June 2006

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Subject Areas: IA Planning and Administration

Responsible Senior Program Officer: Andrew C. Lemer

Research Results Digest 304

TECHNOLOGIES TO IMPROVE CONSIDERATION OF ENVIRONMENTAL CONCERNS IN TRANSPORTATION DECISIONS

This digest presents the results of NCHRP Project 25-22(02), "Technologies to Improve Consideration of Environmental Concerns in Transportation Decisions." The study was conducted by CH2M Hill; Marcy Schwartz was the Principal Investigator.

CONTENTS

Summary, 1

Introduction, 2
Scope of the Research, 2
Limitations of the Research, 3

The Eight Selected Technologies, 4
Interactive Regional Scenario Analysis, 5
Integrated Aerial Data Collection, 6
Road and Rail Alignment Optimization, 7
Web-Based Environmental Screening, 8
NEPA Document Preparation and Review Expert System, 9
Restricted Activity Zone Mapping, 10
Electronic Asset Management System, 11
Life Cycle E-Engineering, 12

Transfer and Use of the Selected Technologies, 13
Limited Initial Implementation, 13
Data Availability and Standards, 13
Buy-in of Agency Staff and Stakeholders, 13
Multiple-User Involvement, 14

Recommendations for Promoting Use of These Technologies, 14
General Recommendations, 14
Application-Specific Recommendations, 14

Notes, 15

Appendix A—Resources for Highlighted Applications, 15

Appendix B—Profiles for the 20 More Promising Applications, 16

SUMMARY

This digest describes eight technologies that can be used by transportation agencies to improve the consideration of environmental concerns in transportation decisions (*1*). These technologies have been applied by agencies, using tools developed by the agencies themselves or others, to support their business processes. The digest presents the results of work conducted in the second, final phase of NCHRP Project 25-22, "Technologies to Improve Consideration of Environmental Concerns in Transportation Decisions." The objective of that project was to identify, critique, and showcase current and emerging technologies that support the integration of environmental considerations into transportation planning, design, construction, maintenance, and operations. The underlying purpose of the research is to accelerate innovation by encouraging application of such technologies by transportation agencies. By effectively applying these technologies, departments of transportation (DOTs) can reduce project development time, reduce costs, and enhance environmental quality, by improving the ability to implement transportation decisions, reducing the number of projects in litigation, reducing paperwork, increasing public understanding of the process, and increasing public trust.

In NCHRP Project 25-22(02), the research team polled DOTs and other agencies to develop an initial list of 70 applications illustrating the use of technologies identified as promising in the project's first phase. These 70 applications met three criteria: they were (1) in use by at least one state DOT or other public agency in the United States, (2) focused on reducing environmental impacts or improving visibility of environmental concerns, and (3) related to one or more business processes of transportation agencies. The research team prepared brief descriptions of candidate applications, categorizing the applications by the business process where the application occurred; some applications were included in multiple categories. The research team then used three additional criteria to select the 20 more promising applications: (1) broad applicability of the application to the work of other DOTs or public agencies within the United States, (2) ease of implementation, considering particularly schedule and budget resources, and (3) innovation inherent in the application. These

20 technology applications were documented in greater detail.

Using this documentation and the help of expert panels, the research team assessed these tools and applications for their broad applicability, adaptability to other agencies' use, opportunities for and barriers to implementation, and major cost considerations. The eight technologies highlighted in this digest were chosen based on these assessments. Additional information and demonstrations of the use of specific software and equipment used in applications of these eight technologies are available in videos produced by the research team; these videos can be accessed from the project description web page [http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+25-22(02)].

The digest is organized into four sections and two appendixes. The introduction describes the scope and limitations of the research project. The second section gives brief descriptions of the technologies and their applications, as well as factors leading to their developments. The third section discusses issues involved with implementing these technologies in other applications. The last section summarizes the research team's recommendations on how to achieve broader adoption of these technologies. Appendix A lists resources who can be contacted for more information about the highlighted applications. Appendix B contains the profiles of the 20 more promising applications.

INTRODUCTION

Scope of the Research

NCHRP Project 25-22, "Technologies to Improve Consideration of Environmental Concerns in Transportation Decisions," was begun in March 2000. The project's objective was to identify, critique, and showcase current and emerging technologies that support the integration of environmental considerations into transportation planning, design, construction, maintenance, and operations. The underlying purpose of the research was to accelerate innovation by encouraging application of such technologies by transportation agencies. By effectively applying these technologies, DOTs can reduce project development time, reduce costs, and enhance environmental quality by improving the ability to implement transportation decisions, reducing the number of projects in litigation, reducing paperwork, increasing public understanding of the process, and increasing public trust.

NCHRP Project 25-22(02), the subject of this digest, is a continuation of the earlier work, focused on investigating emerging technologies in geospatial databases, remote sensing applications, transportation impact modeling, decision science tools, and visualization and simulation tools. This second phase of work was undertaken to showcase innovative applications of new technologies by state DOTs and other public agencies. The applications considered in this project represent all transportation agency business processes. The research team explored the drivers behind agency decisions to implement new technologies, opportunities for and barriers to implementation, major cost considerations, and the lessons that can aid other agencies interested in similar applications.

The research team used a five-step process to select and document the technologies described in this digest:

1. *Compile an initial list of candidate technologies and applications.* The research team used information gathered in the project's first phase and additional communication with DOTs. To qualify, candidate applications had to be (a) in use by at least one state DOT or other public agency in the United States, (b) focused on reducing environmental impacts or improving visibility of environmental concerns, and (c) related to one or more business processes of transportation agencies. A total of 70 candidates qualified. The research team prepared a brief description of each candidate application, categorizing the applications by the business process where the application occurred; some applications were included in multiple categories.
2. *Conduct first-level screening.* The research team further assessed the 70 candidates to identify those that exhibited (a) broad applicability to the work of other DOTs or public agencies within the United States; (b) ease of implementation, considering particularly schedule and budget resources; and (c) innovation inherent in the application. This screening identified the 20 more promising applications for further consideration. The research team documented these 20 technology applications in greater detail.

3. *Develop application profiles.* The research team prepared more detailed descriptions and assessments of the 20 screened applications by considering eight sets of questions:
   - What is the primary function of the example application?
   - What are the performance capabilities of the example application; how is it applied?
   - Who are the main users of the example application; what are the interactions among groups of users?
   - Was the example application developed in-house or outsourced?
   - What are the main hardware and software requirements for the example application?
   - What data requirements are necessary for the example application to operate?
   - How are data managed, including data entry, maintenance, and archiving?
   - What were the necessary interactions among the main users of the technology and with other agencies or organizations in the example application?

   Appendix B presents the resulting profiles of the applications in a standard format.
4. *Conduct second-level screening.* The applications profiles were reviewed individually and compared to others in the group. The research team assessed the candidates in terms of five factors to select a set of technology applications to be highlighted:
   - Availability of a successful example that could be showcased
   - Applicability to more than one transportation agency business process
   - Usefulness to many DOTs
   - Portability and adaptability to use by other agencies
   - Representation of all transportation agency business processes within the selected set

   The research team initially recommended 11 of the 20 candidates to the NCHRP project panel. The panel and research team subsequently selected the eight technologies highlighted in the next section.
5. *Evaluate selected technology applications.* To consider matters related to the adoption of the selected technologies, the research team formed three practitioner focus groups: (a) planning and project development, (b) environmental analysis, and (c) construction and maintenance. Focus group members were recruited from DOTs or other transportation agencies. Groups met via conference call twice during the fall of 2004; each group considered two or three technology applications. During the first call, participants heard a presentation on the selected applications. Between the first and second calls, participants completed an online questionnaire requesting opinions on the appropriateness of the application for their agencies and factors that would affect implementation. During the second call, participants addressed the following questions:
   - How did you like the application?
   - Could it be implemented in your agency?
   - What information should be included in the final project report to present the technology to potential users?

   Observations from the focus group discussions were used to supplement descriptions of the selected technology applications.

Limitations of the Research

The research project was not designed to make a comprehensive survey of all applications of new technologies under development and in use to improve consideration of environmental concerns in transportation decisions. In several instances, the research team and NCHRP project panel were aware that other developers in public agencies or private enterprise had tools or applications similar to those selected to be highlighted in this project. Alternative tools—e.g., hardware, software, procedures, practices—may be available for any of the particular applications reviewed in this project and used to describe the eight selected technologies. DOTs, municipal planning organizations (MPOs), and other potential users of these technologies may find it advantageous to investigate alternatives before committing themselves to adopting specific tools mentioned in this digest or other project documentation. The opinions and conclusions expressed or implied here regarding selection of specific technologies, applications, and tools are those of the research team and not necessarily of the NCHRP panel members, the NCHRP as a whole, or TRB.

THE EIGHT SELECTED TECHNOLOGIES

The limitations of this research notwithstanding, the eight technologies highlighted in this digest can improve consideration of environmental concerns in transportation decisions. These eight technologies are summarized in Table 1.

Each of the technologies was observed in a specific application. That is, there was a particular agency that had a problem to solve and particular developers who used particular tools to solve that problem. Table 2 identifies the agencies that applied each technology and the business process(es) in which the application occurred.

This section presents further information on the eight technologies and their applications. Following a brief description of each technology and application is a discussion of lessons learned in that application regarding cost and implementation of the technology.

TABLE 1 Eight technologies for improving consideration of environmental concerns in transportation decisions

Technology	Description
Interactive Regional Scenario Analysis	Uses long-range forecasting to create and evaluate alternative growth scenarios. Tools using this technology allow public participants to explore quickly how their value choices may influence future growth and livability in a region, thereby helping to create a feeling of ownership in consequent decisions.
Integrated Aerial Data Collection	Gathers and analyzes data from multiple sources in a single aerial flight to produce an information-rich 3-D model of a study area. The multilayered information may be combined with existing GIS layers to create a robust base of environmental analyses.
Road and Rail Alignment Optimization	Uses advanced computational algorithms and computing power to quickly generate and screen very large numbers of alignment alternatives, computing cut-and-fill estimates to find optimal alternatives. The technology represents a major advance in the comprehensiveness and efficiency of route-location studies.
Web-Based Environmental Screening	Database software supports web-based presentation of project information and management of the environmental analysis and review process. Tools provide links to base documents and prompt reviewers to provide commentary, thereby encouraging earlier engagement of stakeholders and identification of issues to be resolved in project development decision making.
NEPA Document Preparation and Review Expert System	"Smart" form analysis and data management software facilitates web-based preparation of documentation for categorical exclusion and environmental assessment decisions meeting FHWA requirements. Software prompts reviewers to provide needed information, guides the input of their responses, and creates a central repository for documentation, significantly reducing processing time and facilitating data sharing among agencies.
Restricted Activity Zone Mapping	Software guides highway maintenance staff on types of maintenance activities that are restricted on specific road segments. Tools draw on data from several sources to produce color-coded route linear maps showing areas where environmental regulations impose constraints on maintenance actions.
Electronic Asset Management System	Database software establishes repository of information on transportation infrastructure assets and facilitates access to that information for management decision making. Tools integrate information from multiple sources to characterize individual assets and asset groups and their condition, facilitate updating with field inspection data, and support preparation of maintenance work orders.
Life Cycle E-Engineering	Applies GPS information and data management software to integrate project data by development phase. Tools capture data from site survey, design, and construction, maintaining data accuracy and reducing duplication of data collection efforts over the course of a project's development.

TABLE 2 Applications examined in the research

Technologies	Application Host Agencies	Agency Business Process to Which Technology Was Applied*
Interactive Regional Scenario Analysis	Idaho Transportation Department	Planning/Project Development
Integrated Aerial Data Collection	Alabama, Iowa, North Carolina, Mississippi, Virginia, and Washington DOTs	Planning/Project Development
Road and Rail Alignment Optimization	Transportation Corridor Agencies (Orange County, CA)	Planning/Project Development
Web-Based Environmental Screening	Florida DOT	Planning/Project Development
NEPA Document Preparation and Review Expert System	Pennsylvania DOT	Planning/Project Development
Restricted Activity Zone Mapping	Oregon DOT	Maintenance
Electronic Asset Management System	Maryland State Highway Administration	Construction/Maintenance
Life Cycle E-Engineering	Minnesota DOT	Construction/Maintenance

*This table lists only those processes for which the technologies were most relevant; however, several technologies can be useful in all business processes.

Interactive Regional Scenario Analysis

Interactive regional scenario analysis uses long-range forecasting to create and evaluate alternative growth scenarios. Tools using this technology allow public participants to explore quickly how their value choices may influence future growth and livability in a region, thereby helping to create a feeling of ownership in consequent decisions.

