DIGITAL DATA LIBRARIES OF GEOSPATIAL DATA AND INFORMATION PRODUCTS FOR TRANSPORTATION ASSESSMENT AND PLANNING

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ABSTRACT

Transportation agency representatives provided case-study input in an investigation of how geospatial data libraries are used for managing remote sensing data and other geospatial data for transportation assessment and planning. This information concerning current practices and methods for using and managing geospatial data resources provides significant insight to the data needs and problems faced by transportation agencies. Case studies are presented, successes are highlighted, and attempts are made to identify areas of use, barriers to implementation, and critical success factors for successfully implementing spatial data, tools, and technologies to improve transportation program delivery. Federal efforts to develop distributed geodatabase systems for providing access to libraries of seamless framework spatial data are described. Improved methods are identified for providing computational middleware for complex image processing tasks. Computational mapping engines (CMEs) are suggested as an ideal mechanism for chaining services using OpenGIS standards to generate and deliver custom map products to end users.

INTRODUCTION

Federal and State agencies are significant users of spatial data, tools, and technologies. Increasingly, state transportation agencies are transitioning or integrating their CAD processes to/with GIS and are incorporating digital imagery into their planning, assessment and engineering processes. Agencies are developing approaches for the use of these data, tools, and technologies and are interested in identifying and implementing best practices that will result in reductions in time and costs to complete the delivery of projects. As transportation agencies adopt work flows that make increased use of spatial data for planning, assessment, design, operation, and maintenance, it becomes increasingly important for agencies to identify best practices, to document success stories, to explain how barriers can be overcome, and to assure that factors critical to successful implementation are included in the agency approach. The National Consortia on Remote Sensing in Transportation conducts research and supports technology application projects to assist transportation agencies to make the best use of spatial data, tools, and technologies (www.ncrst.org).

The Current General Status of Spatial Data, Tools, and Technology in Transportation

To assist people from transportation agencies, government, and private industry, the American Association of State Highway and Transportation Officials (AASHTO), along with URISA, USDOT, and HEEP, sponsor the annual GIS for Transportation Symposium. The state summary from the 2002 GIS-T conference in Atlanta, GA, provided by Roger Petzold, Team Leader, Office of Intermodal and Statwide Planning, Federal Highway Administration, shows the following trends in GIS and geospatial data use for transportation agencies:

- Most transportation agencies have adopted the use of Windows NT/2000 based operating systems.
- Most state agencies have fully operational GIS systems and are adopting *Enterprise GIS* models.
- Staff level and user support for GIS in transportation agencies vary.
- Location of GIS unit is typically split between Planning and Information Services.
- Transportation agencies find it difficult to retain staff with GIS skills.

- Most states transportation agencies use a 1:24,000 scale base road coverage.
- The major trend for transportation agencies is towards development of web-based GIS applications.

Transportation agency trends to make increased use of spatial data, tools, and technologies can be understood best when examined in light of increased pressure to provide the public with transportation services by delivering projects within budget and on-time, and minimizing delays caused by critical work flow processes. Traditional approaches to transportation planning, assessment, and design are giving way to processes that make increased use of advanced geospatial data types, analysis tools, and information technologies. These changing processes are beginning to bring about cultural, technological, engineering, and business practice changes in transportation agencies. However, new high spatial and spectral resolution sources of geospatial and remote sensing data require extensive study and demonstrations of success through applied research, user training to assure appropriate use, careful planning to assure user access and availability, well documented methods for use, and easy-to-use tools for incorporating the data into work flows. Transportation agencies are challenged to determine what spatial data should be used for specific processes, what the real accuracy needs are for specific data types in specific work flow processes, how and when to best acquire the data, how data should best be used and distributed, and how frequently data should be revised and updated.

The potential for use of new geospatial and remote sensing data, tools, and technologies in transportation is great; identifying those areas where need is highest and where successful implementation will provide the best results is the goal of many ongoing research activities. One of the goals of the National Consortia on Remote Sensing in Transportation is to determine the areas of foremost need and to provide applied research and demonstrations on the application of remote sensing and geospatial technologies in the transportation industry.

