highway system. Over time this role has grown in importance as the growth of the state's population and vehicle miles traveled (VMT) has outpaced that of highway capacity growth. The agency has an advanced traffic management system (ATMS), called CHART, that monitors traffic flows over the major highway routes and responds to congestion and delay-causing incidents and helps restore the highway system to normal condition.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

Most of these issues and factors require relevant data to be assembled and used to evaluate how a project might potentially impact one or more segments of society. Before having an online agencywide GIS, these data were in scattered locations and differing formats, and aggragating the data was a time-consuming effort.

The agency's GIS, delivered to more than 450 desktops via the network, is now

- Reducing the time for
  - Aggregating data—from 1.5 weeks to 2 hours for environmental data,
  - Identifying and notifying the impacted public—from 8 weeks to 4 hours,

  - Analyzing cumulative impacts,
- Improving the quality of analysis, and
- Boosting the confidence of key decision makers.

The CHART system uses GIS to both provide the traveling public with real-time map displays of highway system conditions and give operations management mapping of key resources (snow plows, emergency response vehicles) and highway system conditions during weather-related events.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

Having the state's tax map and assessment database as a GIS spatial layer has greatly reduced the time to identify affected property owners and create a database for project mailings. What used to take about 8 weeks for a major project now only takes about 4 to 6 hours.

Having more than 25 environmental, cultural, historical, and other spatial data sets accessible to everyone on an agency server has greatly reduced the time necessary to identify the broader impacts of a project. What used to take about 1½ weeks to assemble by manual means now can be done in about 2 hours.

What barriers or constraints have you encountered in gaining support for spatial data, tools, and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

In Maryland we have been fortunate that senior management was an early advocate and supporter of developing spatial data tools and services. Senior management envisioned GIS as an important component of the project development process and actively pushed the agency toward creating these tools.

As a result, Maryland's barriers to GIS development were related more to aspects of building a GIS capability. Activities that were key to this effort were

- Developing a long-range GIS strategy—securing technology, organization, and funding;
- Developing a technology infrastructure
  - Networking the agency,
  - Building the GIS data warehouse, and
  - Building an easy-to-use GIS analysis tool;
- Obtaining funding; and
- Fostering a culture of data sharing.

What do you believe are the critical pieces that must be in place to ensure success in this area?

Developing an agencywide spatial data resource is a major effort involving significant commitment of staff time and money. Without question, the active support and backing of senior management are critical to the success of such an endeavor. With this as a foundation, a long-range plan should be crafted and consensus reached on what should be built. The experience in Maryland revealed that the following were important contributors to the successful development of an agencywide GIS:

- Senior management support and resource commitment,
- Inter- and intra-agency data sharing,
- Creating a GIS section, a GIS data warehouse, and an agencywide GIS analysis application,
- Training,
- A networked agency, and
- A common LRS.

Pennsylvania Department of Transportation Perspective

FRANK DESENDI
Pennsylvania Department of Transportation

Frank DeSendi of the Pennsylvania Department of Transportation (PennDOT) reported on the specific application of spatial analysis tools in PennDOT.

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

PennDOT sees several key issues as affecting program delivery. One of the most frustrating critical path issues has been environmental review involving cultural resources. The department needs to coordinate with the Pennsylvania Historic and Museum Commission (PHMC) on cultural features. Reviews include archaeological and historic sites, their significance, and integrity. The PHMC is a very small commission, and processing is slow. But the biggest shortcoming has been the nature of the data. Most data are on paper only; folders are often in use and unavailable. Only one fragile set exists for the state. There are seven separate sets of maps, but none are comprehensive. Many of the materials are physically deteriorating. Access is restricted, compounded by availability only during normal business hours. Along with limited workspace and inherent travel time, the entire review process was fraught with inefficiencies, high costs, errors, and oversights.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

Spatial data tools have begun to liberate the cultural resource data. Although the database is not fully populated (the archaeology coverage is completely mapped, and historic buildings mapping will be completed by 2004), the use of spatial tools has essentially put the resources on one map. Therefore, the business practices of PennDOT environmental managers have changed dramatically. Maps are being served up across an Intranet. By clicking on a site, data items are available. Some digital data, maintained by the PHMC, were previously maintained on a large mainframe that required programmer time for reports. In a GIS-supported relational database, simple queries permit sorting or grouping. The environmental people are enabled to ask their questions. Spatial tools have led to early answers, estimates, and scoping. Maps can be taken to the field without assistance; better decisions are being made in minutes. Business practices at the PHMC have been greatly altered, too. Storing data spatially has imposed a rigor on the PHMC in the area of data collection and management. Previously, the PHMC looked at the data case by case. Now it can examine preservation, priorities, and eligibility from a broader perspective. The PHMC can now ask questions such as: is it important, how much effort do we want to put into preservation, is it the last one, how many in this region, and what is the long-term survivability of the property after reviewing the DOT program with spatial tools.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

Since the utilization of spatial tools began, communication with the PHMC has improved. Both sides are looking at the same information. The number of “gotchas!” has greatly declined. During consultations with the Museum Commission, it was common for the agency to point out that certain files or information was missed. Consultant fee savings are being realized. PennDOT staffs now serve as middlemen for cultural resource data. Department consultants are supplied with enough information to begin the environmental reviews without traveling to the PHMC to secure the data.

What barriers or constraints have you encountered in gaining support for spatial data, tools, and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

There have been few barriers or constraints in gaining support for spatial data, tools, and technologies. GIS activities at PennDOT were established and benefits realized when the cultural resource project began. PennDOT environmental staff and top management at the PHMC shared the vision of a cultural resource GIS tool. The department provided the financial and technical resources to plan, develop, implement, and support the initiative. The PHMC was a partner in the development of requirements. However, it was not always easy to keep PennDOT top management sold on the project. The first 4-plus years were devoted to putting information into the database. Therefore, no cost savings or gains were demonstrable to PennDOT senior management. However, they possessed the foresight to stay with the project and permitted it to proceed. The department has paid for the project with transportation planning funds. Additionally, the U.S. Army Corps of Engineers (USCOE) provided funding support. They encountered the same difficulties as DOT when they built dams.

What do you believe are the critical pieces that must be in place to ensure success in this area?

There are many critical pieces that must be in place to ensure success. The most important is continued top management support. A well-thought-out plan, from requirements to implementation, must be documented and progress demonstrated. Other issues, such as software development, training costs, and business culture, must accommodate the changes brought on by spatial tool utilization. Project management data must be integrated with the cultural resources data so both can be analyzed together. The data must be portable. Users need to take the data into the field, make modifications, and upload changes into the central database. The ultimate success will be the construction of predictive modeling algorithms. Additional data items such as orthophotography, soil, slope, and drainage must be current and available. Finally, the end user has to want to use the system. By developing a web-enabled friendly system, training time is minimal, and users will be inclined to take advantage of spatial tools.

Illinois Department of Transportation Perspective

JAMES P. HALL
University of Illinois at Springfield

James Hall of the University of Illinois at Springfield presented an overview of the application of spatial analysis tools in program development at the Illinois Department of Transportation (Illinois DOT). His background includes 25 years of experience with Illinois DOT, including enterprise implementation of GIS technologies in the Office of Planning and Programming. His views do not represent the official views of the Illinois DOT.

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

- Communication with districts, MPOs, local agencies, legislature;
- Integration of disparate databases with differing identifiers, including program management, pavement and structural inventory, crashes, and intermodal transportation databases; and
- Lack of spatial analysis tools for program analysis.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

- Integration of internal databases including roadway and structure inventories, roadway crashes, annual and multiyear programs, and maintenance;
- Integration of external data including archeological, historical, environmental, demographic, and land use data for program and project analysis;
- Presentation in understandable formats;
- Data verification; and
- Program analysis.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

Illinois DOT integrated the program, inventory, and highway crash databases through GIS-enabled immediate mapping of high accident locations (HALs). This provided a 2-year improvement in access to HAL sites, which enabled a more thorough and complete analysis of safety project selection. Estimated benefits due to the projected decrease in accidents are approximately $1 million annually.

What barriers or constraints have you encountered in gaining support for spatial data, tools and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

Development resources for GIS implementation efforts in Illinois DOT have generally been good with the following inhibiting factors:

- Competition with other information system efforts,
- Personnel turnover, and
- Multitude of projects with limited staff.

What do you believe are the critical pieces that must be in place to ensure success in this area?

- Top management support, encouragement, and leadership,
- Prioritization of projects based on agency interest and benefits,
- Funding and organizational commitment,
- Implementation plan with active Steering Committee,
- Enterprise implementation focus with communication of a corporate vision,
- Early development of high-profile and high-benefit applications,
- Encouraging and demanding user involvement,
- Active participation in GIS development groups outside the agency, and
- Encouraging and demanding use of data in GIS formats, which enhances data quality.

Minnesota Department of Transportation Perspective

JONETTE KREIDEWEIS
Minnesota Department of Transportation

Jonette Kreideweis presented the Minnesota perspectives on the application of spatial data tools and specifically in the streamlining of the cultural resource reviews.