In 2000, Idaho Transportation Partners (ITP), a partnership of the Idaho Transportation Department and other stakeholder groups, wanted to determine the long-term needs of Idaho's transportation system. The agency wanted to assure the public that the state's transportation system would be able to meet demands and to share information with the public. ITP's strategy included holding an internal symposium to determine what approach to take; holding regional and statewide workshops and distributing surveys to get the public's input; using scenario planning, mapping, and town hall polling to help the public see the different possibilities for Idaho's future; and presenting results of the public outreach effort in various plans. ITP used interactive regional scenario analysis to support a town-hall polling style of scenario planning in which participants are able to vote for different options and see the results immediately in a computer-generated image. The images helped participants understand the likely consequences of various decisions and move toward consensus.

The Idaho agency applied interactive regional scenario analysis using MetroQuest, a tool for long-range regional growth forecasting developed as a joint effort between the University of British Columbia's Sustainable Development Research Institute and Envision Sustainability Tools, a private company based in Vancouver, British Columbia. This tool comprises a number of interconnected submodels for demographic forecasting, urban growth and land use, transportation, economic activity, infrastructure costing, energy and water use, solid waste, and air quality. The submodels all contain data either collected during previous projects (e.g., household travel surveys, economic surveys, land information surveys, or environmental quality models) or compiled as part of the project at hand.

Once submodels have been created and calibrated for a given region, the tool's interface allows non-technical users to make value choices and evaluate and compare the resulting scenarios. The scenarios graphically illustrate the consequences of different policy options. The interface for choosing values and creating scenarios requires only minimal customization to be applied to different areas and can be customized to show the scenario choices, results, and images that best reflect local issues. The tool can be used over the Internet as well as in public meetings; because computation for alternative scenarios is not instantaneous, users might typically process potential scenarios before public meetings so that participants are not kept waiting.

Data required for MetroQuest and other interactive regional scenario analysis tools are entered during model development, typically using spreadsheets and geographic information system (GIS) software. The data used to run the models include population and historical population trends; employment and historical employment trends; transportation network characteristics; existing zoning and tax lots; household size, income, and other socioeconomic variables; and tax structure.

Software and hardware requirements for MetroQuest are a PC with at least Pentium IV, 1 GHz processor, 256 MB RAM, approximately 10 GB of free hard drive space, a DVD-ROM drive, Microsoft Windows 2000 (with service pack 4) or newer operating system, and a monitor capable of a display resolution of 1024 × 768 pixels and a color depth of 24 bits. MetroQuest can be accessed over the Internet on any computer equipped with Internet Explorer Version 5.0 or higher.

Interactive regional scenario analysis provides quantifiable outputs specific to the study region. However, these outputs are based on assumptions, embedded in the specific tools used, about how policy changes affect travel behavior and energy use. The specific tools must be calibrated to reflect observed regional behavior. For example, the tool used by Idaho was originally developed in Canada and had to be adjusted by the Idaho agency to reflect behaviors more typical in the United States.

Integrated Aerial Data Collection

Integrated aerial data collection gathers and analyzes data from multiple sources in a single aerial flight to produce an information-rich three-dimensional (3-D) model of a study area. The multilayered information may be combined with existing GIS layers to create a robust base for environmental analyses.

Research at the National Consortium on Remote Sensing in Transportation Environmental Assessment (NCRST-E) sponsored by the U.S.DOT's Research and Special Projects Administration (RSPA) was the basis for development of this technology. The NCRST-E is based at the Mississippi State University Remote Sensing Technology Center (RSTC); the research was conducted in collaboration with Earthdata Corporation, ITRES, Digital Globe, and the DOTs of North Carolina, Iowa, and Mississippi.

Integrated aerial data collection incorporates multispectral satellite imagery, color infrared (CIR) and black and white digital ortho-rectified imagery, light detection and ranging (LIDAR) data, and hyperspectral image data—technologies that have been available for some time. However, increased computing speeds and relatively inexpensive data storage have made it practical to integrate these components and use them together on transportation-project applications. These integrated components gather several layers of data from an aerial flight or satellite digital data acquisition. Data can then be integrated to yield such information products as land cover classification, wetland maps, potential corridor alignment plans, field work maps, and 3-D digital terrain models. Compared with conventional field data collection, the integrated applications reduce costs and streamline the project development process, particularly for large projects. In areas that are remote or otherwise difficult to access physically, this technology can also enhance data accuracy.

Specific applications have been undertaken for DOTs in Alabama, Iowa, North Carolina, Mississippi, Virginia, and Washington. These applications include remote sensing for wetlands mapping, analysis, and impact mitigation; multisensor data analysis for streamlining National Environmental Policy Act (NEPA) processing; remote sensing for land-use and land-cover assessments for transportation planning; development of regional GIS databases for multimodal transportation planning; and corridor planning for economic development and rural communities impact analysis.

Because aerial data sets are usually acquired through private vendors that do not serve all states and projects may be located at a significant distance from a vendor's home base, the cost of acquiring data is highly variable. However, the marginal costs associated with adding data sources to a flight service hired initially for one purpose may be low. Efficient data gathering generally will involve interdepartmental coordination, which can be a challenge.

Analyzing and converting the data into useful information represents a separate cost that also can be highly variable. Developing algorithms to identify habitat, in particular, is a complex use of the data that would likely require significant expense. Hardware requirements for data gathering are met by the vendor. Multisensor remote sensing acquisition platforms include LIDAR, digital cameras, multispectral sensors, hyperspectral sensors, and global positioning system (GPS) inertial measurement units. Raw data are processed using standard industry methods to yield input for GIS and computer-aided design and engineering (CAD/CAE) software. Substantial data storage capacity and engineering graphics workstations are needed to accommodate typical work flow.

Some early applications of integrated aerial data collection have encountered problems. For example, LIDAR has sometimes read tree tops or fence posts as ground level, skewing the results of the survey. Computerized methods to calculate quantities of different types of vegetation based on CIR digital photography have not been widely tested. Using hyperspectral data for habitat identification in transportation projects is still in its infancy, and hyperspectral signatures are not yet available for a wide range of vegetation. The technology thus is still a rapidly evolving area for research as well as a practical tool for DOT use.

Road and Rail Alignment Optimization

Road and rail alignment optimization uses advanced computational algorithms and computing power to quickly generate and screen very large numbers of alignment alternatives, computing cut-and-fill estimates to find optimal alternatives. The technology represents a major advance in the comprehensiveness and efficiency of route-location studies.

When the Transportation Corridor Agencies in Orange County, California, became involved in a dispute between two stakeholder factions regarding the route of a new tollway, route optimization was used to examine many possible routes within a very short period of time and to provide alignments, impact measurements, and cost estimates to help identify viable alignment possibilities. The agency relied on a proprietary tool initially developed by Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) and further developed and marketed by Quantm Ltd., a private firm established in 2000 and headquartered in Australia. Other agencies (e.g., the Louisiana Department of Transportation and Development) have developed and used other route optimization tools for other applications.

These tools use advanced algorithms and high-powered computing capability to test millions of possible alignments for any defined set of constraints, including engineering parameters and costs. "Best fit" routes are provided to the project team for further consideration. In the Orange County case, these results were made available to the project team within 48 hours of data entry for each scenario defined. Use of this technology enables rapid testing of alignment variations and greatly reduces the time to develop and screen alignment options. This capability in turn creates a more transparent project development process in which assumptions are known and logically applied by the project team.

Such tools can be used for both realignment and new alignment projects but are more useful for corridor and new alignment analysis because alignment alternatives developed by the route optimization tool typically are limited to mainline segments; the software does not model interchanges or intersections but can impose clearance factors on the alignment and include interchanges as a cost factor. This restriction may compromise the tools' usefulness for alignment projects focused on the placement and geometric features of interchanges.

The tools encourage an iterative approach in which users can easily consider "what if" scenarios involving changes to alignment constraints such as adding zones to be avoided or changing design standards. The tool used in Orange County allows import of pre-existing or proposed alignments from other packages or input using point-and-drag technology. The tool shows cost changes and earthworks and structures and can identify such alignment issues as grades that are too steep or requirements for large cut-and-fill sections. These alignments can also be used as the basis for "seeded" optimization, where the system restricts the investigation to alternatives close to the defined alignment. Alignments can also be constrained by mapping areas that must be avoided or by assigning costs to the use of certain areas, thereby providing a method to reflect environmental or other "fatal flaw" constraints.

Route optimization tools can use coarse or refined data; the characteristics of the input data depend on the required level of accuracy and the cost of data to achieve each level of accuracy. Input data include a digital terrain model, cost information, and design rules.

In the Orange County application, the software tool was provided under a use agreement. Quantm trained agency staff to use the front-end software to input data, define scenarios, and submit scenarios to the firm for analysis with the proprietary software engine. Hardware requirements for the agency (for data input) are a Pentium IV with 512 MB of RAM, Windows XP/2000/NT4, Internet connection with the ability to transfer files up to 3 MB, 4 GB of free hard drive space for data files, and 64 MB of RAM on the graphics card. These requirements are apparently typical, although this study did not undertake a comprehensive comparative analysis of route optimization tools.

Agency personnel in Orange County reported that the cost to use the route optimization tool compared favorably with traditional methods for conducting route alignment studies. Participants in the Orange County application estimated that use of the route optimization tool reduced project planning time by between 6 and 12 months and cut construction costs by more than $100 million, while allowing the team to significantly reduce environmental impacts as well.

Web-Based Environmental Screening

Web-based environmental screening entails database software that supports web-based presentation of project information and management of the environmental analysis and review process. Tools provide links to base documents and prompt reviewers to provide commentary, thereby encouraging earlier engagement of stakeholders and identification of issues to be resolved in project development decision making.

The specific application of the technology reviewed in this project was developed by the Florida DOT (FDOT) with the URS Corporation, in partnership with the University of Florida's Florida Geographic Data Library (FGDL), to respond to the environmental streamlining element of the federal transportation authorization legislation of 1998, TEA-21. Environmental streamlining calls for early NEPA reviews and approvals, full and early agency participation, and the integration of review and permitting processes. Following passage of TEA-21, FDOT's Central Environmental Management Office sought changes to the agency's planning, project development, and permitting processes to shorten total project development time. The effort led to the Efficient Transportation Decision-Making (ETDM) methodology for presenting project planning information to facilitate early and efficient gathering of agency and public input. FDOT's Environmental Screening Tool (EST) was implemented as part of the ETDM process.

The EST is designed as a "smart," electronic process management tool that guides reviewers through the process and provides links to base documents. It also automatically prompts reviewers to provide online feedback at appropriate points in the review cycle, thereby helping agencies and stakeholders to assess potential project impacts between the time projects are proposed in a long-range transportation plan and when they are scheduled in the State Transportation Improvement Program (STIP). An Internet-enabled GIS application composed of several modules, the EST allows users to define project locations and concepts and identify potential environmental issues. It is capable of screening projects for either early identification of critical flaws (the planning screen) or NEPA scoping requirements (the programming screen) when analyzing alternative scenarios. Data for the application are drawn from more than 300 geographic layers in the FGDL.

Using the EST involves four steps:

1. Data are entered into the FGDL, the underlying database. Data typically come from MPOs and the DOT, which provide information on the project and characteristics of the community where the project will be located, and resource agencies, which provide relevant environmental resource data.
2. Buffers around the project site are established, within which possible environmental impacts are identified. The number of acres directly impacted is recorded as well as the percentage of the overall resource involved.
3. A review is conducted by Environmental Technical Advisory Team (ETAT) members and community liaisons and is made accessible to the general public for comment via a public access site. The ETAT comprises representatives from 23 federal and state re-

source agencies. Each reviewer recommends a degree-of-effect designation and issues for further review. Elements to be reviewed during the programming screen include the project purpose and need, expected direct impacts, recommended avoidance/minimization, recommended mitigation strategies, agency involvement (continue or no further action), degree of effect, class of action, and comments.

4. A report is created by ETDM Coordinators at both the MPO and the DOT that summarizes effects, commitments, and responses. A variety of environmental factors such as air quality, floodplains, noise, and archaeology are rated by individual reviewers to determine the degree of effect that the proposed transportation project may have on the resource being reviewed. The designations for degree of effect range from "enhancement" to "potential dispute." "Enhancement" indicates the transportation project is likely to enhance the resource, and "potential dispute" indicates that the project is contrary to a state or federal resource agency's program, plan, or initiative. When reviewers designate degree of effect, they must also provide supporting commentary to identify the impacted resources and describe the perceived impact. The reviewers are also provided areas to suggest avoidance, minimization, or mitigation strategies. Reviewers apply similar criteria to each resource they manage, which allows the ETDM Coordinators to review a variety of reviewer comments on one screen.