CASE STUDIES ON GEOSPATIAL DATA USE IN TRANSPORTATION AGENCIES

Transportation agencies are not all alike in their implementation of spatial data, tools, and technologies. The Transportation Research Board Committee on Statewide Data and Information Systems comprises individuals from transportation agencies who lead the way in the use of these data, tools, and technologies in transportation. A series of case studies were extracted from materials submitted during a peer exchange of the Transportation Research Board Committee on Statewide Data and Information Systems (held March 23-24, 2002 in Charleston, South Carolina) to identify the kinds of spatial data tools and information that are most effective in delivering multi-modal transportation programs. During the meeting, presentations were made by upper-level administrators and representatives from state DOTs about geospatial management, use, and analysis activities in their agencies.

Key Questions

The presenters were asked to focus their content on five questions which follow:

1. What are some of the key issues affecting program delivery in you 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 1-2 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?

Case Study Presenters

From the material presented at the committee meeting, common themes, trends, and highlights are summarized by category for the following state administrators and representatives who attended:

Freddie Simmons, State Highway Engineer, Florida DOT

Ysela Llort, State Transportation Planner, Florida DOT

Charlie Howard, Director, Planning and Policy Office, Washington DOT

Kim Hajek, Director of Data Management, Texas DOT

Rob Bostrom, Transportation Engineering Specialist, Kentucky Transportation Cabinet

Bill Walsek, Chief, Highway Information Services Division, Maryland State Highway Administration

Frank DeSendi, Geographic Information Division, Pennsylvania DOT

James P. Hall, Associate Professor, University of Illinois at Springfield

Jonette Kreideweis, Office of Transportation Data and Analysis, Minnesota DOT

Dan Widner, GIS Program Manager, Virginia DOT

Ron Vibbert, Manager of Strategic System Operations and Maintenance, Michigan DOT

Jim McQuirt, Administrator, Office of Technical Services, Ohio DOT

Chuck O'Hara, National Consortia on Remote Sensing in Transportation, Mississippi State University

Stacy Fehlenberg, Environmental Scientist, United States Environmental Protection Agency (USEPA)

New Spatial Data, Tools, and Technologies

From the presentations of attendees, selected topics have been summarized to illustrate where spatial data, tools, and technologies have are being used to improve program delivery in transportation agencies.

Freddie Simmons, State Highway Engineer, Florida DOT

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

Charlie Howard, Director, Planning and Policy Office, Northwest Washington Division, Washington DOT

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 complex program with the legislature and citizens. 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.

Kim Hajek, Director of Data Management, Texas DOT

Texas is using spatial data, tools, and technologies to address current backlog, to accurately link data with LRS, to locate gaps in program, to project priority shifts, to address environmental issues, to reduce public confusion by the public, and to maximize use of available funding for transportation construction.

Bill Walsek, Chief, Highway Information Services Division, Maryland State Highway Administration

Relevant data must be assembled and are used to evaluate how a project might potentially impact one or more segments of society. Prior to having an on line agency wide GIS these data were in scattered locations and in differing formats and it was a time consuming effort to aggregate the data. The on line GIS is improving the quality of analysis, boosting the confidence of key decision makers, and reducing the time for aggregating data (from 1 ½ weeks to 2 hours for environmental data), identifying and notifying impacted public (from 8 weeks to 4 hours), and analyzing cumulative impacts.

Frank DeSendi, Geographic Information Division, Bureau of Planning and Research, Pennsylvania DOT

Spatial data tools have begun liberating cultural resource data. Although the database is not fully populated (the archaeology coverage is completely mapped, historic buildings will be completed by 2004), the use of spatial tools has essentially put the resources on one map. Therefore, business practices by PENNDOT environmental managers have changed dramatically.

James P. Hall, Associate Professor, University of Illinois at Springfield

GIS enables the integration of internal databases including roadway/structure inventories, roadway crashes, annual/multi-year program, and maintenance. It also permits integration of external data including archeological, historical, environmental, demographic, land use for program/project analysis. The integrated databases allow presentation of data and information in understandable formats, facilitate data verification, and enhance program analysis.