INTRODUCTION

The Minnesota Department of Transportation (MnDOT) has been actively looking for opportunities to capitalize on spatial data, tools, and technologies for some time. There are a number of enterprise information projects under way to build a new location data model and convert the department's mainframe transportation information system (TIS) to Oracle and expand its mapping capabilities.

There also are a number of more specific GIS applications under development that are being designed to enhance aspects of the program delivery process. Like many states, Minnesota is involved in a major initiative aimed at streamlining the time it takes to plan, design, and construct highway improvement projects. This presentation will focus on two examples in which GIS-related tools are helping to improve and streamline MnDOT project development activities. The first example highlights an application that our department built in cooperation with FHWA to streamline the cultural and historical review process in Minnesota. The second example will show how MnDOT Metro Division personnel are working to develop an electronic environmental assessment worksheet that includes linkages to spatial data.

Mn/Model: Streamlining Cultural Resource Reviews Using GIS

For many years, our department experienced severe delays in obtaining approvals and clearance from the Minnesota State Historic Preservation Office. While some highway improvement projects required simple reviews of project documentation, others required very time-consuming and costly field reviews and surveys. In addition, there never seemed to be enough staff in our department and among partner agencies and external consultants to speed up the work and keep up with a growing construction program.

In response to this situation, MnDOT began working on a project called Mn/Model. It is a statewide GIS-based archaeological predictive model for Minnesota. Total costs were about $4.5 million, including geomorphic mapping. It was developed for our department with funding from FHWA over 5 years. Improvements and the programming for new layers of information are continuing, however at a much smaller scale.

Mn/Model is a tool that indicates the probability of encountering an archaeological site anywhere in the state of Minnesota. Its purpose is to help avoid impacts on archeological sites, to streamline the review process, and to focus expenditures for historic preservation on areas likely to yield the biggest benefits.

Mn/Model was developed using Arc/Info GRID and S-Plus statistical software. The grid cell size is 30 m, which is about the same resolution as the department's 1:24,000 scale base map. The model assumes that the present environment can serve as a surrogate for past environments. Values of environmental variables were analyzed using stepwise multiple logistic regression. The results of the regression model were applied to the existing landscape and classified into probability classes.

A number of factors were analyzed using GIS methods. For example, the presence of known archeological sites, land elevation, soil type, vertical distance to water, and distance to nearest stream sites were all calculated to identify areas that have a high probability for cultural, historic, and archeological significance.

GIS-based maps were developed to show the results of applying the model. Color gradations from gray (showing those areas with unknown site potential) to orange, red, and brown were used to show those areas suspected of having a medium or high probability for containing cultural and historic resources.

The map is used as the primary tool for site avoidance and survey design. It is useful because it makes explicit the extent of archaeological knowledge. As the results of more surveys are mapped, the gray (unknown) areas should shrink.

Working with the State Historic Preservation Office and the Office of the State Archeologist, MnDOT staff jointly developed consensus definitions for four primary categories of archeological constraints:

- Areas to avoid, which include Indian burial mounds and earthworks;
- Areas requiring control, which include National Register Sites and sites considered eligible for the National Register, with control involving the recovery of artifacts;
- Areas with limitations, including all other known sites and high- and medium-site potential areas in landscapes suitable for preservation, which will require field surveys before highway construction can commence;
- Areas with no known constraints, which include areas that have already been surveyed and have no known constraints and low site potential.

Mn/Model is used for project scoping, project review, and survey design for all kinds of projects, including new alignments, minor alignment changes, road widenings, bridge replacements, and corridor studies. District personnel involved in scoping studies consult with MnDOT archeologists.

MnDOT archeologists interpret the model and make recommendations to project designers, who, in turn, incorporate Mn/Model considerations into their designs.

The department uses the results of Mn/Model as the basis for a programmatic agreement with the State Historic Preservation Office. Based on Mn/Model results, decisions are made on which individual highway improvement projects will be subject to more extensive surveys and which will be automatically granted historical and archeological clearances.

Mn/Model has made cultural resource reviews more efficient. There is faster turnaround for project reviews. Fewer mitigations are being required, and fewer memorandums of understanding between our department and the State Historic Preservation Office are being written. As a result, the project has resulted in significant cost savings. Cultural and historical surveys are expensive, and in Minnesota, there are only certain times during the year when they can be done. If cultural and historic sites can be predicted and avoided early in project planning, it can greatly minimize field survey needs.

The response to Mn/Model has been overwhelmingly positive. It has demonstrated that archaeological predictive models can make an important contribution to cultural resource management. In summary, significant time and cost savings are resulting from

- Better data and tools for cultural resource reviews,
- Reductions in archeological survey costs via more focused design, and
- Design of projects that from the beginning seek to avoid impacts on archeological sites.

Additional information on the Mn/Model project can be found on the web at http://www.mnmodel/dot.state.mn.us.

MnDOT Metro Division's Electronic Environmental Assessment Worksheet

MnDOT Metro Division staff is taking the Mn/Model concept and applying it in a more generalized manner to prepare electronic environmental assessment worksheets for highway improvement projects. These electronic environmental assessment worksheets are hyperlinked to a variety of layers of environmental data that are being integrated and mapped through use of GIS tools and applications.

This effort began in response to several issues. First, MnDOT Metro Division project designers and planners were encountering project delays for reasons that came down to not having the right data at the right time. In addition, traditional project documents were time-consuming to prepare and costly, relied on a variety of inconsistent data sources, and were hard to copy and share. Project decisions were being held up because partner environmental agencies simply didn't trust or understand where MnDOT staff was coming from.

The solution has been the development of an electronic, online environmental assessment worksheet document. These documents are

- Prepared in Microsoft Word,
- Available on the web with features for sharing agency comments online, and
- Hyperlinked to GIS products.

The GIS products are based on data sources identified early in the process and mutually agreed upon by the environmental agencies that will be reviewing the document later. Data elements include

- Street series maps, aerial photos, and U.S. Geological Survey topographic maps,
- Soil surveys,
- Generalized current land use,
- Future land use,
- Water resources, floodplains, and wetlands,
- Elevation and soil types,
- Bridges, culverts, streams, and water erosion,
- Hazardous waste and identified contaminated properties,
- Accident data,
- Traffic volumes,
- Nearby resources, trails, and recreation areas, and

- Identified contaminated properties.

MnDOT Metro Division staff have used the new tools for several projects, and there seems to be great promise for streamlining environmental review.

CONCLUSION

These two examples show how GIS data, tools, and technologies are helping to streamline program delivery activities in Minnesota. They are successful for four primary reasons:

- They are specifically designed to address current problems, and they are producing measurable results.
- They focus on standardizing, sharing, and making available key data early in the highway design process.
- They use maps and spatial data to highlight specific areas where impacts should be avoided or minimized.
- They were developed in partnership with internal and external agency partners involved in process reviews and approvals.

Virginia Department of Transportation Perspective

DAN WIDNER
Virginia Department of Transportation

Dan Widner presented a summary of spatial analysis activities in the Virginia Department of Transportation (Virginia DOT).

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

Accessibility to Information

Much information remains today in "stovepipes" of data repositories that are limited in their accessibility across the enterprise. This is caused in part by the lack of implemented data standards and also by the lack of truly integrated information systems, both spatial and nonspatial.

Reliability of Information

Since not all data are accessible across the enterprise and not necessarily standardized, questions arise about the reliability of available information.

Disparate and Duplicate Means of Tracking Data

This follows the reliability of information issue noted above, as local-level personnel use the best tools available. This may not be consistent across the enterprise due to the variety of skill sets, abilities, and comfort with certain technologies. As information funnels downward to a single statewide source, processing time and data quality become issues that must be addressed, taking valuable time in the process.

Spatially Enabling Data Throughout the Enterprise

In a large organization such as the DOT, where data are distributed throughout the organization in many locations and formats, it can be difficult to consistently standardize location information so it can meet the demands of greater accuracy and precision that new spatial technologies are capable of offering.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

Standardization of Location Information, Facilitation of Access to Information, and Consistent Technologies

By standardizing location information across the enterprise, access to information is improved. This makes it easier to integrate a variety of data sources. Once data are integrated more uniformly, newer web-based technologies can provide a consistent approach across the board.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

Web Application for Priority Construction Projects

Virginia DOT is currently going through a reprioritization of its construction program due to budget reductions. Spatial data, tools, and technologies have been utilized to facilitate the decisionmaking process by providing ease of access to information and comparative capabilities in an intuitive and familiar map interface.

Web Enabling of Environmental Review Process

This is a top priority for Virginia DOT's environmental and data management organizations. A rule of thumb applied at Virginia DOT states that for each month of delay to each $50 million worth of construction projects, $166,000 is added to the cost of the project. Virginia DOT is working with natural resource agencies in the state to improve the ease of access to data and information using spatial data, tools, and technologies.

What barriers or constraints have you encountered in gaining support for spatial data, tools and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

Education In The Value And Utility Of Such Technologies

Quite often personnel who have never before had exposure to spatial data, tools, and technologies do not know the value that can be provided to their everyday business functions. Education and exposure are the keys to overcoming this deficiency.