The EST's tracking element records when a project is submitted for review and indicates the number of days that remain before a decision is required. To support the review, GIS layers provide the project footprint as well as the location and types of nearby human and natural resources. Detail about the project (including a description, purpose and need statement, and summary of public comments) is included in the system, and reviewers are able to comment on the screen where the project information is presented.

Applying the EST requires that reviewers be trained to provide objective, consistent comments across projects and across environmental disciplines. Training materials that have been prepared include ETDM Guidelines, ETDM Technical User Guide, Public Involvement Handbook, Sociocultural Effects Handbook, agency operating agreements, agency and public websites, and hands-on and web-based training. This NCHRP study found that 164 projects had been reviewed using the EST process, and another 200 projects were under review. More than 400 participants are using the tool for the review process.

The EST server is ORACLE 9i running on a UNIX platform. The tool uses ESRI ArcIMS and ArcSDE for Internet functionality. A dedicated portable document format (PDF) writer is included in the report generator. Other major cost elements associated with the EST include data acquisition, customization of the internet-based GIS tools (e.g., to address such details as format, availability, and organization of data; agency-specific standard reporting requirements; reviewer log-in and security provisions; and comment tracking), and software and data maintenance and updating.

FDOT's application was developed with the University of Florida and this experience suggests the academic setting is ideally suited to meeting the needs of the application. Each participating resource agency has an agreement with the University of Florida outlining data acquisition and update requirements. All data are managed by the University of Florida. Data access is granted by permission and secured through password controls. All data sets are documented using at least the minimal Federal Geographic Data Committee (FGDC) metadata standards.

NEPA Document Preparation and Review Expert System

The technology for the NEPA Document Preparation and Review Expert System uses "smart" form analysis and data management software to facilitate web-based preparation of documents for categorical exclusion (CE) and environmental assessment (EA) decisions that meet FHWA requirements. The software prompts reviewers to provide needed information, guides the input of their responses, and creates a central repository for documentation, significantly reducing processing time and facilitating data sharing among agencies.

In an effort to save time and money in processing and documentation, the Pennsylvania Department of Transportation (PennDOT) in association with McCormick Taylor, Inc., and Ciber Inc. developed the tool reviewed for this study. This project control, development, documentation, review, and approval tool is for projects that require a CE or EA document under NEPA. The tool streamlined PennDOT's CE documentation and approval process and reduced the time required for preparing and approving CEs by an average of more than 32%.

The PennDOT's NEPA Document Preparation and Review Expert System presents the user with a series of questions about the project. If the user indicates that a particular resource is not present, no additional questions will be posed about that resource. If a particular resource is present, additional detailed questions regarding that resource will be posed until the user has provided sufficient information. Upon completion of the form, the user submits the CE and the review process is initiated. The system automatically generates sequential email notifications to the individuals in the review chain until the CE is approved.

The tool also supports the project scoping process; scoping forms are completed in the system and become the basis for the CE evaluation. All reviews and approvals are conducted electronically. The tool guides users through the series of questions and actions to produce FHWA-ready documentation (the underlying forms were developed in cooperation with the FHWA Division Office).

The system can also be used to assemble, review, and approve EAs and serves to archive both the EA and the supporting research reports. Because development of CEs and EAs relies on basic project information, this system serves as the central project control and repository for information other than environmental data. The system includes provisions for downloading the application to a laptop, enabling a user to enter information from the field without having to first take notes and then transfer notes to the system in the office. Upon return to the office, the user can synchronize the data collected on the laptop with the main database, transferring the collected data directly from the laptop to the server.

The PennDOT application uses the Domino web platform from IBM, but the developers stressed that the application could be developed using other platforms. The application also required software to handle internet forms (with the ability to implement "smart" form features), large amounts of data, attachments (for computer-aided design and drafting [CADD] drawings, maps, photographs), and the opening and querying of GIS databases if these latter are to be used as resources.

Agency staff estimated that the more than 32% average time reduction for preparing and approving CEs translated into an annual cost saving of approximate $5.9 million for CE-level projects. Added benefits included consistency and improved quality in CE and EA documents; creation of a central, electronic repository for project documentation; opportunities for data sharing within and among agencies; and significant improvement in data availability to interested stakeholders.

Restricted Activity Zone Mapping

Restricted activity zone mapping uses software to guide highway maintenance staff on the types of maintenance activities that are restricted on specific road segments and when these restrictions are in effect. This technology draws on data from several sources to produce color-coded linear route maps showing areas where environmental regulations impose constraints on maintenance actions.

In the 1990s, several salmonid species were proposed to be listed as threatened or endangered species in Oregon. The Oregon DOT (ODOT) recognized that highway maintenance staff would need to understand, without having to consult a field biologist, when certain maintenance activities would be restricted as threats to the species' habitat. ODOT worked with Mason, Bruce and Girard, and Pacific Meridian (now Sanborn) to develop the restricted activity zone (RAZ) map system, an enhancement of the straight line chart tool familiar to maintenance staff.

Using a variety of electronic data, some of which are readily available, the RAZ map system maps environmentally sensitive areas and indicates what maintenance actions can be taken on a mile-by-mile basis. The top half of each RAZ map is a U.S. Geological Survey map of a 3-mile road segment. The bottom half is a common straight line chart showing road features along the segment; below that are bar charts representing various types of maintenance activities such as mowing or spraying. The bars are color-coded to indicate whether activities are permitted along the segment and under what conditions. Hard copy and electronic map sets are available for every maintenance district in the state; hard copy materials are often carried around in maintenance vehicles for easy reference.

The RAZ maps draw on a sophisticated database and a second set of maps identifying wetlands, drainages, riparian zones, likelihood of archaeological sites, endangered species sites, and habitat. These resources are mapped similarly to the RAZ maps and include resource bars in place of the activity bars. The resource maps are used by planning staff and region environmental coordinators as a quick reference guide to the environmental character and features of an area.

Underlying both map products is a database containing digital, CIR aerial photography of all state roadways, including 500 feet on either side of the centerline. Various methods of photograph interpretation are used to identify and map habitat. The final compilation of data also includes the analysis of other GIS data sets. For example, the likelihood of archaeological sites is calculated using slope and river confluence databases.

This application uses desktop and laptop computers; ArcGIS, ArcView, and ArcPad GIS software; Erdas Imagine software; Trimble GPS software; laser range finders; and custom GIS data processing routines. In addition, MicroStation CAD software, a custom tool to draw data “ribbons” on maps, and Microsoft Access are required. The main data requirements are GPS-registered digital, CIR photography; data from existing agency data sets; GIS roads data; and National Wetlands Inventory data. Land cover, riparian zone, and additional potential wetlands data are derived from the CIR imagery; contiguous riparian area and fill slope data are modeled from existing data. All of these data feed into a linear referencing model; the output is delivered to ODOT as a text file that is input to a CAD program to display data on resource maps. The resource maps are then used to generate a map indicating where designated maintenance activities can and cannot be performed. ODOT’s cost to develop this tool has exceeded $2.2 million.

Electronic Asset Management System

Technology for electronic asset management uses database software to establish a repository of information on transportation infrastructure assets and facilitates access to that information for management decision making. Tools integrate information from multiple sources to characterize individual assets and asset groups and their condition, to facilitate updating with field inspection data, and to support preparation of maintenance work orders.

The Maryland State Highway Administration (SHA) owns and maintains more than 100,000 storm drainage structures and about 1,700 stormwater management facilities. In 1999, the agency became one of the first state transportation agencies to be regulated under the National Pollutant Discharge Elimination System (NPDES) permit program, an element of the Clean Water Act that regulates point and nonpoint sources of pollutant discharge into waters of the United States. SHA—in association with Greenman Pedersen, KCI Technologies, and Enterprise Information Solutions—developed a electronic asset management tool that can be used in the field to collect a range of information on these stormwater management facilities.

The tool is used for stormwater facility inspections, which are performed at least every 3 years to produce ratings on each facility. All inventory and inspection data are stored in the SHA’s central Drainage Infrastructure Database, which includes stormwater facility attributes. The system produces outputs useful for preparing maintenance schedules and generates work orders with a description of the facility, picture, and map.

The core of the system—which could be used to manage any type of transportation asset—is a facility database that integrates information such as condition assessments, photographs, monitoring reports, and field inspections. Using a handheld computer, inspectors can view data, easily update it, and quickly upload it into the central database. The tool also includes features to quickly combine and compare data from all or subsets of the facilities, format and present data in reports, and cut and track maintenance work orders. The application also allows for the collection of descriptive information about assets in the field using a Personal Digital Assistant (PDA) handheld computer device.

The application is used to conduct three main functional activities: office planning, field inventory, and inspection and maintenance. During office planning, relevant existing information is assembled and entered into the relational Stormwater Facilities Database. Each facility is designated as a certain type, such as ponds (e.g., retention ponds, detention ponds, extended detention ponds), swales (e.g., wet swales, dry swales), shallow wetland marshes, underground storage, infiltration (e.g., trenches, basins), and low-impact development practices (e.g., bioretention, tree filters). Each facility is given spatial coordinates to tie it to a GIS. The relational database allows inspectors and data collection personnel in later activities to enter information specific to the type of facility, providing for detailed, consistent information to be collected in the field. When complete, the information is uploaded to a PDA with an ArcPad GPS unit for the field inventory.

During field inventory, data collection personnel visit each of the stormwater facilities with a PDA with ArcPad GPS unit in hand, to verify data previously collected and to supplement this with additional data. Inventory personnel confirm the facility's existence, type, and measurements and identify potential public hazards. Digital photographs are collected for each facility and attached to facility files in the database. The application contains a voice recording element that allows inspectors to record audio notes. This element is provided for safety reasons—many stormwater facilities are located on the edge of roadways and the agency wants to minimize the time inspectors are exposed to the potential safety hazard of passing vehicles. The voice recording option allows inspectors to make comments more quickly than by transcribing them on paper or typing them into a PDA, thus reducing field time at the site. Upon returning to the office, agency staff upload information into the Stormwater Facilities Database, creating a central storage location for all information related to the stormwater facilities.

Inspection and maintenance activities, subject to NPDES permit requirements, are based on a 3-year cycle. Field inspectors use the same PDA units to enter data on facility condition and maintenance issues. Maintenance to correct minor issues is done at this time, and facility deficiencies are identified. Data can be exported directly from the database for report generation and used for prioritization of repairs. The SHA Stormwater Facilities Database can output such reports and recommendations as priority ratings for repairs and improvements and reports to Maryland Department of Environmental Quality for compliance with the NPDES permit program.

The SHA asset management tool is implemented as a program written in Visual Basic that runs on an Oracle database server. The software runs on a personal computer. Other required application software includes Microsoft Access, ArcView/ArcInfo GIS, graphics display software, and Microsoft Excel. Other necessary field equipment includes PDAs, GPS units using Coast Guard differential corrections, digital cameras, and field water-testing kits. The amount of equipment required is determined by the number of inventory and inspection crews in the field.

Life Cycle E-Engineering

Life cycle E-engineering technology applies GPS information and data management software to integrate project data by development phase. Tools capture data from site survey, design, and construction, maintaining data accuracy and reducing duplication of data collection efforts over the course of a project's development.

The leadership of the Minnesota State Department of Transportation (Mn/DOT) sought to integrate data throughout the project life cycle, thereby increasing the value of the agency's investments in data collection and information management. Under the agency's life cycle E-engineering concept, data are collected in the planning phase to be used during design, construction, and maintenance. Similarly, details from the design phase remain available during construction, enabling inspectors to access all project information with handheld computer devices in the field and contractors to use planning and design data in location and terrain models for machine control. Mn/DOT developed this application with support from Bentley Systems, Inc.

The tool integrates Mn/DOT technology investments made in data collection, CAD design, and GIS analysis to support all project phases—including planning, permitting, design, construction, and operations and maintenance—within a handheld computer. The tool supports a work flow process that informs surveyors, inspectors, and contractors during construction about their physical locations in relation to critical environmental areas.

Mn/DOT tested the tool on the Willmar Project, a complex 2.5-year construction effort. GIS data on contours and the location of area wetlands were overlaid onto aerial photography and integrated with the project design model. Environmental permit data, standards, specifications, and other non-graphical data were also included. The data downloaded to handheld computer devices or Trimble GPS units included the project design, drainage information related to structures and pipes, and pay items with associated quantities and locations. Field tests were conducted for electronic staking and inspection for drainage structures and curb- and gutter-based pay items; testing involved using the GPS unit to verify information already collected by survey crews. The results were within mandated tolerances.

Changes made to the design in the field were uploaded at the construction field office at the end of each day. Field records and information regarding review of pay items, quantities, and locations were also included in the handheld units. Contractors used the design information—3-D location and terrain models of ponds, wetlands, and roadway surfaces—for machine control during construction. The models were transferred to GPS units mounted on the excavation equipment. This information enabled avoidance of environmentally sensitive locations and helped assure that commitments made during the permitting process were met.