Dan Widner, GIS Program Manager, Virginia DOT

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 is integrated more uniformly, newer web-based technologies can provide a consistent approach across the board.

Jim McQuirt, Administrator, Office of Technical Services, Ohio DOT

New technology is being investigated by ODOT as a means to improve program and project delivery. A research project is near completion which looks at using low altitude airborne multi spectral scanning for preliminary analysis of highway project sites. It is anticipated that better and more cost effective results can be obtained in identifying environmental sensitive areas such as streams and springs, ponds and wetlands, field tiles, potential hazardous sites and archeological sites. Light Detection and Ranging (LIDAR) technology is also being investigated to lower project costs for detailed mapping and design.

Specific Examples Where Spatial Data, Tools, and Technologies Have Been Successful

Participants identified specific examples of success stories in which the use of spatial data, tools and technologies reduced program delivery timelines, facilitated consensus on project or program alternatives, or enhanced program delivery in other ways.

Freddie Simmons, State Highway Engineer, Florida Department of Transportation

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, plus all types of other 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, 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.

Charlie Howard, Director, Planning and Policy Office, Northwest Washington Division, Washington DOT

Washington has several examples of where geospatial data tools and technologies have benefited transportation programs. Maps prepared using spatial data and tools have been effective in communicating with the governor, legislature and the public. Spatial data and tools have been applied in the corridor planning process to overlay design elements on digital ortho-photos. 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 where these tools helped the project stay on schedule. The Priority Array Tracking System GIS (PATS/GIS) provides a means of analyzing system needs in a spatial environment. Environmental review summaries as part of project summary are supported by a custom GIS application that facilitates access to over 70 GIS and remote sensing based information themes collected from federal, state, tribal, and local organizations. The availability of this information has improved the time it takes to complete project summary by reducing research time and targeting field time. http://www.wsdot.wa.gov/eesc/environmental/programs/envinfo/EGWbHome.htm.

Rob Bostrom, Transportation Engineering Specialist, Kentucky Transportation Cabinet

The high profile corridor project I-66 has used GIS heavily. GIS was used to help build mapping to facilitate public meetings and discussion. Planning has also moved to GIS based and this is greatly increasing their efficiency in map productions so they are able to shorten the cycle between major mappings of information. Program Management is using GIS to help build the Six Year Plan. Planning has used GIS successfully for the long range (20-year plan).

Bill Walsek, Chief, Highway Information Services Division, Maryland State Highway Administration

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. Having over 25 environmental, cultural, historical, and other spatial data sets on line 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.

James P. Hall, Associate Professor, University of Illinois at Springfield

The integration of the program, inventory and highway crash databases through GIS enabled immediate mapping of high accident locations (HAL). This provided a two year improvement in access to HAL sites which enabled a more thorough and complete analysis of safety project selection. Estimated benefits due to projected decrease in accidents are approximately $1,000,000 annually.

Dan Widner, GIS Program Manager, Virginia DOT

Web enabling of environmental review process is a top priority for VDOT's environmental and data management organizations. A "rule of thumb" applied at VDOT 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. VDOT is working with other natural resource agencies in the state to improve the ease of access to data and information using spatial data, tools and technologies.

Jonette Kreideweis, Office of Transportation Data and Analysis, Minnesota DOT

For many years, our department experienced severe delays in obtaining approvals and clearance from the Minnesota State Historic Preservation Office. In response to this situation, Mn/DOT began working on a project called Mn/Model. It is a statewide GIS-based archaeological predictive model for Minnesota. Mn/Model is a tool that indicates the probability of encountering an archaeological site anywhere in the State of Minnesota. GIS based maps show the results of applying the model. The maps are used as the primary tool for site avoidance and survey design. 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. Mn/Model has made cultural resource reviews more efficient. There is faster turn around 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 (http://www.mnmodel.dot.state.mn.us/).