Buy-In at the Highest Levels of the Department

It is absolutely crucial that management at the highest level understand and agree with the need to implement spatial data, tools, and technologies. This then has a ripple effect upon any budget requests and staffing needs for such implementations.

Demonstration of Tangible Results Help in Securing Resources

In the quest to secure buy-in for spatial data, tools, and technologies, a quick and effective demonstration of the power of such technologies helps tremendously in securing the necessary resources. Some rules of thumb are (1) choose simple yet powerful applications, (2) choose for obvious areas of need, (3) choose for ease of access and understandability, and (4) don't oversell your capabilities.

Understanding of the Time and Effort Required to Build Spatially Enabled Systems

Many potential end users lack an awareness of the level of effort involved with the development of spatially enabled information systems. This can create barriers and cause a lack of confidence in the tools and technologies.

What do you believe are the critical pieces that must be in place to ensure success in this area?

Suitable Communications Network with Adequate Bandwidth

As more and more spatial data become available, the necessary infrastructure must be in place to support large quantities of data. Raster data in particular require a large bandwidth. Virginia is in the process of developing a high-resolution statewide digital orthophoto base. How do you share such mass quantities of imagery with those who can most benefit from it?

User Accessibility to the Most Accurate and Timely Information Available

Ease of access to spatial data, tools, and technologies increases the availability of data that are both more accurate and more timely. The obvious advantages posed by the Internet point to this fact. A good example is the Geography Network of ESRI. By using the Internet, one can access spatial data without copying and without the necessary overhead of data maintenance.

Spatial Data Technologies and the Marketplace Must Be in Step

There is a crisis in expectation due in part to the marketing promises that have been given by software vendors and service providers. Often advertised toolsets are not as robust as advertised, or are unstable, which leads to software problems becoming a limiting factor in the implementation of truly integrated spatial data.

Michigan Department of Transportation Perspective

RON VIBBERT
Michigan Department of Transportation

Major program delivery issues in the Michigan Department of Transportation (Michigan DOT) can be characterized in two ways. First, is the ability to have design plans ready in time for contract lettings. This is a problem, as Michigan DOT decided several years ago to front load our lettings such that we would have plans available for lettings in the October–November time frame for the following construction season, instead of spreading the lettings over several months. Having larger lettings has enabled our contractors to have a better idea of the volume of work we will be requiring for the next year and thus better plan for their resources. As a result, we have found somewhat better project pricing as well. The challenge, however, is to have the plans ready. This causes "peaky" workloads. To some degree we have compensated for this by planning our programs 5 years in advance, so we can get started on our project development process in advance and can then take advantage of the long lead times to do the required design, right-of-way, and clearance work.

The second challenge is long term. Are we delivering the long-term performance goals we have committed to? Are our actions contributing to achieving the goals we've said we've wanted to provide to the public? And are we executing efficiently over time? Or are we visiting the same locations over and over?

We have been using spatial technologies in various ways to help resolve some of the longer-term issues, as the shorter-term ones are pretty much contained in our design process. They do use GPS for survey work, but that is farther along the process than where we've been using spatial technologies in the more programmatic decision-making processes.

Much of what can be said here sounds very much like the usual ads for GIS technologies. We have found that our data are analyzed differently when reduced to map form. Most of what we do has a spatial component, and like a picture, a good GIS-based map is worth volumes of text and numbers, making conclusions explainable to policy makers.

Additionally, our data quality has improved too. When people see their data on a map, we've found that they usually comment that "your GIS program is wrong." We then have to show them that it is their data that are goofy and *then* they go to clean it up. We have also gained further support for GIS/GPS activities by helping folks clean up the data and then showing them how to use GIS technology to keep the data clean.

Some of the more common areas where we've used GIS/GPS technologies are

- Environmental clearance. Our environmental clearance staff goes directly to our natural resources site to get maps of environmental features and environmentally sensitive areas. This speeds many of our clearance processes, and because we can reference our natural resources site in our analyses, our credibility goes up as well, while the whole map requesting process has been eliminated, at least with our department of natural resources.
- GPS surveys. We established 12 high-accuracy GPS stations for survey preparation. These are used to speed the survey process and help support the accelerated design schedules. We make these stations available to non-Michigan DOT contractors and other state agencies.

- High-impact project presentations. Every year our regional offices make presentations to executive management about those projects to be constructed in the next year that will have high transportation impacts on the public. These include projects that will constrain traffic and thus cause unexpected congestion, and those that will otherwise affect considerable traffic during construction efforts. The presentations are made with GIS support, because GIS allows presentation of the activities spatially.
- Call for projects. Projects are proposed for construction 5 years out. These projects are identified using a set of systemwide transportation goals, with each region's having a strategy identified for their use to meet the identified statewide goal. This requires system condition forecasts to be made.
- As-is and to-be states. Displaying the existing and future condition states, given the strategy and propose projects, is accomplished using GIS technology. Further, these maps are generated using data that project and systems managers enter into our project planning database, causing a high degree of confidence that the data being displayed are "live," and increasing the level of ownership of the data for each system manager. The impact on our GIS staff is that they must ensure the data are available in a form usable by GIS software and by regular, non-GIS users.
- Asset management data collection. Michigan DOT, in conjunction with our county and city political organizations, local technical assistance program, and several MPOs conducted a pilot pavement condition collection project in several counties. This effort used

  – Off-the-shelf GIS software (Caliper's Maptitude product ~ $400/vehicle),
  – Off-the-shelf GPS equipment (Garman, roughly $250/vehicle),
  – A standard portable, and
  – Our standard statewide framework products.

This effort collected pavement condition and rudimentary roadway attributes, such as number of lanes, pavement type, and pavement condition. As this information was collected using GPS, the information could be immediately displayed and then incorporated into our LRS for subsequent use by other data collection activities.

This pilot supports proposed legislation to collect pavement condition information annually on our Federal Aid system, to perform condition analyses, and to begin to direct expenditures through a Transportation Asset Management Council, also created by the legislation.

Much of our progress in implementing spatial technologies in the past has been the result of

- Not having standards, mainly an underlying GIS base map. The recent delivery of the state's Geographic Framework project has caused a flurry of activity, and we are overcoming this barrier because we now have a base for focus.
- Uncertainty about which GIS tools to implement. Each tool has its own set of advantages and disadvantages. We have found that empowering users with a GIS tool they can use, along with some minimal standards, user training, and subsequent support, goes a long way to building a GIS community. We've discovered we cannot have a cadre of GIS "priests" and still expect to succeed.

- Storage, distribution, and maintenance. They are always issues and continue to be. We are looking to implement Oracle spatial.
- Lack of GIS-savvy IT staff and IT-savvy GIS staff. Our GIS staff is primarily user-based, being expert in the use of the software to produce GIS based results, but not very familiar with data storage principles or methods. Conversely, our IT staff is not GIS/GPS-oriented. This is a stretch for them, as this isn't data processing and it's not report generation. This is a current hurdle we need to overcome.

We have been successful in garnering and continuing the support for GIS/GPS activities. This has resulted in a series of geographic standards and usable products and a geographically referenced LRS. We have spent the money to locate all our projects of the last 10 years or so and to provide a stable future base for referencing our roadway attributes and projects.

Other aspects of gaining and keeping support for GIS/GPS activities are that we have been able to show the payoffs of using GIS in current decision making and other business processes. We have focused on providing solutions, not technology, and we have been able to deliver on almost all of these.

Lastly, we have focused on enabling our users to use the technology and have made considerable efforts to extend GIS training to every region and local office. We then provide updates, basic data, and telephone support to make sure the capabilities we have created are current and useful and that our users can employ them. We have found that our users are advocates for future spatial activities.

Ohio Department of Transportation Perspective

JIM MCQUIRT
Ohio Department of Transportation

Jim McQuirt presented an overview of spatial analysis applications in the Ohio Department of Transportation (Ohio DOT).

What are some of the key issues affecting program delivery in your state or agency? For example, what factors are contributing to the delay of projects and programs?

Environmental hot spots (e.g. archeological and historical sites, wetlands, cultural resources, contaminated sites, etc.) and right-of-way issues can create delays in the delivery of projects and programs. Funding also has a major influence on what and when projects and programs are delivered, including the large dollar amounts that are expended on projects' preliminary engineering (PE), right-of-way, and change orders.

Identification of environmental hot spots historically has been accomplished through a manual search of paper documents or labor-intensive seek-and-find surveys. The paper documents reside primarily in two separate locations at the State Historic Preservation Office (SHPO) and the Ohio Department of Natural Resources (ODNR); they are one of a kind and in many cases are in poor condition. The inefficiency of compiling usable information from the paper documents results in higher program and project costs due to increased delivery times and errors and oversights that require revisiting environmental issues.

Revisiting right-of-way acquisition can delay programs and projects. Often the need to revisit is a result of changes in design due to missed items such as utilities, sewage systems, or environmental discoveries in the planning and NEPA stages. Lack of adequate data to effectively evaluate the impact of a project can increase costs through delay and acquisition costs.

