Prototype Software for an Environmental Information Management and Decision Support System

DETAILS

20 pages | | PAPERBACK

ISBN 978-0-309-43652-6 | DOI 10.17226/23201

AUTHORS

March 2007

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Subject Areas: IA Planning and Administration, IB Energy and Environment

Responsible Senior Program Officer: Andrew C. Lemer

Research Results Digest 317

PROTOTYPE SOFTWARE FOR AN ENVIRONMENTAL INFORMATION MANAGEMENT AND DECISION SUPPORT SYSTEM

This digest summarizes the results of NCHRP Project 25-23(2), "Software for an Environmental Information Management and Decision Support System," conducted by Cambridge Systematics, Inc., with Parsons Brinckerhoff and Venner Consulting, Inc.

Protecting and enhancing environmental quality while managing the transportation systems of a large area such as a state or metropolitan region present a variety of substantial challenges. These challenges are posed not only by the fundamental complexity of the physical, biological, and social processes that influence the environmental consequences of transportation system management decisions, but also by the substantial amounts of information that must be collected, maintained, and used to analyze environmental impact and to report on the analyses for decision making. Professionals engaged with such matters have come to realize that an environmental information management system (EIMS) is a valuable and often essential tool for agencies working to meet these challenges.

This digest describes the results of NCHRP Project 25-23, a multiyear research effort to design, test, and demonstrate a prototype software program for an EIMS that state departments of transportation (DOTs) and others could use to support their environmental decision making throughout the transportation system management process, from long-range planning through project development, construction, operations, and maintenance. The EIMS is intended to serve as one component of an agency's broader environmental management system (EMS).

The research project was a multiyear effort. The first phase of that effort, completed in 2002, was described in *NCHRP Report 481: Environmental Information Management and Decision Support System—Implementation Handbook.* That report focused on the current and future needs of state DOTs, metropolitan planning organizations (MPOs), and other large transportation agencies. The second phase, designated NCHRP Project 25-23(2) and begun in 2004, was undertaken to design, test, and demonstrate a prototype software program for an environmental information management and decision support system (EIM&DSS) building on the concepts presented in *NCHRP Report 481.* The prototype software developed in this project (referred to in this work simply as the EIMS) will support environmental management for transportation and planning agencies. The prototype software can be downloaded from http://www.trb.org/news/blurb_detail.asp?id=7310. The full report of Project 25-23(2), which includes a user's guide, is available online as *NCHRP Web-Only Document 103* at the same URL.

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

The research described herein was conducted by Cambridge Systematics, Inc., with Parsons Brinckerhoff and Venner Consulting, Inc. William Robert of Cambridge Systematics was the principal investigator.

This digest has three sections. Section 1 describes the objectives and approach taken in the research. Section 2 describes the prototype EIMS software developed in NCHRP Project 25-23(2). Section 3 discusses how the prototype software may be deployed and what future enhancements might be made to the application's functions.

SECTION 1: PROJECT OBJECTIVES AND RESEARCH APPROACH

The objective of NCHRP Project 25-23 was to design, test, and demonstrate a prototype software program for an EIMS that state DOTs and others could use to support their environmental decision making throughout the transportation system management process. In *NCHRP Report 481,* which resulted from the first phase of the project, an EIM&DSS was defined as

> . . . any system that strives to provide decision makers involved in planning, programming, project development, operations and maintenance for any mode of transportation with the right information and analysis, in the right format, and at the right time to make specific decisions and to continually improve the outcomes of the agency's activities, operations, products, and services when measured in terms of transportation, environmental, social, cultural, and economic factors. (p. S-1)

The project's terminology was subsequently shortened to refer simply to an EIMS, intended to serve as one component of an agency's broader EMS. An EMS incorporates software systems and other elements, such as agency policy, processes, and practices. The International Standards Organization (ISO) Standard 14001 defines an EMS as

> the part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy.

To provide a basis for developing the EIMS, the research team first reviewed existing practice and systems for environmental management. An initial review found considerable activity in the area of environmental management, including efforts by a number of states in support of environmental screening of plans and projects, commitment tracking, document management, and performance evaluation. These examples are summarized in the appendix of this digest. However, despite the considerable activity in environmental management, relatively few distinct software systems are being used in these activities. Agencies typically have used general-purpose office software (e.g., spreadsheet and database applications) along with geographic information system (GIS) and document management system packages.