The response to Mn/Model has been overwhelmingly positive. In summary, significant time and cost savings are resulting from:

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

Overcoming the Barriers to Spatial Data, Tools, and Technologies

Identifying and overcoming barriers or constraints against the effective use of spatial data, tools, and technologies is important to the successful implementation of spatial data, tools, and technologies. A representative look at ways to overcome barriers was compiled from materials presented.

Charlie Howard, Director, Planning and Policy Office, Northwest Washington Division, Washington DOT

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.

Funding for data development: The funding to collect and build geo-spatial data like ortho-photography, needs to be available during the earliest phases of project design.

Interagency coordination: Interagency coordination, cooperation and funding for geo-spatial base data used to integrate data across agencies are challenging.

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. Demonstration projects are needed to add value for the transportation community.

Rob Bostrom, Transportation Engineering Specialist, Kentucky Transportation Cabinet

The biggest challenge is cultural. Many people fear change. If you show the users how their jobs will be easier/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 is sharable enterprise-wide. There is a high learning curve associated with these technologies. We have to help guide/train the users so that the technology can be more easily incorporated into their work process.

Dan Widner, GIS Program Manager, Virginia DOT

Important concerns include education in the value and utility of such technologies, demonstration of tangible results help in securing resources, buy-in at the highest levels of the department, and understanding of the time and effort required building spatially enabled systems. It is absolutely crucial that management at the highest level understand and agree with the need to implement spatial data, tools and technologies. This has a ripple effect upon any budget requests and staffing needs for such implementations. 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: develop simple yet powerful applications, choose obvious areas of need, assure ease of access and understandability, and don't oversell your capabilities.

Jim McQuirt, Administrator, Office of Technical Services, Ohio DOT

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 the issues and concerns were alleviated through the creation of a committee consisting of owners of all the major systems.

Critical Success Factors

Attendees were asked to provide input about the factors that are critical to the successful implementation of spatial data, tools, and technologies in transportation. The input from the presenters was extensive, but common themes emerged. A representative cross-section of the content addressing critical success factors is provided.

Ysela Llort, State Transportation Planner, Florida DOT

New processes are needed to provide a coordinated approach to collection and use of data and a better understanding of data accuracy needs. To successfully implement spatial data, tools, and technologies in a transportation agency there must be agreement on best method for obtaining data; data must be available to all offices; benefits must be determined; cost savings documented; improvements in data collection and utility; safety in data collection; executive buy-in; secure contractual funding; education and training of users; careful planning, cooperation, and coordination; and aggressive implementation.

Charlie Howard, Director, Planning and Policy Office, Northwest Washington Division, Washington DOT

Easy access to base data, a data clearinghouse, interagency cooperation, funding, and 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 remote sensing and spatial technologies. We are starting to see the analysis and cost benefit assessment from these projects.

Bill Walsek, Chief, Highway Information Services Division, Maryland State Highway Administration

Developing an agency wide spatial data resource is a major effort involving significant commitment of staff time and money. Without question having the active support and backing of senior management is 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.

Rob Bostrom, Transportation Engineering Specialist, Kentucky Transportation Cabinet

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 a more enterprise approach. Resistance to change or build shared systems must be addressed. 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 since each of the 12 districts has a unique way of viewing or addressing data needs. This mindset has been eroding away over the past few years. Middle and upper management understand the need for data for accountability, to gauge the performance of the highway system, and ultimately improve the highway programming process.

Dan Widner, GIS Program Manager, Virginia DOT

Suitable communications network with adequate bandwidth are needed to support large quantities of data. Raster data in particular requires 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?

Jim McQuirt, Administrator, Office of Technical Services, Ohio DOT

Top level management support is crucial to ensuring success as is a clear 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 success. Finally, good software, application development, training and communication are needed to ensure current and future success of GIS.