Large dollar amounts are expended annually in PE and right-of-way activities ($40 million) and change orders ($50 million) in delivering Ohio's $1.2 billion construction program. Any savings in these areas could be used to increase the annual construction program. In addition, maximum utilization of available funds for program and project delivery can be drastically influenced by the types of decisions that are made in program and project development.

How are information and new spatial data, tools, and technologies helping you address the issues and factors?

Several efforts are complete or are under way to convert paper documents into formats compatible for use in GIS. Ohio DOT has jointly funded these efforts with SHPO and ODNR:

- In the past, archeological sites were located and the location was written on paper quad sheets. The records were located at SHPO and were indexed in a card filing system. Ohio DOT would have to locate sites of interest by using the quad sheets and the index cards. The needed quad sheets and associated typed inventory reports were scanned and copied, and the copies were returned to Ohio DOT for incorporation into the planning and environmental process. To improve this cumbersome procedure, a two-phase effort was undertaken to convert paper documents to a digital format compatible for GIS use. The first phase, creating a digital file of archeological sites and associated attributes, is now complete. The second phase of quality assurance (QA) and QC is now under way to resolve inaccuracy issues between maps and attribute databases; it is scheduled to be complete in 2003. QA/QC is complete for 22 of Ohio's 88 counties and is being used by environmental staff. It has significantly reduced time and costs for preparing site maps.

- Historical sites are handled similarly to the archeological sites mentioned above, and an effort is under way with SHPO to create a format for GIS use. This effort will be complete in 2003. It will also reduce time and costs for preparing site maps.
- A wetlands inventory was created from paper maps residing at ODNR. The wetlands were originally identified by ODNR using Landsat photos from the mid 1980s. Even though the ODNR interpretation of wetlands differs somewhat from those of both Ohio and EPA, the digital data have provided a very good planning tool and starting point for environmental work. As actual field surveys are completed for projects, the boundaries of wetlands are updated from location information obtained from mobile GPS backpacks.
- Similar efforts are under way in the location and creation of digital formats for underground mines (2004), bedrock topology and geology (2002), soil types (2006), and hydrography (pilot complete). As these projects are completed, it is anticipated that they will help to lower program and project costs.

New technology is also being investigated by Ohio DOT as a means of improving program and project delivery. A research project is near completion that looks at using low-altitude airborne multispectral scanning for preliminary analysis of highway project sites. It is anticipated that better and more cost-effective results can be obtained in identifying environmentally sensitive areas, such as streams, springs, ponds, wetlands, and field tiles; potentially hazardous sites; and archeological sites.

LIDAR technology is also being investigated to lower project costs for detailed mapping and design.

GIS tools are being used to analyze data from numerous other in-house data files on pavement and bridge condition, congestion, accidents, and highway sufficiency to help develop multiyear district and county work plans.

Are there one or two specific examples where spatial data, tools, and technologies reduced program delivery time lines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways?

Example 1

The Ohio DOT director recently testified before the Ohio Senate's Highways and Transportation Committee. His testimony was in preparation for the next biennium budget. The presentation consisted of our bridge and pavement analysis process; it impressed the committee and assured them that the state transportation system is in good hands. The analysis that so impressed the committee would not have been possible without the use of GIS and the department's Base Transportation Referencing System (BTRS) efforts to establish an enterprise data warehouse. That analysis enabled Ohio DOT to more clearly predict our system trends and conditions. The presentation came at a time when legislatures in some states were attacking their DOTs for inefficiency. The Ohio DOT instead was being held up as an example to all Ohio cities and counties seeking to improve their infrastructure management.

Example 2

GIS was used to integrate a variety of spatial data—soil, wetlands, land use, land cover ,and aerial photography with highway network—from different sources to help expedite a proposed project (GAL–Bob Evans Ave. on State Route 7) in the city of Gallipolis. The information was used as the basis for a Purpose and Need Statement for a proposed new transportation facility designed to alleviate congestion on State Route 7. The information was also used at several public meetings to gain support for the project, which had local opposition.

What barriers or constraints have you encountered in gaining support for spatial data, tools and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

Perhaps the largest constraint in implementing GIS in the past was the lack of a sound enterprise-level data warehouse. One of the major barriers originally encountered was the proprietary view of owners of the various system and/or datasets available throughout the department. Many of these issues and concerns were alleviated through the creation of a committee consisting of owners of all the major systems. It was called the BTRS Committee and was charged with developing recommendations on standards and policies for the development of an enterprise data warehouse that would facilitate integration with GIS.

Implementation of GIS in each of Ohio DOT's 12 districts has been a challenge. In addition to decentralization and other organizational changes, the department has reduced staff by nearly 1,400 employees, statewide. As a result of reduced staffing levels and increased district responsibility for program and project deliveries, dedicated staff for GIS related activities are not always available.

Ohio DOT has standardized on Sybase for our enterprise database; this has created additional challenges in implementing a GIS, because the major GIS vendors don't support Sybase to the level that other database vendors, such as Oracle, DB2, and Microsoft, do.

What do you believe are the critical pieces that must be in place to ensure success in this area?

Top-level management support is crucial to ensuring success, as is a clear and well-defined action plan. The action plan must be developed with input and consensus from all potential GIS users. An accurate, integrated, seamless, and easily accessible enterprise data warehouse with local maintenance is an absolute requirement for long-term success. Finally good software, application development, training, and communication are needed to ensure the current and future success of GIS.

Using Spatial Data, Tools, and Technologies

CHUCK O'HARA
Mississippi State University

Chuck O'Hara represented the National Consortium on Remote Sensing in Transportation—Environment (NCRST-E), one of four consortia funded by the Research and Special Programs Administration's program on remote sensing for transportation.

KEY ISSUES

- Funding in transportation agencies is shrinking, which places increased pressure on project delivery.
- Agencies are directed to streamline planning and assessment processes as well as other components of project delivery.
- Environmental assessment and other project planning and assessment processes can be streamlined using appropriate data.
- Geospatial data of appropriate scale used early in projects can significantly assist in planning, assessing constraints, and screening and presenting alternatives.
- Funds for enterprise data development, management, and analysis application development are very limited.
- Developing appropriate data and enterprise resources requires considerable investment and commitment by agency leadership. The competition for resources within agencies can be significant, and there is risk involved in investing in enterprise GIS IT.

DATA DEVELOPMENT AND MANAGEMENT ISSUES

Agencies must determine requirements for specific geospatial data types for different applications to increase resolution and collection rate and frequency:

- Basemap data (NCRST-E focus),
- Planning data (NCRST-E focus),
- Assessment data (NCRST-E focus),
- Design data,
- Engineering data, and
- Operations data.

DATA ISSUES

- Digital data libraries of geospatial data layers must be distinguished from the collection of operational time series or real-time information collected at locations.
- Geospatial data layers must be maintained, basemap and image data refreshed, and operational data collected at appropriate intervals to facilitate change assessment and decision making.

- To conduct GIS analysis of operation data, geospatial data must be available, attributed, and relationally linked to operational data. Therefore, geospatial base map data layers are a prerequisite for assessing operational data in the geospatial context.
- Look at data needs from a fresh perspective and assess the accuracies and tolerance that can actually be used in the construction process. Many of the practices taken as standards were developed decades ago and may not be appropriate today. Since very high accuracy measurements are expensive, overmeasurement can be very costly, so reexamination of measurement standards could have significant payoffs.

HELPFUL TECHNOLOGIES

New technologies make it possible to use geospatial data and information products in ways that are surrogates for, improve upon, or substitute for existing processes:

- New data technologies such as
  - Improved spatial and spectral resolution, and
  - Improved elevation data;
- Improved computational solutions;
- Improved data models;
- Improved data delivery and distribution strategies;
- Improved availability of real-time or near real-time data;
- Improved data visualization and presentations.

SPECIFIC EXAMPLES: INTEGRATING TECHNOLOGIES

Web-based access to map features and video log files raises issues such as

- How are images stored?
- How are they accessed by spatial query methods?
- How can they be effectively streamed?
- What can I use my existing IT resources to accomplish?

Web-based access to orthoimagery for feature assessment raises these questions:

- How can I store the imagery for thin-client access and use?
- How can I provide mosaics of large areas from high-resolution data?
- How can I assure the effective, efficient use of data to provide needed information?

Example Project: National Environmental Protection Act (NEPA) Streamlining, Randolph County, North Carolina

EarthData has a Research and Special Programs Administration–funded Technology Application Project (TAP) on NEPA Streamlining in Randolph County, North Carolina. Project partners include Mississippi State University (MSU), EarthData, ITRES Research, and North Carolina DOT. MSU was asked to develop research to accomplish the following tasks:

- Evaluation of new hyperspectral image, elevation, and hydrologic data;

- Development of enhancements for wetland identification methods; and
- Evaluation of the differences between traditional wetland mapping techniques for assessment.

What barriers or constraints have you encountered in gaining support for spatial data, tools and technologies? How have you been able to secure the resources for these new data, tools, and technologies?