The Mn/DOT application used Bentley Systems, Inc.'s MicroStation and GEOPAK software packages, ESRI's archive, and Trimble Navigation GPS software (for machine control). Hardware requirements included standard CAD, CAE, and GIS support infrastructure and handheld mini-tablet or another type of mobile computer. Trimble GPS units are required for surveyors doing stakeout or inspectors collecting GPS information while inspecting. Programming was done with C/C++, Java, Visual Basic, and the NET framework.

Mn/DOT staff credited the technology's use on the Willmar Project for an improved understanding of environmental issues during design, a result of integrating GIS data with MicroStation. The agency also was able to reassign survey crews from the construction site to other locations because using machine control to build ponds did not require traditional staking. Contractors, realizing the advantages of machine control on the Willmar Project (faster construction and, in the case of computer-driven hydraulics, the ability to assign less skilled operators), encouraged the agency to adopt the technology for other projects.

TRANSFER AND USE OF THE SELECTED TECHNOLOGIES

The eight technologies documented in NCHRP Project 25-22(02) have potentially wide applicability to other agencies and applications beyond those for which they were developed. The experiences of agencies in developing and using these eight examples offer lessons for implementing applications that would improve consideration of environmental concerns in transportation decisions.

Limited Initial Implementation

Limited initial or incremental implementation is recommended for applications of all eight technologies. Implementation can be limited to a region or metropolitan area with the necessary resources (e.g., data quantity and quality, committed leadership) or to a single application of the technology (e.g., types of reviews, a single project). For technologies that rely heavily on data collection (e.g., integrated aerial data collection, RAZ mapping, electronic asset management), data can be collected incrementally by geographic region and/or by area critical to the agency's overarching goals.

Data Availability and Standards

Four of these technologies—interactive regional scenario analysis, integrated aerial data collection, web-based environmental screening, and NEPA document preparation—depend on the availability and quality of necessary data inputs. Implementing agencies will need to clearly identify what data are available at the local level, what national data can be used, and whether any additional data should be collected at the local level. In addition, standards on minimum data quality and guidelines on data sharing, use of data, and responsibility for updates to data will need to be established early in the implementation.

Buy-in of Agency Staff and Stakeholders

For these technologies to be implemented successfully, key players—whether the users, the leadership of the users, the users' support staff, or the public—must buy into their usefulness. For interactive regional scenario analysis, representatives of government, public, industry, and environmental interests should be consulted to guide development of models and scenarios. For road and rail alignment optimization, agency project managers and team members should become familiar with the technology and how it can be used efficiently through software demonstrations and agency discussions with agencies or consultants who have used it previously. For technologies that require coordination among many resource agencies and jurisdictions and data collection from numerous sources, strong leadership support is needed to push the implementation forward. For NEPA document preparation, DOTs will need to coordinate their efforts not only with FHWA, but also with their internal information technology departments, who need to understand that control of the approval process is where the time savings can be gained and that this part of the application should not be compromised.

Multiple-User Involvement

Use of a technology by multiple agencies can be cost effective and can create richer databases that will support broader data analysis opportunities. Interactive regional scenario analysis, web-based environmental screening, and electronic asset management are most conducive to use by multiple agencies. To facilitate implementation of these technologies, cross-user working teams, established at the start of the tool development process, may be a useful mechanism to ensure the tool is developed so that it meets the needs of all participating agencies.

RECOMMENDATIONS FOR PROMOTING USE OF THESE TECHNOLOGIES

Applications highlighted in this research involve proven tools that support the integration of environmental considerations into transportation planning, design, construction, maintenance, and operations. As a set, they offer innovative approaches for DOTs and other transportation agencies to explore when addressing their business line issues. On an individual basis, the applications may illustrate solutions to particular problems faced by individual agencies.

The aim of this research is to accelerate innovation by promoting the use of such tools to improve consideration of environmental concerns in transportation decision making. Toward that end, the research team has developed a series of generic recommendations for encouraging adoption of any of these tools, as well as a set of particular recommendations for each application or group of applications. The recommendations are also grounded in the understanding that the current operating climate for DOTs and other transportation agencies, as well as the rapidly changing nature of GIS technology, makes difficult any investment in new GIS-based approaches to meet environmental goals.

General Recommendations

A number of strategies should be pursued to encourage further application of the technologies and tools highlighted in this digest:

- *Showcases.* The applications herein can be showcased not only by distribution of this digest, but also through presentations by the various tool "champions" at conferences and other professional meetings.
- *Peer exchanges.* One- or two-day informal dialogues among state DOT practitioners could be arranged to include representatives from states that have experimented with these tools and representatives from other states interested in adopting them. Peer exchanges can be initiated through various FHWA offices or by TRB committees that can seek FHWA funding. Electronic circulars are often produced to capture the results of peer exchanges; broad distribution of these through TRB networks extends the sharing of information beyond those who participated in the face-to-face meeting.
- *Demonstration projects.* Requests from state DOTs or other transportation agencies for FHWA funding of demonstration projects could provide opportunities for establishing these applications as business line best practices.
- *Technical assistance.* At the request of state DOTs, AASHTO's Center of Environmental Excellence and a number of the university centers for transportation research can assist agencies in implementing innovative tools that promote environmental stewardship and streamlining.

The new Future Strategic Highway Research Program provides for time-specific, concentrated, short-term, results-oriented research focused on solving the problems of highway safety, reliability, capacity, and renewal. The "capacity" problem area includes research on tools for systematically integrating environmental requirements into the analysis, planning, and design of new highway capacity.

Application-Specific Recommendations

In addition to these general strategies, the research team recommends other strategies that may encourage the application of particular technologies and tools highlighted in this study.

Integrated Aerial Data Collection

Further application of multisensor aerial remote sensing will rely on the continued development of spectral profiles for additional plants and habitat communities to allow their recognition in analysis of photogrammetric imagery. As more plant "signatures" become available, the application of this technology will be possible in more locations and for more diverse purposes. Developing these plant profiles would seem to be an appropriate subject for research funding. Neighboring states, or regions within states, could propose such research to state DOT research institutions, academic communities, or TRB's Cooperative Research Programs. Partnerships between transportation agencies and private-sector geospatial data development and analysis companies could also be developed.

NEPA Document Preparation and Review Expert System

The broad applicability and documented benefits of PennDOT's expert system make this type of application a good candidate for AASHTOware. Although one DOT has developed such a system, no off-the-shelf software is available. Pooled-fund research could be directed at developing methods for linking and formatting commonly available resource data, incorporating analytic tools, designing customizable work flow and tracking elements, and creating customizable regulatory and reference library functions.

Electronic Asset Management

Agencies interested in developing electronic asset management systems can tap into recent NCHRP research, including an interim report summarizing existing software products appropriate for assessing transportation assets (NCHRP Project 20-57, "Analytic Tools to Support Transportation Asset Management"). Agencies could also seek assistance from FHWA's Office of Asset Management, whose mission is to promote asset management, leverage resources, and develop collaborative efforts supporting asset management. This type of application is also very well suited for development of a pooled-fund AASHTOware project.

Life Cycle E-Engineering

DOTs interested in pursuing life cycle E-engineering applications, especially for implementation in construction activities, could seek support from FHWA's Highways for Long Lasting, Innovative and Fast Construction of Efficient and Safe Highway Infrastructure (LIFE) program. The program components include funding assistance for highway construction projects that demonstrate innovative approaches to achieving the Highways for LIFE goals, partnerships with both the highway industry and other industries to accelerate the advancement of proven innovations into routine practice, extensive technology transfer, and training. Joint applications for support from facility owners and construction contractors might be especially attractive.

Pooled-fund studies would also be a likely source of support for further development of life cycle E-engineering applications led by FHWA or a state DOT. Large CAD software companies and survey equipment companies may also be suitable technical assistance partners.

NOTES

1. The Transportation Research Board of the National Academies, FHWA, and AASHTO do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this digest.

APPENDIX A—RESOURCES FOR HIGHLIGHTED APPLICATIONS

Interactive Regional Scenario Analysis

Matt Moore, Idaho Transportation Department, (208) 334-8296, matthew.moore@itd.idaho.gov

Integrated Aerial Data Collection

Charles O'Hara, Mississippi State University, (662) 325-2067, cgohara@erc.msstate.edu

Road and Rail Alignment Optimization

Paul Bopp, Transportation Corridor Agencies, (949) 754-3427, bopp@sjhtca.com

Web-Based Environmental Screening

Peter McGilvray, Florida Department of Transportation, (850) 410-5885, peter.mcgilvray@dot.state.fl.us

NEPA Documentation Preparation and Review Expert System

Charles Campbell, Pennsylvania Department of Transportation, (717) 772-2563, chacampbel@state.pa.us

Restricted Activity Zone Mapping

Milton Hill, Oregon Department of Transportation, (503) 986-3769, milton.e.hill@state.or.us

Electronic Asset Management System

Sonal Sanghavi, Maryland State Highway Administration, (410) 545-8414, ssanghavi@sha.state.md.us

Life Cycle E-Engineering

Lou Barrett, Minnesota Department of Transportation, (651) 296-3070, lou.barrett@dot.state.mn.us

APPENDIX B—PROFILES FOR THE 20 MORE PROMISING APPLICATIONS

NCHRP Project 25-22, completed in 2001, identified, critiqued, and showcased current and emerging technologies that support the integration of environmental considerations into transportation planning, design, construction, maintenance, and operations. The continuation of research under that project was designed to advance the use of the most promising of those technologies.

Through contact with state DOTs and other agencies, the research team developed an initial list of 70 applications illustrating the use of technologies previously identified as promising. These 70 applications met three criteria: (1) in use by at least one state DOT or other public agency in the United States, (2) focused on reducing environmental impacts or improving visibility of environmental concerns, and (3) related to one or more transportation agency business processes.

The research team prepared brief descriptions of candidate applications, categorizing the applications by the business process where the application occurred: planning, project development, construction, or maintenance. Some applications were included in multiple categories. The research team then selected the 20 more promising applications by applying three additional criteria: (1) broad applicability of the application to the work of other DOTs or public agencies within the United States; (2) ease of implementation, considering particularly schedule and budget resources; and (3) innovation inherent in the application.

Presented here are profiles for each of the 20 selected applications. These profiles were used by the researchers in subsequent work leading to selection of the eight tools presented in the project report. The profiles are presented here for those who may be interested in considering the broader range of new and emerging technologies showing promise as ways to facilitate integration of environmental considerations into transportation planning, design, construction, maintenance, and operations. Table 3 presents an index to the 20 application profiles.

TABLE 3 Profiled applications and tools*

No.	Application or Tool†	Agency Host	Business Process‡	Selected for Final Reporting
1	ICF CommentWorks	U.S.DOT, Surface Transportation Board	Project Development	N
2	CommunityViz	Various	Planning‡	N
3	Environmental Screening Tool	Florida DOT	Planning	Y
4	MetroQuest	Various	Planning	Y
5	Screening Application for Vegetative Wood Plants and Grasses	Minnesota DOT	Maintenance‡	N
6	Life Cycle E-Engineering	Minnesota DOT	Construction‡	Y
7	Asset Management Inspection	Maryland SHA	Maintenance	Y
8	Multisensor Airborne Remote Sensing	Various	Planning‡	Y
9	Multiple Attribute Utility Analysis	City of Sacramento	Project Development‡	N
10	Restricted Activity Zone Maps	Oregon DOT	Maintenance	Y
11	CE/EA Expert System	Pennsylvania DOT	Project Development	Y
12	Environmental Management System	Pennsylvania DOT	Maintenance	N
13	Road and Rail Alignment Optimization (Quantm)	Transportation Corridor Agencies (Orange County, California)	Project Development	Y
14	Model to Assess Net Benefits of Reusing Waste Materials	Minnesota DOT	Construction‡	N
15	U-Plan	Merced County Association of Governments	Planning	N
16	Data Sharing System	Virginia DOT	Planning	N
17	WeedSeeker	California DOT	Maintenance	N
18	GIS Workbench	Washington DOT	Planning	N
19	Animal Detection System	Wyoming DOT	Maintenance	N
20	Handheld X-Ray Element Analyzer	Minnesota DOT	Maintenance‡	N

Notes:
*It is sometimes difficult to distinguish between specific tools and the applications for which those tools were developed. Particular products and services mentioned here were selected by personnel of the agencies hosting the technology applications that are the subject of this digest. TRB, FHWA, and AASHTO do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this digest.
†Certain of the tools listed are proprietary and may be protected by patent or copyright.
‡Some applications can be useful in more than one stage of the project life cycle.