DISTRIBUTED GEODATABASE SYSTEMS

The World Wide Web had fundamentally changed the way technical work is done. For those who work in transportation and must plan transportation services, assess impacts, and design services, the availability of geospatial information from distributed sources — both within their agencies and from other sources — offers the promise of reduced time to complete tasks and increased efficiency in work flows. For agencies responsible for transportation services, the collection and use of data is becoming an increasingly technically challenging task made more complex by the variety of data types in different resolutions and of varying accuracies. Old practices of collecting paper-source data for single projects and not reusing the data are giving way to Enterprise GIS and DBMS systems that store and make data available throughout the agency. In the effort to minimize duplication of effort and gain increased efficiency in work flow tasks, agencies are becoming increasingly aware of the need for distributed data warehouses, from which data that are needed for a project in a specific area may be acquired without the need to pay for costly data. The desire to reduce costs and increase efficiencies is tremendous and it is critical that effective reuse be made of available data. Cost effective strategies and technologies must be developed to maximize the sharing of data for the public good.

While the need for geospatial data and the technology to deliver it are both a concern, the costs are still high. In some cases, federal programs are underway to develop infrastructure and resources for serving a framework of spatial data to any and all users. The infrastructure and resources being developed are an important step towards an improved data sharing model, but many in the field of transportation are not certain about how these programs will affect their need for highly accurate base map, image, feature, and attribute data sets. What remains to be determined and worked out is how these federal programs will complement existing data and fit into the needs of transportation agencies for data appropriate to plan, design, operate, and maintain transportation service. Transportation agencies will likely participate in a dual role as producers of high quality image and feature data for the federal spatial data portals and as consumers with ongoing need for standard data to assist with the delivery of transportation programs. Some states such as Virginia are aggressively building high resolution base map layers based on detailed digital ortho-imagery, acquiring continuous image coverage in their statewide data acquisition efforts. Managing, using, and distributing these data are challenging tasks. Coordinating with federal agencies for the cooperative use of the data in federal programs will require extensive communications, collaboration, planning, and overcoming significant information technology challenges.

USGS National Map

The USGS is involved in an effort to develop a National Map of seamless data updated continuously through partnerships and innovative data acquisition and sharing arrangements (http://nationalmap.usgs.gov/).

The USGS is committed to meeting the Nation's needs for current base geographic data and maps. Our vision is that, by working with partners, we will ensure that the Nation has access to current, accurate, and nationally consistent digital data and topographic maps derived from those data. This synthesis of information, products, and capabilities, The National Map, will be a seamless, continuously maintained set of public domain geographic base information that will serve as a foundation for integrating, sharing, and using other data easily and consistently.

The National Map will provide public domain core geographic data about the United States and its territories that other agencies can extend, enhance, and reference as they concentrate on maintaining other data that are unique to their needs. The National Map will be a foundation of information to which the private sector can contribute core feature content and to which proprietary datasets can be linked to provide access to higher resolution data, additional (non-base) features, and enriched attribute information. The National Map will promote cost effectiveness by minimizing the need to find, develop, integrate, and maintain geographic base data each time they are needed.

Geospatial One-Stop

The Geospatial One-Stop is being developed through an E-Gov initiative to provide a comprehensive web portal to the National Spatial Data Infrastructure (NSDI) seven framework themes of geographic data. The Geospatial One-Stop will be a collaborative effort to provide accurate and accessible geospatial data available from local to national levels (http://www.bts.gov/gis/geospatial_onestop/). The seven National Spatial Data Infrastructure (NSDI) framework themes are:

Cadastral*: Describes the geographic extent of past, current, and future right, title, and interest in real property.*

Digital Ortho-Imagery*: Geo-referenced images of the earth's surface, collected by a sensor.*

Elevation: *(terrestrial) Geo-referenced digital representations of terrestrial surfaces, natural or manmade, which describe vertical position above or below a datum surface; and (bathymetric) Information collected to ensure that Federal navigation channels are maintained to their authorized depths.*

Elevation Geodetic Control*: Common reference system for establishing coordinates for all geographic data.*

Governmental Units*: Describe, by a consistent set of rules and semantic definitions, the official boundary of Federal, state, local, and Tribal governments.*

Hydrography*: Surface water features such as lakes, ponds, streams and rivers, canals, oceans, and coastlines.*