Improved software and processing algorithms are needed to extract specific information products from geospatial image data.

Computational resources requirements for new data types, dense data, and large areas of coverage are poorly understood and underestimated.

Existing commercial solutions do not adequately deal with data complexities of new data types or quantity of data for large areas of coverage (e.g., web mapping, LIDAR mass points, and HIS).

What do you believe are the critical pieces that must be in place to ensure success in this area?

- Success stories must be appropriately validated, benchmarked, and presented to decision makers.
- Strategic partnerships and funding approaches are required to develop appropriate data resources. For example, Virginia is using Wireless E911 funds for aerial photography.
- Computational middleware is required for doing the heavy lifting of data processing and analysis to extract needed information.
- Data serving, storage, and archival will require significant IT development, investment, and planning for future needs.
- Technical outreach must match research support and IT resources with agency projects that seek to deploy new geospatial technologies.
- Technology reviews and case studies should be developed to improve technology transfer.
- Economics of geospatial data development and technology implementation must be better documented so that decision makers can balance cost with benefit in technology deployment.

The Program Manager Perspective

YSELA LLORT
Florida Department of Transportation

CHARLIE HOWARD
Washington State Department of Transportation

Ysela Llort, Florida DOT State Transportation Planner Highway Engineer, and Charlie Howard, Washington State DOT Division Director of Planning and Policy, presented their perspectives as upper-level program managers on the critical issues and spatial analysis needs raised at the peer exchange.

YSELA LLORT

- Institutional arrangements are critical to success. They are important from development through to upkeep (maintenance) and expansion of spatial data applications.
- Freight and logistics are a gap in these discussions.
- The genesis for use of spatial data is planning. It is now focused on environment and will likely move to operations. What institutional arrangements will expedite this transition?
- Who are the relevant federal partners, and how can they help? Who are the best contacts?
- How can we integrate expert systems with spatial data technology to help make decisions on project and program priorities? Several states are struggling with these systems.
- How can performance measures best be integrated with spatial data applications?
- There's a significant gap in modal integration. State DOTs need advice on how to guide private investment in other modes as appropriate.
- How can the quality of data be improved?
- How can we best deal with shared participation in data collection?
- Where should responsibility lie?
- Should the integrator of data set the data standards?
- Systems need to be relevant for future decisions. How much can we anticipate and plan for?

CHARLIE HOWARD

Concurred with Ysela's comments and added the following:

- There are always growing pains with the introduction of a new technology. The institutional evolution of GIS and spatial data usage are still being sorted out. A summary of successful examples would be useful.
- The transportation community needs better ways to use spatial data in multimodal applications. Transit usage in major travel corridors where capital project decisions could be affected is a significant need.

- Business needs have pushed the development of spatial data technology. Now the reverse is happening. The business community is often slow to pick up on the value of GIS in decision making. How can we best communicate potential applications?
- IT can now drive planning and operations decisions. We need good institutional arrangements to facilitate this process and maybe business process reengineering.

Common Themes of the Peer Exchange

At the conclusion of the meeting, the Peer Exchange participants developed a list of common themes centered on the five discussion areas. A primary list of common themes was also developed.

KEY ISSUES AFFECTING PROGRAM DELIVERY

- Decision Support, Network Analysis, and Executive;
- State, District, Local, and Public Communication;
- Reduction in Resources and Funding;
- Multimodal Issues and the High Number of Assets;
- Data Verification;
- Ad Hoc Product Generation;
- Length and Uncertainty of Environmental Review;
- Scheduling Projects and Scope Creep;
- Wide-Scale Project Analysis;
- Need for Coordinated Data Programs.

IMPACT OF SPATIAL DATA, TOOLS, AND TECHNOLOGIES

- Large Benefits from Improvements in Data Access, Speed, Communication Capabilities, and Decision-Making Products;
- Faster Environmental Review Process;
- Promotion of Data Integration and Verification;
- Improved Decision Support Products—Maps and Analysis;
- Data Warehouse Capabilities;
- Internet/Intranet Delivery to Many Entities;
- Access to External Geographic Information;
- Integration of Multimedia (e.g., Remote Sensing and Video);
- Preconstruction Status;
- Annual and Multiyear Plan Development and Presentation;
- More Comprehensive Analysis of Interrelated Information;
- Greater Ability to Develop Forecasting and Modeling Tools; and
- Improved Decision Making.

SPECIFIC EXAMPLES

- Access to Program-Related Information,
- Network and Modal Analysis,
- Inventory and Traffic Flow Information,
- Intranet and Internet Delivery,
- Improved Environmental Reviews,
- Corridor Planning, and
- Safety Data Integration.

BARRIERS AND CONSTRAINTS

- Enterprise and Organizational Issues—Turf,
- Business Process Change Difficulty,
- Technical Staffing and Support,
- GIS Product Coordination and Responsibility,
- Training,
- Difficulties in Quantifying and Communicating Benefits,
- Development of User-Friendly Applications,
- Funding,
- Inter- and Intra-Agency Coordination,
- End User and Decision-Maker Focus,
- Layering of Data—Compatibility Issues,
- Data Gaps,
- Data Quality, and
- Determining Critical Data Elements.

CRITICAL PIECES TO ENSURE SUCCESS

- Top Management Support and Department Vision,
- Staffing—Dedicated Team
- Funding,
- Benefits Analysis for Quantification and Prioritization,
- Technical and Consultant Support,
- Integration of Legacy Databases,
- Common LRS,
- Incremental Implementation,
- Participation in Peer Committees,
- Quick Payoff Products,
- Implementation Plan—Enterprise Approach,
- Easy Access to Data,
- Interagency Cooperation,
- Pilot and Prototype Development, and
- Funding.

LIST OF PRIMARY COMMON THEMES

- Benefits: Better, Cheaper, and Faster Communication to Deal with Complex Issues and, Present Them to a Diverse Audience;
- Top Management Support Uniform;
- Key Element for Higher Productivity with Fewer Staff;
- Next Level—Better Teaming of Management and Technologists;
- Essential Data from Outside Transportation (Transport Dollars);
- Different Organizational Scales
  - Individual Projects and Applications,
  - Enterprise Systems
    - Statewide Data Sets Served on the Web to Multiple Desktops,
    - Data sets of interest to more districts or more programs,
    - The Next Level—Integrate Technologies to Reengineer Business Processes;
- Lack of Clear Federal Role;
- Organizational Capacity Building
  - Best Practices,
  - Training,
  - System Interoperability, and
  - Consensus Standards Setting; and
- Proposed Research—Institutional Evolution of GIS.

DISCUSSION

There is a need for a "cookbook" package that could contain examples of GIS best practices and benefits in improving transportation development and delivery in transportation agencies. This body of evidence could be used by others to present and sell the benefits of GIS and other spatial tools. This could be accomplished by the committee or through an NCHRP Synthesis project.

Another Peer Exchange to follow up on the benefits discussion was discussed. The follow-up peer exchange could be held approximately 6 months from this Peer. Another discussion item could be the cookbook. Examples of benefits may include quantifiable benefits or benefits expressed as added value to the agency.

There was discussion of the need for an NCHRP project to investigate how business process reengineering must take place in state DOTs to better manage data for decision making using the constantly emerging spatial technology tools. Some items brought up by Ysela Llort should be investigated though this mechanism (e.g., inclusion of freight and multimodal considerations, institutional arrangements necessary for success, federal partner involvement, integration of performance measures, data accuracy, and data analysis).

An idea for another Peer was also discussed to examine the role of roadway information systems and why state DOTs collect what they do.

It was agreed that this committee is not the only body that has a stake in the topic of GIS and turning data into information for decision making. Others include AASHTO, GIS communities, and federal agencies.

Compilation of Benefits from Spatial Analysis Technologies

At the conclusion of the meeting, the Peer Exchange participants were instructed to develop a list of benefits accruing from the applications of spatial analysis technologies to agency operations. These benefits were identified by Peer Exchange participants and are not a comprehensive listing of benefits within their agencies:

BENEFIT CATEGORIES

- Environmental Analysis,
- Accident Mapping and Analysis,
- Roadway Inventory Data Management,
- Pavement Asset Management,
- Structure Asset Management,
- Public and Legislative Communications and Customer Service,
- Cartography and Mapping,
- Organization Communication,
- Internet Road Conditions,
- Maintenance and Operations,
- Right-of-Way and Land Acquisition Mapping,
- Construction,
- Plans and Records Management,
- Permits, and
- Aeronautics.

Environmental Analysis

The Texas DOT's Environmental Division also uses GIS applications for environmental assessment work related to noise barriers, wetlands, navigable waters, Indian homelands, historic registered sites, archeology, black-capped vireo habitat areas, Federal Emergency Management Agency–designated flood plains, impaired water bodies, Class IV wells, and air quality (Texas).