APPLICATION 1: ICF CommentWorks (not included in detailed analysis)

Example Applications Profile

Name of Agency: USDOT, Surface Transportation Board
Application Name: ICF CommentWorks for Bayport Loop Rail Extension Project
Business Process: Project Development

1. What is the primary function of the example application?
Used for managing public comments received through scoping (738 comments) and DEIS (615 comments) for Bayport Loop Rail Extension Project. Comments were submitted on-line, orally, or in writing. On-line comments were automatically imported into system; written comments were scanned in by project staff.

2. Describe the performance capabilities of the example application. How is it applied?
The application allows the project team to create excerpts from comment letters. Excerpts are categorized by subject area and automatically sent to the appropriate staff person for response. Excerpts form the starting point for response letters. Reports showing complete letters, excerpts, responses, or more can be produced.

3. Who are the main users of the example application? What are the interactions between groups of users?
The application is Web-based. In addition to the public making on-line comments, users consist of the project team. Each member of the team is given a username and password, and they can log onto the Web-based system to share information, view comments, and draft and finalize responses. This allows seamless coordination among different agencies and different office locations. For this project, the team with access included the client, ICF Consulting, and subconsultants.

4. Was the example application developed in-house or outsourced? Please explain.
Outsourced to ICF Consulting. CommentWorks is an off-the-shelf application that requires little customization to be used for NEPA projects (including scoping, DEIS, etc.). The system could be hosted by ICF or by the client—client pays for a license for each user. Application is not proprietary.

5. What are the main hardware and software requirements for the example application? Be specific.
For the Bayport Loop project, ICF hosted the site. In this scenario, the client needs to have a Web browser with plug-in, Windows 2000, and 100 MB of free hard disk space. For projects where the client hosts the site, additional needs include Windows 2000 Server Edition, SQL Server 2000, and Word 2000.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.
Customization includes framework of issues (how to organize comments), list of users, and list of reports to be produced. Main data requirements are public comments. Other data input includes response letters and coordination amongst team members.

7. How is data managed? This includes data entry, maintenance, and archiving.
Data entry: on-line comments automatically exported into database, and written comments are scanned into system. Maintenance: ICF hosted this project and ran daily backups. Archiving: comment letters, excerpts, and responses are exported into document format and delivered in report format. Can export all data to a CD in database format.

8. List necessary interactions between the main users of the example application and other agencies or organizations.
Team members (including client, consultants, and coordinating agencies) shared information and drafted/finalized responses comments through system. NOTE: Client is allowed to use application for future projects without additional fee. This assumes that client does not wish to update application and will perform customization functions in-house.

APPLICATION 2: CommunityViz (not included in detailed analysis)

Example Applications Profile

Name of Agency: Various agencies; CommunityViz (vendor)
Application Name: Scenario 360
Business Process: Planning; Project Development

1. What is the primary function of the example application?
Scenario 360 is a GIS-based decision support and visualization application that supports facility planning, land use planning, and resource management. It allows the development of scenarios and calculates and reports the impacts and benefits that result from these scenarios. It then creates real-time visualizations of the alternatives that graphically augment such calculations and reports.

2. Describe the performance capabilities of the example application. How is it applied?
Performance capabilities include: visualize/compare alternatives; calculate impacts; real-time analyses updates; communicate and collaborate; create/explore 3D scenes; site and route selection/suitability analysis; ROW acquisition assessment; travel demand forecasting; and project prioritization.

3. Who are the main users of the example application? What are the interactions between groups of users?
The software allows a variety of professional disciplines and the public to engage on transportation projects. GIS professional, 3D visualization experts, and subject matter experts such as transportation planners, engineers, long-range planners, and natural resource managers all are users of the application. The application supports use in a meeting or public setting, whereby the operator enters input and executes operations based on participation from several other "users."

4. Was the example application developed in-house or outsourced? Please explain.
Scenario 360 is developed by CommunityViz. The SiteBuilder 3D component is developed by Multigen Paradigm. Models built using CommunityViz are currently developed and performed by end-users, and are transportable from one user organization to another.

5. What are the main hardware and software requirements for the example application? Be specific.
The application operates as an extension of ESRI ArcGIS. Software requirements include ESRI ArcMap™ 8.3 with Service Pack 3. System requirements (Scenario 360): Windows 2000® or XP; 256 MB RAM; 450 MHz Processor; 1 GB hard disk space. System requirements (SiteBuilder 3D): Pentium III processor; 256 MB RAM; OpenGL-based graphics card with at least 32 MB texture memory; Reasonably sized hard disk; 3-button mouse; Windows 2000 or XP Professional.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.
Specific data requirements vary depending upon the application needs, but in general include geospatial feature classes stored in ESRI GIS format.

7. How is data managed? This includes data entry, maintenance, and archiving.
Data are managed in a similar manner to complex GIS analysis. Typically, geospatial data files will be acquired from public agencies, metadata developed, and organized into a logical file and directory structure. Geospatial data are stored in ESRI GIS formats; the preferable method is to store vector data in a geodatabase. Other data, such as rules-based assumptions, are entered by the user through interactive user dialog forms and wizards. Analysis data (rules, assumptions, equations) resides in an Access database (personal geodatabase).

8. List necessary interactions between the main users of the example application and other agencies or organizations.
GIS professional, 3D visualization experts, and subject matter experts such as transportation planners, engineers, long-range planners, and natural resource managers all are users of the application.

Example Applications Profile

Name of Agency: Florida DOT
Application Name: Environmental Screening Tool (EST)
Business Process: Planning

1. What is the primary function of the example application?

The EST is an early-screening environmental analysis, tracking, and reporting tool. The application is designed to help agencies and stakeholders assess potential project impacts between the time they are proposed in the long-range transportation plan and when they are scheduled in the STIP.

2. Describe the performance capabilities of the example application. How is it applied?

EST is an Internet-enabled GIS application made up of 5 modules which use over 300 geographic themes from the Florida Geographic Data Library maintained by the University of Florida (UFL). The modules allow users to define project locations and concepts, and identify potential environmental issues. The tool allows for public comment. The tool provides two levels of project screening for alternative scenario analysis - early critical flaw identification and program screening. Program screened data is input directly into the NEPA scoping process.

3. Who are the main users of the example application? What are the interactions between users or groups of users?

Users include agency planners and environmental specialists, the public, and environmental contractors. There are currently 400+ registered users of the system.

4. Was the example application developed in-house or outsourced? Please explain.

Outsourced. EST is operated by the UFL Geoplan Center who also maintains the Geographic Data Library. EST was designed through a process with participation from FDOT, resource agencies, and the environmental community. The database was designed by UFL and the application was developed by a consultant/contractor. The system has been under development for 4 years with each module being released as available. The primary reason for outsourcing operations was the difficulty of supporting external access into FDOT's secure network.

5. What are the main hardware and software requirements for the example application?

Because the application and data inputs are outsourced, the DOT has no requirements. The application server is ORACLE 9i running on a UNIX platform. The application uses ESRI ArcIMS and ArcSDE. There is a dedicated .pdf writer included in the report generator.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

Agencies enter project scope, purpose, geometry, alignments, and other project information, as well as commitments and responses to issues and concerns raised by external stakeholders. External users add issues, comments, and reviews. Information is transparent to all registered users, allowing issues to be raised and commented on by multiple agencies. The lead agency determines a "degree of effect" indicator for all projects, based on the number and kinds of issues raised. Each participating resource agency has an agreement with UFL outlining data acquisition and update requirements.

7. How is data managed? This includes data entry, maintenance, and archiving.

All data are managed by the University of Florida. Data access is granted by permission and secured through password controls. All datasets are documented using USGS metadata standards.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

The State of Florida reorganized their environmental work processes with the development of EST, eliminating process and data redundancy. All environmental planning and review interactions are now conducted through EST.

APPLICATION 4: MetroQuest

Example Applications Profile

Name of Agency: Various agencies; Envision Sustainability Tools Inc. (vendor)
Application Name: MetroQuest
Business Process: Planning, Project Development

1. What is the primary function of the example application?

MetroQuest allows users to create and evaluate long-range alternative scenarios for metropolitan regions. MetroQuest's visual interface allows users to test policies and changes in transportation, land use, housing, and the economy. Results display a wide range of potential impacts, from air quality and congestion to changing land use patterns and infrastructure investment. MetroQuest is typically used in visioning and planning exercises requiring long-range analysis and broad stakeholder engagement.

2. Describe the performance capabilities of the example application. How is it applied?

It is comprised of an integrated model attached to a game-like interface. MetroQuest's model is made up of a number of interconnected submodels, including demographic, urban growth and land use, transportation, economic, infrastructure costing, water use, and air quality. The models are developed as templates that could be adapted and calibrated for different regions. Once MetroQuest has been applied to a region, the interface allows non-technical users to create, evaluate and compare scenarios rapidly.

3. Who are the main users of the example application?

Main users of MetroQuest include regional planners, stakeholder groups, and the general public. Some applications of MetroQuest have used the tool with key decision makers while others have used it for broad outreach activities. In the case of community outreach activities (via interactive workshops or the Internet), MetroQuest has been used in an open process that allows stakeholders to create and explore their own scenarios while others present a range of pre-run scenarios for comparison and feedback.

4. Was the example application developed in-house or outsourced? Please explain.

MetroQuest was developed as a collaborative effort between the University of British Columbia's Sustainable Development Research Institute and Envision Sustainability Tools.

5. What are the main hardware and software requirements for the example application? Be specific.

MetroQuest is deliverable either on DVD for use on PCs or over the Internet. If being used on the Internet, MetroQuest can be used on any computer running Internet Explorer 5.0 or newer. The PC-based application will run on the following platform or better: Pentium IV, 1 GHz processor, 256 MB RAM, approximately 10 GB free hard drive space, DVD-ROM drive, Microsoft Windows 2000 operating system (or newer) with service pack 4 and a monitor capable of a display resolution of 1024×768 pixels.

6. What data requirements are necessary for the example application to operate?

MetroQuest can be calibrated with a wide range of local information, including: calibrating with output from local MPO four-step transportation models, customizing MetroQuest with GIS layers, and outlining a range of future transportation infrastructure projects to be explored.

7. How is data managed? This includes data entry, maintenance, and archiving.

Data entry into MetroQuest by Envision, Inc. via Excel spreadsheets and GIS layers during model development. Clients may supply their own data to replace MetroQuest's existing baseline data during the development and calibration of the models and as new data become available over time, MetroQuest can be quickly updated and recalibrated.

8. List necessary interactions between the main users of the application and other or organizations.

One common use of MetroQuest is for the collection of informed feedback from stakeholders and the public on the most desirable long-range plans and which tradeoffs seem most palatable for achieving those goals. In this mode, there is an interaction between the public and the planning agencies in the form of quantitative and qualitative outputs of scenario exploration workshops or Internet activity.

APPLICATION 5: Screening Application for Vegetative Wood Plants and Grasses (not included in detailed analysis)

Example Applications Profile

Name of Agency: Minnesota DOT
Application Name: Screening Application for Vegetative Wood Plants and Grasses
Business Process: Maintenance/Construction

1. What is the primary function of the example application?

The application determines optimal plantings for roadside vegetation based on soil types (salt loadings, depth of ground water, moisture content, sunlight/shade, etc.).

2. Describe the performance capabilities of the example application. How is it applied?

The application user enters information regarding the location of the plantings (47 attributes). Based on the data entered, a set of compatible plants is generated. These plants can then be viewed in different life cycles (e.g., young, old, flowering). Growth rates can also be used as a criterion to allow for faster fill of an area.

3. Who are the main users of the example application? What are the interactions between groups of users?

Mn/DOT landscape staff are the primary users of the application. Most of the work is conducted during the design phase for implementation during construction and maintenance/operations phases.

4. Was the example application developed in-house or outsourced? Please explain.

Mn/DOT developed the application in-house, whereas installation services were initially contracted out. The application is now available to all Mn/DOT staff on the intranet.

5. What are the main hardware and software requirements for the example application? Be specific.

Windows PC and Internet browser.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

A library of plants is included with the application and is the main data requirement for this application.

7. How is data managed? This includes data entry, maintenance, and archiving.

Data is largely static within the application. Two versions of the application have been created - the first version just contained wood plants, whereas the second version added grasses.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

N/A

APPLICATION 6: Life Cycle Engineering

Example Applications Profile

Name of Agency: Minnesota DOT
Application Name: Life Cycle Engineering
Business Process: Planning, Project Development, Construction, Operations/Maintenance

1. What is the primary function of the example application?

The life cycle engineering application integrates technology investments made in data collection, CAD design, and GIS analysis to support all project phases, including planning, permitting, design, construction, and operations/maintenance.