Transportation*: Data used to model the geographic locations, interconnectedness, and characteristics of the transportation system within the United States.*

COMPUTATIONAL MAPPING ENGINES (CME)

Efforts to build distributed geodatabase systems are fundamental to the successful, cost-effective implementation of spatial data, tools, and technologies for transportation agencies who must deliver programs and projects for the public good. Geospatial One-Stop and the National Map efforts will make available standard mapping products presenting them seamlessly to users who need data. However, for transportation agencies increasingly reliant upon the use of remote sensing and geospatial technologies to enhance program delivery, there are needs for specific data types in specific formats (projection, datum, image type, etc.) sometimes covering broad geographic areas-of-interest. To use these distributed geodatabase systems in traditional image-processing work flows requires that data sets be downloaded from the “portal site” to a another location, where the data could be accessed by an image analyst using complex software on an expensive image processing workstation. The downloaded data might then be registered, projected, tonally balanced, merged, and provided to planners, environmental analysts, or engineers who use the data for a specific purpose. Image processing tasks are time consuming, technically complex, and require expensive hardware and software. Training and retaining staff to complete complex image processing tasks is a difficult requirement for transportation agencies. The need for user-friendly web-based methods of accessing, pre-processing, and using data was one of the most oft-repeated themes for use of spatial data, tools, and technologies in transportation agencies.

Computational Processing

Complex computer tasks can typically be broken down into smaller tasks and [instead of all the processing being accomplished on a single machine] submitted to a group of machines working in parallel to accomplish the entire task. Parallelization of complex computer tasks can be thought of as computational work flows that are significantly different from traditional work flows. Computational work flows are designed to separate the user from the complexities of the job and to provide distributed resources for completing complex tasks and delivering products.

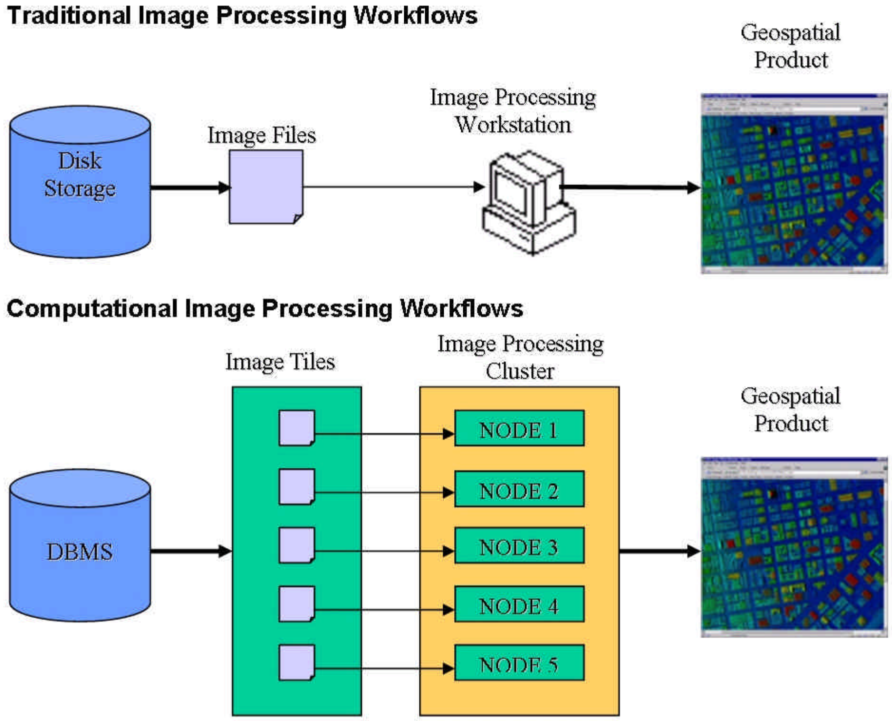

Figure 1. Diagram showing traditional image-processing and computational image-processing workflows.