Of the systems that did integrate EIM support functions, the following were reviewed in detail by the research team:

- **The Washington State DOT Environmental Workbench** is a custom-built GIS application designed to allow transportation agency staff access to a broad range of statewide environmental and natural resource management data for use in scoping projects and identifying potential environmental issues at an overview level. More than 60 GIS environmental and natural resource management data layers are available as ArcView-readable files for easy downloading, overlay, and manipulation to support project planning and delivery. The tool allows users to locate and buffer proposed projects and view environmental layers, with tools linking the maps to state highway video log images.
- **The Texas DOT Environmental Tracking System** monitors projects during project development, focusing on managing the requirements of the National Environmental Policy Act (NEPA) and environmental permits prior to construction. The system supports archiving of environmental review documents with the project record. Email notifications alert reviewers when a document has been sent and when the review is completed.
- **The planning, permitting, and project review process of the Florida DOT, the Federal Highway Administration (FHWA), and other partner agencies** was redesigned

to link land use, transportation, and environmental resource planning, thereby facilitating early and interactive involvement of these functions and consequent consensus on environmental decisions.
- **The Pennsylvania DOT Categorical Exclusion/Environmental Assessment (CE/EA) Expert System** guides users through the environmental evaluation process. It prompts required information; validates the data entered; and provides step-by-step directions, sample forms, and electronic CE and EA handbooks.
- **ICF Consulting's CommentWorks,** a web-based application, facilitates the public comment process and agency review of comments received. ICF is a private consulting firm, and its system is proprietary.

The review of the above systems informed the design of the EIMS. In addition, the research team considered the substantial resources available from federal agencies and other national organizations to support environmental management activities. Some of these resources include the following:

- The AASHTO Center for Environmental Excellence has become a key resource for state DOTs and other agencies interested in building their capacity for environmental stewardship. The center has established a demonstration program for best practices, providing a web-based clearinghouse about agencies' environmental initiatives.
- The FHWA and Federal Transit Administration (FTA) provide support to the highway, transit, and planning communities, including resources to organizations conducting research, training, and technical support.
- The FHWA's Environmental Stewardship and Transportation Infrastructure Project Reviews website presents technical resources to enhance environmental stewardship and to streamline decision-making processes.
- The U.S. Environmental Protection Agency (EPA) has worked closely with the U.S. DOT and state transportation agencies, as well as with other public agencies, to build awareness of, and capabilities for, environmental management. In particular, the EPA supports the Public Entity Environmental Management System Resource (PEER) Center to assist local, county, and state governments in implementing environmental management systems. The PEER Center provides a clearinghouse of information, EMS materials, best practices, and technical support, and its efforts have led to the establishment of seven local resource centers.

The research team developed the prototype EIMS initially based on the assessment of current activities and on the team's understanding of current and future requirements for environmental decision making. The initial EIMS implementation was tested with two agencies, Missouri DOT (MoDOT) and North Carolina DOT (NCDOT). The tests suggested several enhancements of the application. Following the testing, the research team made changes to produce the final prototype software described in the next section.

SECTION 2: THE PROTOTYPE EIMS SOFTWARE

The prototypical EIMS is a tailored information management system with a web-based user interface, relational database, and map interface. (See Figure 1.) The system supports the following functionality:

- **Long-term planning,** including definition of long-term plans and related environmental management data; definition of alternatives associated with long-term plans; management of data related to any environmental analyses performed for a plan alternative and data related to impacts indicated by an analysis; management of public involvement steps and actions for a plan or plan alternative; and association of long-term plans with projects.
- **Project development,** including definition of projects and related environmental management data; definition of alternatives associated with projects; management of data related to any environmental analyses performed for a project alternative and data related to impacts indicated by an analysis; management of public involvement steps and actions for a project or project alternative; and association of projects with specific assets.
- **Asset definition,** including definition of up to three types of assets, such as roads, bridges, and maintenance facilities or other assets;