2. Describe the performance capabilities of the example application. How is it applied?

The application creates an interoperable work flow process that uses data collected and created during the planning phase for the basis of design and analysis. This information informs surveyors, inspectors, and contractors during construction about actual project location in relation to critical environmental areas. Crews carry handheld computers with updated design information, GPS, and GIS information. Any changes made to the design in the field are uploaded at the construction field office at the end of the day. Updated design detail is downloaded the next morning.

3. Who are the main users of the example application?

The users of the application are planners, hydraulic engineers, construction surveyors, visualization professionals, and GIS professionals. A primary purpose of this application is the sharing of data between project applications and project phases and disciplines.

4. Was the example application developed in-house or outsource? Please explain.

The concept, system design, and development oversight were completed in-house, as were deployment and testing. The application development was completed by Bentley Systems.

5. What are the main hardware and software requirements for the example application? Be specific.

Core software requirements include Bentley's MicroStation and GEOPAK, ESRI's archive, standard visualization tools, and Trimble Navigation GPS application. Hardware requirements include standard CAD, CAE, GIS support infrastructure, Bentley's field handheld computer, and Trimble GPS.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

All data collected: the project enterprise data set which is continually upgraded with newly collected and developed data through the various phases of a project from planning through operations.

7. How is data managed? This includes data entry, maintenance, and archiving.

The initial project step required work flow analysis and restructure completed in conjunction with a new data architecture design. All data collected and created feeds the project enterprise data set, which is continually upgraded with newly collected and developed data. Data collected during the construction and operation phase are captured in the field using handheld computers, and are synchronized with the field office database at the end of each workday. Updated designs are then downloaded to the handheld computers the next morning.

8. List necessary interactions between the main users of the application and other organizations.

At the current time, this application is used within Mn/DOT only. However, as it is expanded, FHWA, PCA, MPCA, and DNR would be considered involved parties.

APPLICATION 7: Electronic Asset Management System

Example Applications Profile

Name of Agency:	Maryland State Highway Administration
Application Name:	Asset Management Digital Inspection
Business Process:	Planning, Maintenance, Construction

1. What is the primary function of the example application?

This application allows the Maryland State Highway Administration (SHA) to manage, locate, inspect, and maintain 1,700 stormwater management facilities for which it is responsible. In many cases stormwater facilities are synonymous with Best Management Practices (BMPs).

2. Describe the performance capabilities of the example application. How is it applied?

The application stores information on stormwater management facilities, inventory, and performance details (including interaction with the community). Inspections are performed at least every 3 years to produce ratings on each facility. These ratings go into the system. The system produces outputs useful for a maintenance schedule and generates work orders with a description of the facility, picture, and map. Elements identify which parts of the highway system have treated versus non-treated stormwater.

3. Who are the main users of the example application? What are the interactions between groups of users?

Main users include the stormwater management facility team and consultants. Regarding NPDES activities, SHA staff and consultants are treated as equal partners. The SHA program manager is ultimately responsible for all stormwater facilities condition, maintenance and improvement.

4. Was the example application developed in-house or outsourced? Please explain.

The application was developed by consultants within the NPDES and SHA framework. There are actually multiple applications—in addition to the basic system, a GIS is being integrated, and personal digital assistants with differential GPS are used for field data collection.

5. What are the main hardware and software requirements for the example application? Be specific.

PCs with good graphics and processing. The main application is written in Visual Basic running on an Oracle data base server; ArcView GIS/ArcInfo running on spatial data servers (also Oracle); PDAs running Pocket PC; and Trimble GPS using Coast Guard differential corrections.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

INPUTS: location referencing, drainage system, and area (including pipes, infalls, outfalls, open drainage), description of facilities, pictures of facilities, maps, inspection data specific to each type of stormwater facility, initial functional assessment obtained in field, inspector repair recommendations, and more detailed functional improvements identified if needed. OUTPUTS: inputs can be printed out. BMP facility managers prepare priority ratings for repairs and improvements based on output of system.

7. How is data managed? This includes data entry, maintenance, and archiving.

Data are managed by the process owners. After undergoing a quality assurance process, data are managed by the facility manager. Data are stored in the database and when collected in the field, temporarily stored in the PDA.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

The application generates work orders that go to SHA maintenance staff and consultants. Some work orders become the basis for contract work. Some construction work follows from the recommendations and priorities of the system. There is also interaction with natural resource agencies and the counties.

APPLICATION 8: Multisensor Airborne Remote Sensing

Example Applications Profile

Name of Agency:	Mississippi State University *GeoResources Institute* in conjunction with North Carolina DOT, Iowa DOT, and Mississippi DOT.
Application Name:	Multisensor Airborne Remote Sensing
Business Process:	Planning, Project Development, Construction

1. What is the primary function of the example application?
Provide enhanced information products to planners, environmental analysts, and engineers to expedite transportation projects during project development, planning, and construction.

2. Describe the performance capabilities of the example application. How is it applied?
The combination of LIDAR, digital imagery, and photogrammetric products provides data acquisition capabilities to improve and expedite transportation project delivery processes. Typical tasks include selecting feasible routes, identifying preferred alignments, and determining stream impacts. The utilization may be extended to such areas as estimation of cuts and fills, vertical optimization of alignment, and drainage design characteristics.

3. Who are the main users of the example application?
DOT Departments: planning, environmental, GIS, design, construction; Other agencies: federal, state, local agencies; Private: engineering and environmental consultants, constructors, the public.

4. Was the example application developed in-house or outsourced? Please explain.
Developed by U.S.DOT RSPA (Research and Special Projects) sponsored research conducted by the National Consortia on Remote Sensing in Transportation Environmental Assessment (NCRST-E) at Mississippi State University Remote Sensing Technology Center (RSTC) in collaboration with Earthdata Corporation, ITRES, Digital Globe, and the DOTs of North Carolina, Iowa, and Mississippi.

5. What are the main hardware and software requirements for the example application? Be specific.
Multisensor remote sensing acquisition platforms include LIDAR, digital cameras, multispectral sensors, hyperspectral sensors, GPS inertial measurement unit for initial data acquisition from airborne platforms. Raw data are processed following industry standard methods. Data products are further processed using novel algorithms developed to operate on COTS GIS, remote sensing, photogrammetry, and CAD/CAE software to provide a variety of information products. Significant data storage and engineering graphics workstations are needed for typical work flow.

6. What data requirements are necessary for the example application to operate?
The systematic use of multisensors acquisition provides topography, hydrology, land use, aerial imagery, and other derived information. Ground control of observations, locations, land-use class training sites and other in-situ conditions are collected to complement aerial acquisition.

7. How is data managed? This includes data entry, maintenance, and archiving.
Data are managed from work flow processing, hierarchical management of directories and data set, and routinely conducted backup of all data interim and final product storage. Data storage can be significant depending on size and scale of the project site.

8. List necessary interactions between the main users of the application and other organizations.
It is anticipated that close coordination among data vendors, consultants, and DOT practitioners can significantly enhance successful application of these technologies. It is not likely that individual agencies would develop inclusive in-house capabilities.

APPLICATION 9: Multiple Attribute Utility Analysis (not included in detailed analysis)

Example Applications Profile

Name of Agency:	Miami Valley Regional Planning Commission, Dayton, Ohio—Vision Process City of Sacramento, California—Northeast Area Transportation Study Missouri DOT, City of Columbia, Boone County—Improve I-70 Advisory Group
Application Name:	Multiple Attribute Utility Analysis (MUA)
Business Process:	Applicability to all business processes. Most applicable to planning, project development.

1. What is the primary function of the example application?

Multiple attribute utility (MUA) analysis technology is an approach used to evaluate and select alternatives based upon multiple attributes or criteria. The technology allows for the management of multiple objectives, the quantification of objectives, and the illustration of tradeoffs. It is typically applied on complex projects when multiple stakeholders are required to select one alternative, and/or when multiple projects must be prioritized. Multiple attribute utility analysis technology is an approach used to evaluate, rank, and select alternatives based upon multiple attributes or criteria.

For the MVRPC project, MUA provided first-level weights to evaluate a large number of different projects across a host of criteria so that decision makers had a more manageable set of decisions to make.

The NEATS project used MUA to prioritize multiple projects to provide the benefit to the community and stakeholders.

The Improve I-70 Advisory Group used MUA as a methodology to screen corridor alternatives to a preferred one.

2. Describe the performance capabilities of the example application. How is it applied?

MUA can be applied as the driving force of a project or task, or as a component of a larger public involvement process. In all cases, performance capabilities include structuring the values and criteria of the decision makers, and displaying the tradeoffs among options.

3. Who are the main users of the example application? What are the interactions between groups of users?

There are two groups of main users of the MUA methodology. The first group would be the sponsoring organization of a transportation project (e.g., a DOT or planning commission). Primarily the projects shepherd a public involvement process that generates a context-sensitive solution and support for a project. The second group would be the public, usually in the form of a working group or advisory group. The public groups use the methodology to capture values and objectives, and produce structured and agreed-upon recommendations for the sponsoring agency(ies).

4. Was the example application developed in-house or outsourced? Please explain.

In all three examples listed at the top of this profile, the MUA application was initially developed by a consultant team. However, the flexibility of the methodology allowed for significant customization to meet the specific needs of the client and the decision teams.

5. What are the main hardware and software requirements for the example application? Be specific.

The entire MUA methodology may be applied with simple graphics and charts. However, a commercially available software tool called Criterium Decision Plus (CDP, created and sold by InfoHarvest.com) is a $600 tool that captures all the data required for a MUA application. This software will run on a current or recent Windows platform. The MVRPC project used matrices and the CDP software. The NEATs example exclusively used the CDP software. The I-70 project used meeting summaries and Excel spreadsheets.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

The amount of data is very dependent upon the project and the stakeholders involved. At a minimum, the data requirements include the values and the importance of those values, the options or alternatives considered, and the performance of the options against the values. The NEATS project also involved structured criteria generation, weighting and rating steps over a number of months to populate the decision model.

7. How is data managed? This includes data entry, maintenance, and archiving.

Three basic methods of data management are appropriate for MUA applications, with increasing degrees of sophistication: (1) meeting documentation; (2) spreadsheets; and (3) CDP software.

8. List necessary interactions between the main users of the example application and other organizations.

MUA is a universally available methodology. Any transportation agency may integrate these tools into decision support processes. Consultant expertise was used in all three case examples to take advantage of their specific experience and tool application expertise.

APPLICATION 10: Restricted Activity Zone Maps

Example Applications Profile

Name of Agency: Oregon DOT
Application Name: Restricted Activity Zone Maps (RAZ Maps)
Business Process: Maintenance

1. What is the primary function of the example application?

To communicate environmental commitments made pursuant to the Endangered Species Act to maintenance staff as they plan their daily work.

2. Describe the performance capabilities of the example application. How is it applied?

The end product is a paper straight-line map showing mile by mile what maintenance activities are restricted in the area. The groups of activities that are addressed are: surface and shoulders, drainage, vegetation management, bridges, snow and ice, guardrails and grindouts. Maps indicate green for go, yellow for caution—refer to the "Blue Book" for best management practices, and red for contact the regional environmental coordinator before proceeding.

3. Who are the main users of the example application?

Maintenance and environmental staff are the primary users of the maps. Planners and environmental staff use the data gathered to produce the maps in planning, project development, and monitoring activities.

4. Was the example application developed in-house or outsourced? Please explain.

Data gathering, data analysis and interpretation, field checking, and data modeling were all outsourced. The negotiations with maintenance staff, the workshops to educate staff and the production of the maps, both the Resource Maps and the Restricted Area Maps were performed in-house.

5. What are the main hardware and software requirements for the example application? Be specific.

Desktop and laptop computers, ArcGIS, ArcView, and ArcPad GIS software, Erdas Imagine software, Trimble GPS and software, laser range finder, and custom GIS data processing routines. In addition, MicroStation CAD software, custom application to draw data "ribbons" on maps, and Microsoft Access.

6. What data requirements are necessary for the example application to operate?

Main data requirements include GPS-registered aerial CIR digital photography, data from existing agency data sets, GIS roads data, National Wetlands Inventory. Land cover, riparian zone and additional potential wetlands are derived from the CIT imagery; contiguous riparian area and fill slope are modeled from existing data. All of the above feed into a linear referencing model as input and the output is delivered to ODOT as a .txt file that is input to a CAD program to display data on Resource Maps. The resource maps are used to develop a map showing where activities can and cannot be performed.

7. How is data managed? This includes data entry, maintenance, and archiving.

Data entry: digitized from CIR photography, acquired and converted existing databases; for field data, entered into Access databases from laptops. Maintenance: originally, 5-year updated cycle, but now considering a more dynamic mechanism. Archiving: base digital data stored on ODOT servers, RES and RAZ maps converted to Acrobat format and archived. CIR imagery on state GIS data clearinghouse for access by external entities.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

Negotiations with regulatory agencies for acceptance of this product as fulfilling the requirements set out in a 4(d) agreement regarding best management practices for maintenance in areas where protection of critical habitat and endangered or threatened species is required.