GIS is currently being used to analyze land use, traffic flows, and cultural and natural resources impacts, and to improve environmental documentation. District planners and predesign engineers are able to produce maps that show construction projects by year and those that are part of 20-year plans. GIS has increased the quality of the maps and reduced the amount of time to keep them updated. GIS has also enhanced access to large amounts and many different layers of data that were not easily available in the past. Additionally, it has improved personnel's ability to try more "what ifs" and improved their ability to create exhibits to aid in program and project discussions. Having statewide aerial, quad, county, and city maps online has reduced the cost and time of stocking lots of paper maps (Minnesota).

MnDOT has developed a GIS application called Mn/Model for archeological predictive modeling, natural resource mapping, and wetland inventory and monitoring. Mn/Model is helping MnDOT identify natural and cultural resource impacts at an early stage to better analyze alternatives or include mitigation efforts early in the project delivery. It is estimated that Mn/Model is resulting in savings of approximately $50,000 for each highway project and $25,000 for each bridge project included in the construction program that requires Phase I cultural resource surveys. In addition, Mn/Model has permitted the department to accommodate an expanding construction program without adding cultural resource personnel. In other environmental services activities, GIS applications are reducing the need for field reviews by allowing specialty staff to make preliminary evaluations using the data on servers. GIS has allowed them to prepare better exhibits to help designers and regulatory agencies. Overall, they say, their evaluations are quicker and at a higher level of detail than before (Minnesota).

In environmental and related reviews, access to more than 25 environmental, cultural, historical, and other spatial data sets for everyone on an agency server has greatly reduced the time necessary to identify the broader impacts of a project. What used to take about 1 ½ weeks to assemble by manual means now can be done in about 2 hours (Maryland).

Mapping smart growth areas and other issues, including sidewalks, is done with GIS, and would almost be impossible without it. All archeology and historical site information as well as threatened and endangered species information is available in the GIS DataViewer, and analysis would be very difficult without it. Census and environmental justice information is available in the GIS DataViewer, and analysis would be very difficult without it. Enterprise and empowerment zones information is available in the GIS DataViewer; and analysis would be very difficult without it. Project planning uses all these layers to analyze the potential positive, and negative, effects of a road project (Maryland).

GIS provides for the integration of environmental information in the preliminary design phase of a roadway or structure project. This environmental information include wetlands, endangered species, archaeological sites, park districts, historical sites, and water resource data. This information assists in obtaining appropriate signoffs from agencies by identifying projects within the geographic limits of sensitive areas. Efficiency benefits—$200,000 estimated annually—result from the rapid identification of the sources of environmental impacts for action in the preliminary engineering process (Illinois).

As impacts on the I-69 project, the I-69/Delta Framework GIS effort

- Provided consistent baseline environmental data to DOTs, contractors, and NEPA reviewers, saving time and money by eliminating duplication of efforts by each staff member;
- Shortened primary review time of scoping materials, DEIS, proposed alignments, and other NEPA documents by NEPA reviewers because relevant environmental data were available and on hand; and
- Identified ecological and programmatic priorities for natural resource agencies in the Mississippi Delta, leading to the development of proposals for the creation of large-scale enhancement projects, such as habitat and carbon banks and wetland restoration via TEA-21 funding. These projects (still in the pipeline) will be of exponentially greater environmental value than traditional highway mitigation efforts and streamline future highway mitigation procedures with established (and functional) banks and reserves (EPA).

Accident Mapping and Analysis

GIS is currently used to map accidents, identify locations with higher concentrations, and target safety improvement investments. This is resulting in better analysis and communication of potential project needs. MnDOT is also using GIS for data quality checks (i.e., an accident may be coded on a section of road, but coded to a wrong county) (Minnesota).

Accident analysis is sped up using GIS (Maryland).

Illinois DOT's Accident Mapping and Analysis GIS project provides the ability to display and analyze accidents on the highway network. This project is of major use to the department in program development and in roadway operations. GIS enables not only the display of HALs, but also the detailed evaluation of individual accidents at these locations. Examples of accident analysis GIS displays include roadway deficiencies, intersection analysis, collision diagrams, HAL identification, and rail crossing accidents.

The accident cluster sites are also analyzed with information from the roadway inventory files on parameters such as friction characteristics, lane width, and truck traffic. Other relevant information includes historical trends, fatal and personal injury accidents, and wet weather accidents. Efficiency benefits directly result from the automated and rapid preparation of HAL maps that were previously manually prepared (with a 2-year delay in usage). Efficiency benefits also result at the district level from the access to complete accident inventory and history. Effectiveness benefits (better decision making) result from the accessibility and use of more current accident information and the selection of the most appropriate high accident sites and remediation strategies for program development and roadway operations activities ($290,000 estimated annual efficiency benefits and $1,050,000 estimated annual effectiveness benefits) (Illinois).

Roadway Inventory Data Management

GIS improves data accuracy. Viewing maps as opposed to tabular reports makes the identification of data entry errors easy. Staff can look at a map and say, "We didn't do that there; we did that here." Improved data accuracy means better decisions are being made. Additionally, data QA/QC can be done in a highly productive manner (Pennsylvania).

The Illinois DOT uses GIS to access, display, and plot roadway, structure and rail crossing inventory information to verify data for the department's transportation infrastructure. Efficiency benefits accrue from reduction in effort in accessing inventory information. GIS also enables the mapping of commonly queried data elements, such as functional classification, roadway jurisdiction, and maintenance responsibility. Districts experience personnel savings through access and management of inventory information in a cartographic form. GIS enables more efficient maintenance of the spatial link/node base, which results in direct personnel savings. Illinois DOT uses GIS to submit the LRS base map to FHWA ($210,000 estimated annual benefits) (Illinois).

State and federal legislative district boundaries and urbanized area limits change with every new census. The work to prepare new maps displaying these boundaries was very time- and labor-intensive. These legislative and urbanized area boundary revisions resulted in a large number of changes to the road inventory data elements, which were very time-consuming for district and central office personnel to incorporate. GIS provides the capability to prepare work maps to develop new urbanized area boundaries. In addition, the digital incorporation enables the automatic conversion of data in road inventory for changes in functional classification, legislative district, and urbanized area. This results in significant central office and district personnel savings ($110,000 in benefits) (Illinois).

GIS helps verify the validity of generated average daily traffic (ADT) data with the raw traffic counts supplied by the district. The project also provides a direct GIS interface between the personal computer traffic count database and road inventory files. Benefits at the district level would result from the automated production of traffic work maps to check the reasonableness of raw traffic counts. GIS also enables the electronic preparation of traffic count maps for submittal to the central office for county and state highway traffic map verification and preparation ($120,000 in estimated annual benefits) (Illinois).

Pavement Asset Management

Zap-A-Map currently is used by pavement engineers to produce district maps displaying various pavement data for analysis (Texas).

MnDOT is using GIS as part of the pavement management system to map, analyze, and forecast pavement conditions and estimate needed treatment types and dates. GIS is helping staff prepare better exhibits faster to display the results and recommended treatments (Minnesota).

MnDOT is also using GIS to analyze and create maps for various traffic and roadway data sets. For example, one application maps data on 20-year cumulative estimated equivalent single axle loads (ESALs) and heavy commercial truck traffic to assist district materials and maintenance engineers in determining what materials to use for spot overlays and pothole repairs. This office maintains the department's roadway inventory, construction history logs, and other core transportation data (accidents, pavement, sufficiency, bridge, rail grade crossing, and traffic counts). GIS is helping them see data errors and conduct analyses. GIS also helps them map products that were not as feasible in the past for customers. GIS also holds promise in helping this area move more responsibilities for data maintenance closer to local government data sources, resulting in more timely and higher-quality data (Minnesota).

The Pavement Division puts together a report on the annual pavement activities with some maps describing where they were working and why (Maryland).

Illinois DOT uses GIS displays showing critical pavement performance and inventory characteristics to assist the planning and programming process. This includes assessment of pavement conditions such as the Condition Rating Survey (CRS) values, distress, roughness, and rut depth. Other analysis elements include historical condition values, latest improvement type, and location of backlog for pavement condition trigger values. Efficiency benefits result from the automated annual production of the CRS map using inventory data by district offices ($220,000 in estimated annual benefits) (Illinois).

Structure Asset Management

GIS is being used to map annual overweight truck traffic permit holders with the locations and restrictions on MnDOT bridges statewide. Users are able to instantaneously retrieve bridge hydraulic information on bridges over water using a custom-built GIS application. Bridge hydraulic personnel are able to view real-time waterway information to determine river flow and flood stage using a GIS application that ties to the USGS real-time gauge station network. This is used extensively during flood events in creating daily flood-stage maps for the state bridge engineer. Scour-critical bridges are mapped, and the flood plans are supplemented with a GIS application. District hydraulic personnel are able to create, store, maintain, and analyze data on nonbridge hydraulic features under MnDOT’s roads. Hydraulic engineers use specific sets of GIS data to aid in the development of hydraulic models for bridge and nonbridge hydraulic features. All of these examples lead to time and resource reductions due to the efficient and fast availability of necessary data to an individual's workstation (Minnesota).