Service Chaining: Augmented Functionality

The Geospatial One-Stop and other National Efforts such as the USGS National Map are being developed based upon open standards. Working closely with the OpenGIS Consortium, developers are incorporating a concept called "Service Chaining" into the design of these national distributed geodatabase portals. Service chaining will facilitate creating complex chained services that will allow data to be requested, processed, and ultimately delivered to the end user. The national portals will provide standard data and other will be able to design, develop, and implement solutions to process and deliver custom data products to end users. One of the key building blocks of the Geospatial One-Stop is providing the ability to develop augmented portal functionality, and fundamental to that is the need to support service chaining for complex processing tasks, data analysis, and delivery of custom products to the end user.

Mississippi State University: Computational Mapping Engine and Image Processing GeoLibrary

Mississippi State University is currently developing an on-line computational mapping engine demonstration web site. The application allows the user to browse to specific locations, view areas covered by specific complex data types in the library, and request custom products to be generated by the cluster of computers that perform complex computational image processing tasks. This application is part of a larger geospatial data library effort at MSU.

A preliminary demonstration of the CME's capabilities is being developed for the CSX/I-10 railroad relocation and corridor planning project that is in progress on the Mississippi Gulf coast as part of a joint NASA-DOT project to investigate the use of remote sensing and geospatial technologies for transportation assessment and planning. The corridor planning project will make broad use of remote sensing data and geospatial technologies to evaluate the environmental impacts associated with a railroad relocation effort to move the railroad out of highly populated areas along the coast.

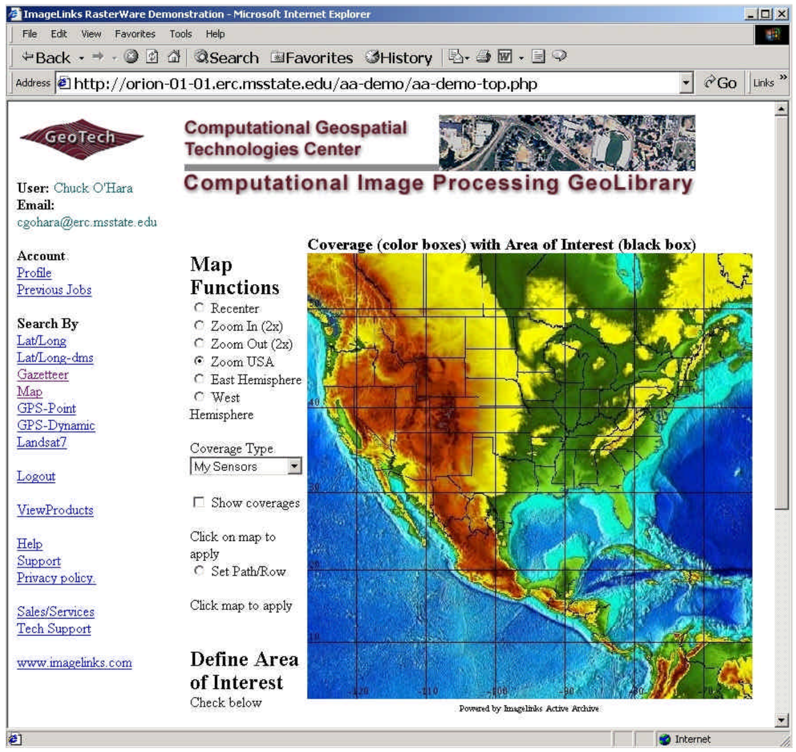

Figure 2. Interface to the MSU Computational Mapping Engine showing a browse image of the USA.