APPLICATION 11: Categorical Exclusion and Environmental Assessment Expert System

Example Applications Profile

Name of Agency: Pennsylvania DOT
Application Name: Categorical Exclusion and Environmental Assessment Expert System
Business Process: Programming and Project Development

1. What is the primary function of the example application?

The Expert System is used for the electronic development, documentation, review, and approval of CE and EA level NEPA documents in Pennsylvania. The system supports scoping, evaluation, and re-evaluation. The user electronically collects and documents environmental and project information required to gain FHWA approval for project NEPA classification and to streamline approvals by electronic file transfer.

2. Describe the performance capabilities of the example application. How is it applied?

The application is a large, Web-based database displayed as a form that can be filled out by approved users. Documents can then be sent electronically to approvers and returned. Process elements are built into the application that automatically send messages to key staff notifying them of the need for review and/or approval. Application also has data warehouse and archiving capability.

3. Who are the main users of the example application?

Main users include PennDOT and consultant staff with the need to develop CE and EA level NEPA documents for transportation projects, and FHWA staff who are able to review and approve documents.

4. Was the example application developed in-house or outsourced? Please explain.

The application was developed by McCormick Taylor, Inc. and Ciber Inc., with PennDOT Environmental Quality Assurance Division staff providing project management and business process support.

5. What are the main hardware and software requirements for the example application? Be specific.

This application was built using IBM Notes/Domino technology. Screens are composed of DHTML, Formulas, LotusScript, JavaScript, Java and edit-On Pro coding. The system is housed on a central server made available outside PennDOT's firewall for statewide and federal usage. Users do not need any special software beyond Microsoft Internet Explorer to use the system. This allows for a "thin client" approach whereby PennDOT does not have to update user software as part of application maintenance.

6. What data requirements are necessary for the example application to operate?

The application shares data from and with other PennDOT systems. As authors create documents in the application, information is pulled from PennDOT's project management system. This saves time and reduces data entry errors. Authors are responsible for completing documents. Approvers are responsible for reviewing documents and marking them with concurrence. When documents are finalized, approval dates are published to other systems within PennDOT, reducing information tracking efforts.

7. How is data managed? This includes data entry, maintenance, and archiving.

Users that are allowed to change data must first be authenticated by logging into the application using a predetermined user id and password. Data are saved to the Domino database throughout the life cycle of the CE/EA documentation. Data are held in the main database until approved and finalized, at which time the data become eligible to be migrated to the archive database. Finalized documentation is moved to the archive after a predetermined period of inactivity. The archive database is accessed by users through an interface similar to the main database. Users can review and/or reevaluate old documents.

8. List necessary interactions between the main users of the application and other organizations.

Although the application is self-contained, it can accept input relative to other PennDOT applications (e.g., CAD, GIS) as appropriate. Once documents are ready for review, they are made available to various departments in PennDOT and FHWA. The application automatically generates an email notification for each reviewer at a time that is appropriate for their involvement.

APPLICATION 12: Environmental Management Compliance System (not included in detailed analysis)

Example Applications Profile

Name of Agency: Pennsylvania DOT
Application Name: Environmental Management Compliance System
Business Process: Maintenance/Monitoring

1. What is the primary function of the example application?

PennDOT's Environmental Management Compliance System is a strategic environmental program that coordinates maintenance activities from each of PennDOT's engineering districts. PennDOT is especially concerned with erosion and sediment control, and stockpile management during winter maintenance. The application is able to improve environmental considerations during maintenance and provide best practices for winter maintenance conditions. The application is key to obtaining ISO4001 certification.

2. Describe the performance capabilities of the example application. How is it applied?

The Environmental Management Compliance System provides policies and processes for the evaluation/tracking of environmental issues related to maintenance operations. It also helps maintain the plan.

3. Who are the main users of the example application? What are the interactions between groups of users?

All maintenance employees use the system. Functionalities of existing roles were mapped to roles and tasks in the application.

4. Was the example application developed in-house or outsourced? Please explain.

The application was developed by an outside consultant (TLI Systems)

5. What are the main hardware and software requirements for the example application? Be specific.

The Environmental Management Compliance System is mainly a paper-based system. Therefore, there are no specific hardware or software requirements.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

7. How is data managed? This includes data entry, maintenance, and archiving.

District-level senior management define the maintenance process for the district. Some districts with a Computerized Maintenance Management System (CMMS), manage data from that system. Other districts without a CMMS duplicate data on paper.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

Some inter-district coordination takes place during the creation of the Environmental Management Compliance System. Further coordination occurs with any change in district boundaries, where practices may be transferred from one district to another.

APPLICATION 13: Quantm

Example Applications Profile

Name of Agency: Transportation Corridor Agencies; Quantm (vendor)
Application Name: Quantm system
Business Process: Route Alignment Optimization/Route Selection Support System

1. What is the primary function of the example application?

Quantm's primary function is to serve as a route optimization planning tool for large and complex transportation projects. The application integrates environmental, engineering, social, and economic constraints for analysis purposes.

2. Describe the performance capabilities of the example application. How is it applied?

The Quantm system helps determine optimal vertical and horizontal alignments using pre-defined environmental, community, engineering, and economic constraints. Project planners input data, define scenarios, and review alignments using front-end Quantm Integrator software. Optimization requests are submitted to the optimization engine (Quantm Pathfinder) which operates on an advanced IT infrastructure in Quantm's office. The optimization engine is proprietary; Quantm runs the optimization model and provides the client with results. Planners can then display and review the optimized alignments in collaboration with the various agencies and stakeholders.

3. Who are the main users of the example application? What are the interactions between groups of users?

The Quantm system has been developed to enable/support interaction with various agencies, organizations, and consultants involved in EIS studies, public consultation, route selection, and compliance demonstration/approval. Data can be input from GIS, CAD, or hard copy format.

4. Was the example application developed in-house or outsourced? Please explain.

The Quantm system was originally developed by the Australian Government's scientific research organization, CSIRO. A private firm, Quantm Ltd., was established in 2000 to further develop the technology to be applicable to US and European projects.

5. What are the main hardware and software requirements for the example application? Be specific.

Pentium IV with 516MB of RAM, Windows XP/2000/NT4, Internet connection with ability to transfer files up to 3MB, 4GB free disk space for data files, 64MB graphics card.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

Data inputs include: geology zones, geotechnical data, engineering/geometric/design parameters and linear constraints, unit costs for earthworks and structures, and zones to define location and rules for environmental, community, heritage, cultural resources, land-owner, urban, and floodplain constraints.

7. How is data managed? This includes data entry, maintenance, and archiving.

Quantm provides front-end software called Quantm Integrator and a project-specific Quantm database. Following comprehensive training provided by Quantm, agency staff input data, define scenarios, and submit scenarios to Quantm for optimization. The agency then receives and reviews optimized alignments that meet the defined constraints. Project data can be stored both locally and in the Quantm archive.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

Significant front-end interactions take place between the project lead agency and relevant resource agencies and stakeholders to develop scenarios and define constraints. Further interaction takes place between the project lead agency and Quantm about the scenario optimization process.

APPLICATION 14: Model to Assess Net Benefits of Reusing Waste Materials in Highway Construction and Maintenance Projects (not included in detailed analysis)

Example Applications Profile

Name of Agency: Minnesota DOT
Application Name: Model to Assess Net Benefits of Reusing Waste Materials in Highway Construction and Maintenance Projects
Business Process: Planning, Construction, Maintenance

1. What is the primary function of the example application?

Minnesota DOT receives requests to reuse wastes from outside sources in highway construction and maintenance projects. Mn/DOT developed a policy for accepting such wastes. Among the criteria is whether there are long- and short-term net benefits. A decision framework and spreadsheet computer model was developed to determine if there are indeed short- and long-term net benefits from reusing waste materials.

2. Describe the performance capabilities of the example application. How is it applied?

The spreadsheet can evaluate the costs and benefits of placing virtually any kind of waste material in the pavement, shoulder, base, subbase, or embankment of a portion of the highway network. The spreadsheet calculates the difference between the avoidable costs (e.g., benefits) of placing a waste material in a landfill (or disposing of it at the point of origin, such as a taconite mine) and the change in costs of using the waste in the road. A comprehensive cost model is used to calculate the incremental costs of reusing the wastes in the road and includes the delivered price of the waste, material transport costs, design costs, installation costs, inspection costs, maintenance costs, and road user costs. Costs and benefits are calculated over a 20-year period and discounted to the present.

3. Who are the main users of the example application? What are the interactions between groups of users?

Mn/DOT's Office of Environmental Services. Applicants offering waste materials to the department need to furnish information that the spreadsheet requires.

4. Was the example application developed in-house or outsourced? Please explain.

The application was developed by a consultant. It was developed under the guidance of both Mn/DOT's Office of Environmental Services and Mn/DOT's head of materials and research. Also, the staff in the Office of Environmental Services carefully tested the application.

5. What are the main hardware and software requirements for the example application? Be specific.

The application runs on Microsoft Excel spreadsheet software.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

INPUTS: fraction of maximum annual quantity of material that will be placed for each of 20 years; where the waste will be placed (e.g. in pavement, shoulder, base, subbase, embankment); units placed per lane-mile, shoulder-mile, embankment-mile, etc.; ratio of lane-miles to centerline miles, ratio of embankment-miles to centerline miles, etc.; distribution of placement by functional class; incremental change in cost of delivered price of material; incremental cost of placing, inspecting, maintaining the waste material; changes in life cycle costs and user costs; planned average centerline miles of roadwork per year by functional class; remaining capacity of landfill; projected annual rate of disposal of wastes into landfill; landfill tipping fee; landfill construction, operating, and maintenance costs per unit of capacity; quantity of future waste disposal capitalized. OUTPUTS: discounted costs for 1 to 20 years of the costs of placing the waste in the highway; discounted avoidable costs (benefits) of not placing the waste in the landfill (or leaving the waste in the point of origin); net present value in each year, for 1 to 20 years, of reusing the waste.

7. How is data managed? This includes data entry, maintenance, and archiving.

The spreadsheet uses color to highlight data entry requirements. Data are entered by hand. Data are unique to each case or type of waste material evaluated. Input data can be archived simply by saving the spreadsheet to a suitable archival memory.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

The principal interaction is between the Office of Environmental Services and applicants that would like Mn/DOT to use its waste materials. Applicants would provide much of the key input data regarding incremental costs of reusing the waste. If the waste materials are problematic, natural resource agencies might become involved.

APPLICATION 15: U-Plan (not included in detailed analysis)

Example Applications Profile

Name of Agency: Merced County Association of Governments/University of California at Davis
Application Name: U-Plan
Business Process: Planning

1. What is the primary function of the example application?
U-Plan projects land use scenarios using population data and various sets of assumptions, rules, and control screens. From the "vision" scenarios, various transportation systems can be tested, analyzed, and planned.

2. Describe the performance capabilities of the example application. How is it applied?
The application uses population growth data, translating it into households and employees in several categories, according to attraction weights. Attractions represent access to services and transportation facilities. Masks where growth is prohibited are also utilized to represent parks, floodplains, surface water bodies, and important habitats.

3. Who are the main users of the example application? What are the interactions between groups of users?
Main users of the application include local planning staff and transportation planners, interacting with public stakeholders. Resources agencies have input in identifying areas that will have masks or buffers (discouragement weighting).

4. Was the example application developed in-house or outsourced? Please explain.
The software was developed by the University of California at Davis by Professor Robert Johnston. It is currently housed at the University in the Department of Environmental Science and Policy.

5. What are the main hardware and software requirements for the example application? Be specific.
U-Plan is scripted in Avenue for ArcView 3.2 currently, but is in the process of being rewritten in VBA for ArcGIS8. Requires Spatial Analyst Extension.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.
Data inputs include population projections, demographic and employment assumptions, attraction weights, and a determination of areas that should be masked. Data from resource agencies are input, as are relevant goals and policies from local land use plans.

7. How is data managed? This includes data entry, maintenance, and archiving.
Data are managed with user data management screens. The application has a built-in data manager to load attractions and discouragements weights. All data are stored in one directory and given a unique name, time and date field. Archives are created to CD.

8. List necessary interactions between the main users of the example application and other agencies or organizations.
State and federal agencies may be contributors to information from which buffers and weights forecast layer scenarios will be developed. For example, a federal agency would supply the location of endangered species or critical habitat, which would be used to create buffers or masks.