The Illinois DOT uses GIS to display and analyze critical bridge and structure characteristics. GIS outputs include the identification of load ratings, structural deficiencies, inspection status, condition history, and the location of backlog structures. Also important is the analysis of functionally obsolete and structurally deficient structures. Efficiency benefits result from the automated visual identification of structures that meet certain structural analysis criteria, such as load rating, functional obsolescence, and structural deficiency. This project would also provide external benefits to local agencies ($87,000 in estimated annual benefits) (Illinois).

Public and Legislative Communications and Customer Service

The bridge locations from the department Bridge Inspection and Appraisal System (BRINSAP) database were ported into GIS. The bridges with load restrictions were identified and displayed as a point on the GIS centerline network. These locations were then published on the web as a Load-Restricted Bridge application. The application provides a way to communicate to the public the locations of hazardous structures. The use of the BRINSAP application system and the GIS network provided a much cheaper and faster way to communicate this information than would have been accomplished through field inventory. The project was completed in 3 months instead of the 18 to 24 months that would have been needed to inventory all bridges in the state (Texas).

Project-planning maps are a great communication tool for community meetings, and these are produced in GIS. Design files with imagery provide a great communication tool, as people can see what areas will be impacted. Using design files with imagery helps people make good decisions about where and how plans may affect the current conditions of the area (Maryland).

Spatial data technologies are especially effective at legislative, public, and media meetings. In particular, hard-copy maps help convey decisions to all levels of understanding. For example, legislators regularly compliment the spatial capabilities of the department during legislative contact meetings. They quickly grasp the roadway program in their district and frequently request maps to hang in the office. During a public meeting, a district engineer's decision on safety improvements at a certain intersection was challenged. Attendees believed a more pressing need existed elsewhere. The district engineer produced a crash map that supported his decision by showing a higher crash rate where the work was being done. At the same time, he showed that the department had already noted the same location the public had identified (Pennsylvania).

GIS provides user-friendly products. Maps enable the conveyance of information effective to all levels of understanding. They also are difficult to challenge. The public at a meeting was willing to accept a map as justification for a controversial decision. Data QA and QC are made easy by spatial data, tools, and technologies (Pennsylvania).

GIS improves customer service. The sum total of all the other benefits is improved customer service. The taxpayers are getting more productivity and better decisions for their money (Pennsylvania).

Cartography and Mapping

With the Texas DOT's GIS centerline network, the State Departmental map can be created in a shorter time frame, producing a time savings of 3 man-months and $15,000 annually.

With the GIS centerline map, District Control Section Maps can now be created in 3 weeks instead of in 6 months ($20,000 annually). Texas DOT's GIS centerline map, when combined with the TRM database (Texas DOT's LRS), is an invaluable tool for reviewing location data visually. Other examples of thematic maps generated from TRM include:

- Highway performance monitoring system (HPMS) sample maps for 25 districts to aid in HPMS field reviews;
- HPMS-LRS portion of HPMS submittal done in Arc;
- National Highway System maps; and
- Strategic Highway Network (STRAHNET) map (Texas).

Texas DOT's Travel Map is being converted to a GIS-based application. This will allow the Travel and Information Division (TRV) to have an accurate and current basemap for the 2.2 million copies of the Texas Travel Map printed annually. A detailed explanation of quantitative cost benefits for the TRV Travel Map project is detailed below:

- Decrease TRV full-time equivalent (FTE) time spent in duplicating data maintenance efforts ($5,000/year),
- Decrease TRV FTE time spent managing contract for manual cartography ($2,000/year),
- Discontinue existing contract for manual cartography services ($14,000/year),
- Produce maps within the division for use in other TRV publications ($10,000/year),
- Produce maps within the division for use in other travel business functions ($10,000/year), for
- Total annual cost savings of $41,000/year; and
- Estimated savings for transfer of attribution of centerline route data to TPP for use on departmental map ($42,000/one-time investment),
- Estimated savings for future HCR Web Site/GIS function/eKiosk projects ($270,495/one-time investment). (This savings is based on the transfer of technology and knowledge from this project to those mentioned. The total savings figure is the sum of hours spent in analysis and design processes and processes related to creation of data layers. Investment in analysis of current data flow, maintenance and update of cycles, design of effective data flow, identification of additional data layers necessary, creation of additional data layers, and development of in-house GIS knowledge will provide a solid basis for future projects.);
- Current estimated savings for rescribing entire Travel Map ($468,560/one-time cost) (This savings is based on the premise that if the map is not produced through digital cartographic means, it will be necessary in the near future to have the entire map rescribed using manual cartographic methods to provide consistent map quality and to ensure the ability to update and print new map versions. The estimated cost reflects current labor and production prices. It is expected that in the future, as persons with manual cartographic skills become more scarce, this cost will increase.); for
- Total one-time cost savings of $781,055.

Previously, Illinois DOT prepared most maps manually. Due to linkage capabilities to real-time information in the road inventory database, GIS enabled the automated production of the Key Route, Structure Number, Rail/Highway Crossing, and Functional Classification Maps. These maps are used extensively by many functional areas in the department. In addition, GIS provided the means to access the digitized corporate limits from the Illinois Department of Revenue rather than each municipality individually having to obtain updated annexation information. One additional cartographic benefit is the graphical display of annual changes in inventory information that accelerated normal cartographic production. For example, cartographers are able to rapidly identify and incorporate annual changes, such as road surface type, into the county map series ($310,000 estimated annual benefits) (Illinois).

The Aerial Photography Index GIS project provides a digital index of all existing aerial photography for the Illinois DOT Aerial Surveys Section. GIS enables a visual graphic showing available aerial photography at any location in Illinois. This information is displayed overlaying digital raster graphic quadrangle maps. Efficiency benefits result from a reduction in time of searching through mylar overlays to determine aerial coverages for a specific area ($55,000 estimated annual benefits) (Illinois).

Annual and Multiyear Program Development

The Annual and Multiyear Highway programs development process involves the extensive use of geographic information to make decisions on the selection and prioritization of roadway improvement projects. This process also involves the development of maps for public hearings and briefings with the executive office. GIS provides displays and work products to enable program development and promote communications among districts, the central office, and executive management. Efficiency benefits result from the automated preparation of maps displaying such items as project length and scope, legislative districts, program years, pavement condition, accident information, and structure status.

For effectiveness benefits, GIS enables the more efficient analysis and compilation of information from the separate files for more effective programming decisions. A major benefit is the more efficient selection of roadway resurfacing projects on the basis of forecasted pavement condition, resulting in increased pavement life and public serviceability ($340,000 estimated annual efficiency benefits; $2,000,000 to 4,000,000 estimated annual effectiveness benefits) (Illinois).

Transportation Data Analysis

GIS enables viewing data in a new way. Management has been freed from analyzing data and making decisions from tabular reports. Spatial tools make it easier to comprehend a large amount of data covering a wide geographic area (Pennsylvania).

GIS applications are being used to locate and track freight transfer facilities and analyze rail-grade crossing safety information. GIS has helped improve map products and perform studies faster and better than in the past (Minnesota).

Using GIS in analyzing and mapping transportation project investments has been key in helping MnDOT produce maps for the Statewide Transportation Improvement Program (STIP). GIS has increased the quality of the maps and reduced the amount of time it takes to keep them updated. GIS has also allowed them to access large amounts and many different layers of data they could not get at easily in the past, and it has improved their ability to try more what-if's and to create exhibits to aid in program discussions (Minnesota).

GIS increases productivity. As we are automating tasks, realizing savings on computer programming, and making better, informed decisions, we are getting more bang for our buck. Staff is available for additional duties and priorities (Pennsylvania).

Organizational Communication

Using GIS to improve coordination between functional areas in big organizations, such as MnDOT, can be difficult. For example, the functional area that completes pavement maintenance (such as mill and overlay) was not communicating well with the functional area that is in charge of pavement striping. There were times when a road was striped with expensive durables (which should last years), only to have a mill and overlay later that summer. Communication with tables and textual information was not enough. The GIS process takes the Access database maintained by the striping area, generates a metrowide map as well as individual maps for each subarea. The maps are distributed to the functional areas that maintain the pavement. This provides better coordination of effort and reduces the amount of rework, saving time and money (Minnesota).

MnDOT is using GIS to help locate radio tower placement and analyze options. GIS has helped improve map products and perform studies faster and better than in the past (Minnesota).

GIS reduces mainframe programming. PennDOT's GIS database works like a data warehouse. Regularly used data are extracted from legacy roadway, bridge, crash maintenance, and project systems and then put into a relational client/server database. The information can then be queried using standard SQL to generate tabular reports. In contrast, the traditional method of extracting this information from mainframe database flat files requires programmer time. Jobs fail, reports are difficult to format, and a programmer's time is impossible to get (Pennsylvania).

Internet Road Conditions

For the Maryland Traffic Management Center, the state's CHART system uses GIS to provide the traveling public with real-time map displays of highway system conditions and provide operations management with the location of key resources (snow plows and emergency response vehicles) and highway system conditions during weather-related events (Maryland).