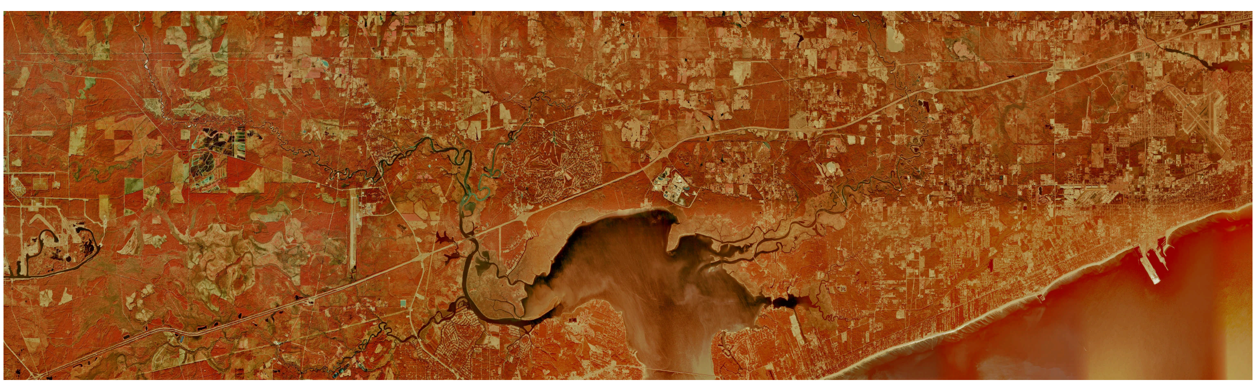

Figure 3. The Computational Mapping Engine was used to mosaic twenty quads of digital ortho-imagery and transform the resultant image to a custom map projection. These images exceed 50MB per file in raw format, requiring extensive storage. Creating custom products from such image files requires numerous complex steps and is a time consuming process if done using tradition methods.

SUMMARY AND CONCLUSIONS

Transportation agencies are making increased use of spatial data, tools, and technologies to deliver projects within budget and on-time, and to minimize delays caused by critical work flow processes. Traditional approaches to transportation planning, assessment, and design are being augmented or replaced by processes that make increased use of advanced geospatial data types, analysis tools, and information technologies. To effectively implement the use of spatial data, tools, and technologies requires agency buy-in, management support, stable funding for pilot efforts, extensive study and demonstrations of success through applied research, user training to assure appropriate use, careful planning to assure user access and availability, well documented methods for use, and easy-to-use tools for incorporating the data into work flows. Transportation agencies and applied research efforts are making progress to determine what spatial data should be used for specific processes, what are the real accuracy needs for specific data types in specific work flow processes, how and when to best acquire the data, how data should best be used and distributed, and how frequently should the data be revised and updated.

Case studies have been compiled that illustrate how spatial data, tools, and technologies are a making positive impact on the delivery of transportation programs. Success stories are promising, barriers are being identified and overcome, and critical success factors are increasingly well understood and incorporated in implementations. Critical to the outcome, are increased efforts being made to improve the manner in which data are being acquired and effectively managed, used, and shared for the public good. Transportation agencies are major data users, and data developers. Enterprise GIS plays an important role in these agencies for the management of their geospatial data libraries. These agencies recognize the need for improved data portals for providing access to GIS framework data as well as the need for user-friendly web applications for custom products and work flow applications. Furthermore, they are aware of technology barriers and strongly support applied research and demonstrations efforts targeted at breaking down the barriers to successful implementation and use of spatial data, tools, and technologies.

Transportation agencies will have a significant role in being both producers and consumers of geospatial data for national spatial data portals such as the USGS National Map and the Geospatial One-Stop. Because of the high accuracy and frequent update requirements for transportation data, the collection of image and feature data by transportation agencies may prove to be one of the best sources of data for updating ortho-imagery, transportation, and elevation framework data layers.

The creation of custom products from spatial data can be very complicated, requiring significant resources in hardware, software, and trained personnel. Creating custom products from spatial data can be very time consuming and inefficient. A key area for the successful implementation of spatial data, tools, and technologies is the development of web-based, user-friendly applications that will hide the complexity of work from the user and allow the user to be more productive. Creating custom geospatial data products useful for specific tasks can be accomplished using standards-based computation mapping engines. Mississippi State University, as part of its efforts to develop a Computational Image Processing GeoLibrary, is currently developing a Computational Mapping Engine for the creation of custom spatial data products. A demonstration of these capabilities is ongoing in support of a joint NASA-DOT project to investigate the use of remote sensing and geospatial technologies for transportation assessment and planning.

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