APPLICATION 16: Data Sharing System (not included in detailed analysis)

Example Applications Profile

Name of Agency: Virginia Department of Historic Resources (DHR) Virginia DOT (VDOT)
Application Name: Data Sharing System (DSS)
Business Process: Planning, Design

1. What is the primary function of the example application?
Statewide repository of all identified archeological and architectural resource sites (any structure eligible for inclusion in the National Register of Historic Places) in Virginia. The repository is used by any federally funded project that must go through the Section 106 process.

2. Describe the performance capabilities of the example application. How is it applied?
The DSS collects, organizes, and disseminates location and attribute data about historic resources in VA. The DSS is an Internet-accessible data collection/reporting application containing information for over 153,000 historic resource sites. Approximately 4,500 new sites are entered annually.

3. Who are the main users of the example application? What are the interactions between users?
Primary users include VDOT, DHR staff, consultants, applicants, FEMA, HUD, Corps of Engineers, tax credit project applicants, and state and local government planners and researchers and educators. At this time, there are an estimated 350–400 registered users of the system.

4. Was the example application developed in-house or outsourced? Please explain.
DSS was designed by DHR and VDOT, funded by VDOT, developed by a DOD contractor, enhanced by VDOT and is operated by DHR. During the first year of operation, VDOT provided most of the technical and operational assistance. These responsibilities are now primarily handled by DHR.

5. What are the main hardware and software requirements for the example application? Be specific.
DSS is an Internet-accessible application running under Windows NT on two Dell multi-processor servers (application server and web server) at DHR. The system incorporates Oracle 8.5i, Crystal Reports 85, ESRI ArcSDE and ESRI ArcIMS web server software. Application was written primarily in Java. Clients need MS Internet Explorer v5 or higher to access the system.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.
The system maintains locational data and attribute data for historic resources. Archeological and architectural features are registered to USGS Digital Raster Graphic quadrangles. DSS contains over 100 attribute tables which are maintained using 13 data entry screens for architectural sites and 7 for archeological sites. The 25 predefined reports are a combination of maps and tabular reports. Data access/availability is password protected at two levels of access—limited (for data entry access only) and full (for complete access and reporting). There is no "live" database access.

7. How is data managed? This includes data entry, maintenance, and archiving.
Inventory and register surveyors conduct site surveys and compile field notes which are then entered remotely into the system over the web. This data is held in a staging area pending DHS review and loading into the production system. While attribute data can be entered directly into the system, positional data is noted on paper quads, sent to DHR, and manually digitized into the database. Demolished structures are marked obsolete but not deleted from the system. Metadata is documented in a hardcopy data manual and a shorter job aid for surveyors. Some collection process metadata is stored in the database itself.

8. List necessary interactions between the main users of the application and other organizations.
DSS is a multi-agency application with DHR as system owner and administrator. As such, DHR provides access, training, ad hoc research and reporting, and on-going communication with DSS user community. VDOT provides technical assistance and software enhancements as necessary.

APPLICATION 17: WeedSeeker (not included in detailed analysis)

Example Applications Profile

Name of Agency: Minnesota DOT, California DOT
Application Name: WeedSeeker automated vegetation sensing equipment and herbicide applicator
Business Process: Maintenance, Operations

1. What is the primary function of the example application?
The WeedSeeker technology uses sensors to detect the presence of weeds between pavement cracks and along the pavement or shoulder edge and then uses an automated applicator to spray herbicides directly on the plants. This technology results in a sharp reduction in chemical usage and substantially improves productivity. Caltrans has a goal to reduce pesticide use by 80% by 2112. Caltrans met its prior goal of reducing pesticide use 50% by 2000. The WeedSeeker equipment is expected to help meet the 2112 goal. Caltrans is exploring using acetic and citric acid, which the WeedSeeker can apply.

2. Describe the performance capabilities of the example application. How is it applied?
WeedSeeker uses sensors that detect chlorophyll in plants and automated spray equipment to apply an herbicide in a targeted manner at speeds up to 10 miles per hour. Only one operator is needed. WeedSeeker does not differentiate between different types of plants. In Minnesota, it is used in the Minneapolis/St. Paul area and is very effective around guardrails and medians. The boom with sensors will retract if it encounters obstacles. In California, the equipment is used in the Eureka district area and elsewhere. There are computers and controls in the cab with the operator. There are manual controls to extend the boom out to various distances. Training is needed for effective spraying.

3. Who are the main users of the example application? What are the interactions between groups of users?
The main users are the portion of District maintenance organizations responsible for roadside vegetation management. At Mn/DOT the Metro district interacts with the Office of Environmental Services. In Caltrans the main users are the applicators under the oversight of a supervisor of roadside vegetation management.

4. Was the example application developed in-house or outsourced? Please explain.
Purchased from the manufacturer, NTech Industries (formerly Patchen).

5. What are the main hardware and software requirements for the example application? Be specific.
The main elements of the WeedSeeker include the boom, sensors, pumps, tubes, tanks, chemicals, computers, controls, and truck. In northern California, Caltrans mixes 10 gallons per acre instead of 50 gallons per acre mixed in the past. Currently, WeedSeeker is not widely used in California, but is expected to increase as pressure increases to achieve reduction in herbicide use.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.
WeedSeeker senses the chlorophyll in plants on the road edge or in pavement cracks. It issues a beam of infrared and red light which is reflected off a plant and detected by LEDs.

7. How is data managed? This includes data entry, maintenance, and archiving.
Data on chemical usage are exported and analyzed.

8. List necessary interactions between the main users of the example application and other agencies or organizations.
Mn/DOT interacts with the Office of Environmental Service, the Department of Agriculture, County weed inspectors, chemical suppliers, and at times manufacturers for repair components (sensors, pumps). Caltrans interacts with the Department of Pesticide Regulation and the California EPA.

APPLICATION 18: GIS Workbench (not included in detailed analysis)

Example Applications Profile

Name of Agency: Washington DOT
Application Name: GIS Workbench (Environmental)
Business Process: Planning, Design, Operations (minimally)

1. What is the primary function of the example application?
To search, browse, integrate, and visualize Enterprise GIS, mapping, and imagery databases. The GIS Workbench is the key technology supporting the WSDOT Environmental Procedures Manual.

2. Describe the performance capabilities of the example application. How is it applied?
The Workbench assists environmental specialists and others in project scoping, preparation of Environmental Assessments, and environmental permit preparation. The system allows concurrent access to tools and data. The application supports a linear reference system so that users can enter project locations in order to "zoom" into a project area across multiple data sets.

3. Who are the main users of the example application? What are the interactions between users or groups of users?
There are two primary user groups. The first is the headquarters Environmental Information Group, which administers the application, trains users, manages the databases, negotiates data sharing agreements, and owns and maintains several databases. The other group consists of environmental specialists, planners, programmers, designers, and maintenance staff who use the application in read-only mode. The application is not currently available to other agencies or the public.

4. Was the example application developed in-house or outsourced? Please explain.
The application was developed in-house by the Department's cartography and GIS Support Team. The Environmental Information Program is the application owner. The application was developed in 1999 and took less than one calendar year to deploy.

5. What are the main hardware and software requirements for the example application? Be specific.
The original system was implemented in ArcView 3.1 running under Windows NT and programmed in Avenue scripts. The upgrade release is being developed in Visual Basic as an ArcMap 8.0 extension. Both run on standard Windows, Pentium-class workstations. An SQL Server database stores the application and manages floating licenses. The data repository is managed on a single server. Contents are distributed to ten replication servers located in the Regional offices.

6. What data requirements are necessary for the example application to operate?
The application is primarily a data viewer and does not have specific data input/output requirements. Users have access to more than 150 data sets in the geographic data library. Environmental data is obtained from federal, state, tribal, and local sources at a variety of extents and scales. WSDOT does very little data processing. Sensitive data (e.g., archeological, endangered species habitat) is protected by user permission and password security.

7. How is data managed? This includes data entry, maintenance, and archiving.
The headquarters Environmental Information Group is responsible for data management, data sharing relationships with external agencies, and the creation of metadata. All themes are updated at the data set level. Once a new data set is available, the prior set is archived and replaced by the new set. No time series data is available. WSDOT does not perform additional quality checks on the data, although they do create and maintain a small number of in-house data sets.

8. List necessary interactions between the main users of the example application.
WSDOT Headquarters Environmental Group negotiates formal data agreements with external agencies and receives geographic data sets from them. Regional environmental specialists interact with their regulatory counterparts. Major external data and regulatory partners include Federal and State Fish and Wildlife, NOAA Fisheries, BLM, Forest Service, EPA, Corps of Engineers and FHWA. State partners include Departments of Ecology, Health and Natural Resources.

APPLICATION 19: Animal Detection System (not included in detailed analysis)

Example Applications Profile

Name of Agency: Wyoming DOT
Application Name: Animal Detection System
Business Process(es): Operations

1. What is the primary function of the example application?
The primary purpose of this project is to detect large wildlife (deer and elk) and warn motorists when the animal is on or near the roadway.

2. Describe the performance capabilities of the example application. How is it applied?
The application has been deployed along a 11/2-mile section of highway near Pinedale, WY (located in the western Wyoming). The application detects large wildlife on or near the roadway through the use of infrared sensors, geophones, and digital (motion sensing) cameras. When a large animal exceeding a specified size is detected a warning is posted on variable message signs along the roadway.

3. Who are the main users of the example application? What are the interactions between users or groups of users?
The main users (benefactors) of this application include motorists, the Wyoming DOT ITS unit, and the DOT roadway maintenance staff.

4. Was the example application developed in-house or outsource? Please explain.
The first operational prototype project was designed and deployed in-house. A second project is being designed by a consultant and will be awarded to a contractor.

5. What are the main hardware and software requirements for the example application? Be specific.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.
Data input includes standard design requirement, communication link, and animal crossing / incident data. Data output includes frequency of detection and incident data.

7. How is data managed? This includes data entry, maintenance, and archiving.

8. List necessary interactions between the main users of the example application and other agencies or organizations.
Interaction takes place with Wyoming Game and Fish to determine deployment information, as well as with maintenance crews to respond to incidents.

APPLICATION 20: NITON Handheld X-Ray Fluorescence Non-Destructive Chemical Element Analyzer (not included in detailed analysis)

Example Applications Profile

Name of Agency: Minnesota DOT
Application Name: NITON Handheld X-Ray Fluorescence Non-Destructive Chemical Element Analyzer
Business Process: Construction, Maintenance

1. What is the primary function of the example application?

This product, the Xli/Xlt 800, is used to analyze the presence of heavy elements, including those listed under RCRA. Mn/DOT uses the product to be assured that various materials, components, and structures placed in the right-of-way do not have chemical elements that pose a potential liability.

2. Describe the performance capabilities of the example application. How is it applied?

The user targets this rugged (high strength, dust proof, splash-proof, injection molded plastic housing), lightweight (1.7 pounds), gun-shaped analyzer and beams it at the material to be analyzed. Within a few seconds, results that rival laboratory analysis for accuracy are returned. Alternatively, bag samples analyzed by the X-Ray Analyzer, again with results that rival the quality of laboratory analysis.

3. Who are the main users of the example application? What are the interactions between groups of users?

Mn/DOT's Office of Environmental Services is the main user. Mn/DOT's district-level OSHA safety staff is involved because the device uses X-rays. Four-hour safety training is required because X-rays are involved. The device is deemed safe to use.

4. Was the example application developed in-house or outsourced? Please explain.

The device was purchased from Niton LLC.

5. What are the main hardware and software requirements for the example application? Be specific.

The handheld analyzer is the principal piece of equipment. Data in the analyzer can be transferred to a PC via a standard RS-232 cable and port. Data can be easily exported to spreadsheet packages and incorporated into a spreadsheet report.

6. What data requirements are necessary for the example application to operate? Include input/output, data availability, conversion requirements.

The X-Ray Analyzer requires no data inputs. The instrument automatically calibrates at startup as determined by the user. Niton received the prestigious R&D 100 Award for this and similar devices.

7. How is data managed? This includes data entry, maintenance, and archiving.

Data are transferred from the analyzer to a PC where they can be maintained. For purposes of archiving, data can be transferred to more permanent storage such as another computer, a CD-ROM or a removable hard drive.

8. List necessary interactions between the main users of the example application and other agencies or organizations.

When Mn/DOT identifies chemical elements within the highway right-of-way that are potentially problematic (e.g. RCRA metals in wooden walls, soils), it can notify the source and request appropriate mitigation or remediation. Mn/DOT may talk to owners of disposal facilities and to natural resource agencies. A Minnesota natural resource agency has borrowed the device to detect heavy metals. Also, Mn/DOT is using the analyzer to scan for contamination before purchasing sites and to scan for heavy metals of new products brought in by third parties.

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