The Internet Road Condition GIS Project automates the geographical display of roadway condition data. Illinois DOT already gathered roadway condition information, such as snow coverages, lane closures, construction activity, maintenance activity, and reduced height and weight restrictions. Some of this information is updated hourly or daily. The department then disseminated this information internally and to the public via various manual maps and the Internet in computer text listings. GIS enables the intranet/Internet delivery of this information in map form for winter road conditions, which is by far the most accessed web page on Illinois DOT's web site. The map is also more visually informational than simple text listings of road conditions ($5,000 estimated annual benefits and intangible benefits, including improved public communications) (Illinois).

Maintenance and Operations

The Texas DOT Maintenance Division is using a GIS application to generate the end-of-year statewide maintenance report from maintenance management information system (MMIS) data. It takes a couple of weeks to create the report using GIS as opposed to up to 8 months to do it with Microstation and Excel, as done previously (Texas).

GIS is currently used to help in snowplow routing, mapping weed control areas, and conducting snowtrap and snowfence inventories. GIS is reducing the time it takes to prepare yearly snowplow route maps and making it much easier to update them as conditions change. Using GIS for the snowtrap inventory is helping designers and planners track problem areas and include mitigation efforts when a project is in the area. They are also looking at other options, such as living snow fences to reduce snowdrifts, and the amount of maintenance needed to keep the roads open for winter travel (Minnesota).

Maintenance is using GIS in two ways to help manage activities: making maps of daily work activities and mapping results from the database (facility maintenance) monthly and annually to gain an overall picture of activities on the roadway (Maryland).

Previously, certain routine or seasonal tasks were labor-intensive. With the implementation of spatial data, tools, and technologies, many of those tasks are handled in an automated fashion. For example snow maps or winter service maps display each snowplow run and municipal agreement in a county. Maps are placed in each truck and maintenance shed and as public display. Before spatial data, tools, and technologies, it took staff several days to create the maps by hand. Now one person can set up the maps once, and the application is mostly automated for subsequent years (Pennsylvania).

Right-of-Way and Land Acquisition Mapping

The San Antonio Right-of-Way Map Locator is a web application, currently in test phase, that serves digital scans of right-of-way maps to the public, thus freeing up an FTE that previously had to run bluelines all day to comply with ad hoc requests (Texas).

Currently using GIS to manage the department's 1:24,000 base map, MnDOT staff also use GIS to integrate right-of-way information with project-specific information to help in tracking and displaying the status of right-of-way purchasing (Minnesota).

GIS helps in identifying property owners affected by a project. Having the state's tax map and assessment database as a GIS spatial layer has greatly reduced the time to identify affected property owners and create a database for project mailings. What used to take about 8 weeks for a major project now takes only about 4 to 6 hours (Maryland).

Construction

Currently using GIS to improve the project notification process, MnDOT mails notification of upcoming projects and other notices to people living in and around areas where construction projects are planned. Previously this was done by contacting each affected county or city, sending them a copy of the mailing area hand drawn on a copy of a Hudson's map book page, and waiting. The time frame and cost varied from county to county and from city to city. The average time was 3 weeks at a cost of around $.50 per parcel. This process produced hard-copy mailing labels, which staff then had to manually affix to the flyers. If the labels had a printing error (which occurred too often), new labels had to be requested, which meant another 3-week wait. The GIS process brings the parcel data with the needed addresses directly to the project manager. It now only takes a few minutes to generate an electronic mailing list, a savings in both time and dollars (Minnesota).

The recycled Materials Locator is a web application in development to let Texas DOT contractors locate recycled construction material generator plants. No numbers are available yet on time and cost savings (Texas).

The Material Supplier Location Mapping GIS project displays the location of material suppliers throughout the state. This includes bituminous plants, quarries, concrete plants, and pipe manufacturers. This project also provides the ability to analyze material usage and inspection patterns. Immediate efficiency benefits resulted from the automated mapping of material supplier locations that were previously manually mapped, mapped with computer-aided drafting and designs, or distributed in text form ($7,000 in estimated annual benefits) (Illinois).

Plans and Records Management

The District Records Management GIS project, currently under development in Illinois DOT, would improve the storage and accessibility of district records. This project would provide a listing of all project documents related to a particular roadway section or intersection. Eventually, records would be electronically linked to geography through access to GIS. The GIS stations for this project would be in daily use for accessing project records and for management assessment of ongoing projects. Efficiency benefits would result from a significant reduction in time for identifying and retrieving project records. Time-consuming manual searches, especially for historical referencing, would be greatly reduced. Potential effectiveness benefits would result from more rapid access to accurate information to improve decision making. Implementation of this project is not anticipated until fiscal year 2004 due to the complexity of the project ($900,000 in estimated annual benefits) (Illinois).

Permits

Illinois DOT manages a roadway permitting process for overweight and oversized vehicles that operate on the state highway system. This process makes extensive use of roadway and structural inventory information. A stand-alone mainframe system currently accomplishes this process. Roadways are referenced by marked routes and verbal descriptions with permit routing directions issued in text form. This GIS project will enable the graphical display of road and structure network barriers to define efficient routing schemes with the preparation of visual maps. Efficiency benefits would result from an automated visual analysis of the network and potential intranet/Internet applications ($120,000 in estimated annual benefits) (Illinois).

Aeronautics

MnDOT is using GIS to locate display, and analyze airfield data. GIS has helped aeronautics personnel improve their map products and perform their studies faster and better than in the past (Minnesota).

List of Participants

Rob Bostrom
Kentucky Transportation Cabinet
Division of Multimodal Programs
125 Holmes Street
Frankfort, KY 40622
502-564-7686; Fax: 502-564-4422
rbostrom@mail.state.ky.us

Carol Brandt
Bureau of Transportation Statistics
400 Seventh Street SW, Room 3430
Washington, DC 20590
202-366-6662
carol.brandt@bts.gov

Frank DeSendi
Pennsylvania DOT
Geographic Info Division
P.O. Box 3654
Harrisburg, PA 17105-3654
desendi@dot.state.pa.us

Stacy Fehlenberg
Environmental Protection Agency
Atlanta, GA
404-562-8309
fehlenberg.stacy@epa.gov

Kim Hajek
Texas Department of Transportation
Transportation Planning & Programming Div.
P.O. Box 149217
Austin, TX 78714-9217
512-486-5052; Fax: 512-486-5099
khajek@dot.state.tx.us

James P. Hall
University of Illinois
Dept. of Management Information Systems
P.O. Box 19243
Springfield, IL 62764
217-206-7860
hall.jim@uis.edu

Charlie Howard
Washington State Department of Transportation
Northwest Washington Division
206-464-6083
howardc@wsdot.wa.gov

Patricia S. Hu
Oak Ridge National Laboratory
Bethel Valley Road
P.O. Box 2008 Building 3156 MS-6073
Oak Ridge, TN 37831-6073
865-574-8267; Fax: 865-574-3851
psh@ornl.gov

Jonette Kreideweis
Minnesota Department of Transportation
Mail Stop 450
395 John Ireland Boulevard
St. Paul, MN 55155
651-215-1854; Fax: 651-296-3311
jonette.kreideweis@dot.state.mn.us

Susan J. Lapham
Bureau of Transportation Statistics
400 Seventh Street SW, Room 3430
Washington, DC 2059
202-366-9913
susan.lapham@bts.gov

Ysela Llort
Florida Department of Transportation
MS #57
605 Suwannee Street
Tallahassee, FL 32399-0450
850-414-5235
ysela.llort@dot.state.fl.us

James E. McQuirt
Ohio Department of Transportation
Office of Technical Services
1980 W. Broad Street, 2nd Floor
Columbus, OH 43223
614-752-5752; Fax: 614-752-8646
jmcquirt@dot.state.oh.us

Charles "Chuck" O'Hara
Mississippi State University
#2 Research Boulevard
Mississippi State, MS 39762
662-325-2067
cgohara@erc.msstate.edu

Thomas M. Palmerlee
Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001
202-334-2907
tpalmerl@nas.edu

Roger Petzold
Federal Highway Administration
400 Seventh Street SW
Washington, DC 20590
202-366-4074
roger.petzold@fhwa.dot.gov

Freddie Simmons
Florida Department of Transportation
605 Suwanne Street, MS 57
Tallahassee, FL 32399-0450
850-414-5240
freddie.simmons@dot.state.fl.us

Ron Tweedie
3 Carriage Road
Delmar, NY 12054
518-439-4463
rtweedie@nycap.rr.com

Anita Vandervalk-Ostrander
Cambridge Systematics, Inc.
3501 Kimmer Rowe Drive
Tallahassee, FL 32309
850 668 3137
avandervalk@camsys.com

Ronald L. Vibbert
Michigan Department of Transportation
P.O. Box 30050
Lansing, MI 48909
517-373-9561; Fax: 517-373-9255
vibbertr@michigan.gov

William Walsek
Maryland State Highway Administration
Highway Info Services Division
707 N. Calvert Street MS C-607
Baltimore, MD 21202
410-545-5529; Fax: 410-209-5033
bwalsek@sha.state.md.us

Daniel K. Widner
Virginia Department of Transportation
1401 E. Broad Street
Richmond, VA 23219
804-786-6762
widner_dk@Virginia DOT.state.va.us