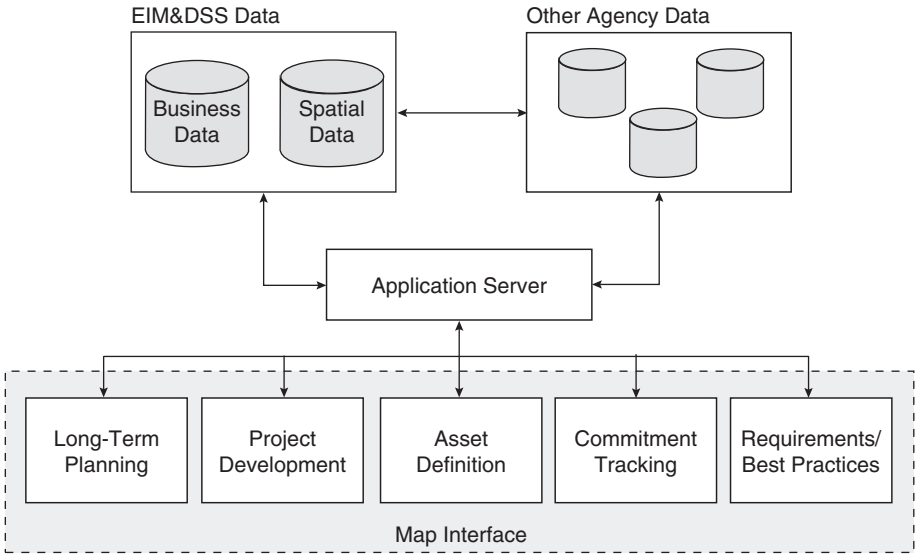

Figure 1 EIMS Components.

definition of any environmental management data or other data associated with an asset; and association of an asset with map features.

- **Commitment tracking,** including definition of commitments and specific actions taken related to a commitment, as well as association of commitments with a specific plan, project, or asset.
- **Requirements/best practices,** including definition of specific requirements and/or best practices related to environmental management; grouping of requirements/best practices into sets; and association of plan, project, or asset alternatives with a specific requirement/best practice set.

The EIMS application is a thin client (i.e., an application in which most of the processing occurs on the server) developed using the latest generation of Microsoft technology, including C# and ASP.NET. The software, developed in Microsoft Visual Studio and reliant upon the Microsoft .NET Framework, is intended to be deployed as a web-based application running on Windows Server 2003 with the Microsoft Internet Information Services (IIS) web server. In this environment, the system is accessible from any Windows machine using Microsoft Internet Explorer.

The EIMS incorporates a commercial off-the-shelf (COTS) map server sufficient for demonstrating and evaluating the functionality of the application. For the prototype version, the TransCAD map server was used. The map server uses the spatial data exported from an agency's GIS into the format that is most efficient for the COTS map server. In a production version of the system, agencies presumably would integrate their spatial data with the EIMS; they would need to have a map server with a web map service and web feature service compliant with Open GIS Consortium specifications.

The system supports Business Objects' Crystal Reports for reporting. Aladdin Enterprises' Ghostscript is used to generate Portable Document Format (PDF) reports. PDF reports are displayed using Adobe Acrobat Reader.

The EIMS database, including business logic, is developed in Structured Query Language (SQL) using Microsoft SQL Server. Database connectivity is provided through Microsoft Data Access Components (MDAC), including Object Linking and Embedding for Databases (OLE DB) and Open Database Connectivity (ODBC, used by the report engines).

In the system, one can define links to a wide variety of resource documents. For example, one can create links to photos of an asset or project site, or to PDF versions of planning reports or detailed environmental analyses. List and detail views may be used to gain access to data. In list views, one can view data on long-term plans, projects, and assets, as well as other environmental features, and select objects for editing using a map. Once a selection has been made from the list view, the user can see

detailed data on the selected item on a detail view, from which the user can edit, save, and validate detailed data. The contents of detail views (e.g., the fields shown and their organization on the screen) may be configured by a system administrator. From the detail view, one can navigate to other list and detail views with related data. For example, when viewing the detail on a project, one can navigate to lists of assets, alternatives, commitments, and documents associated with the project.

The database contains tables for each of the important entities in the system, including plans, projects, assets (such as maintenance facilities or other physical assets), and alternatives. The conceptual data model shows what these entities are and describes how they are related (for instance, one alternative may relate to one plan, project, or asset; one plan may contain a number of projects; one commitment may map to a number of commitment actions; and so forth). The database is designed to provide maximum flexibility in defining the attributes of each entity; that is, one will be able to define for a given installation exactly what attributes each entity has, and these attributes can be defined differently from one agency to another. Table 1 lists the tables in the EIMS database and the attributes associated with each EIMS table.

TABLE 1 EIMS database tables.

Table Name	Description
Data Tables	
assets	Contains one record for each asset. Assets are flexibly defined and can include roads, bridges, facilities, and/or other physical assets.
projects	Contains one record for each project. All projects must be associated with a plan and can be associated with one or more assets.
plans	Contains one record for each plan. Each plan can be associated with one or more projects.
alternatives	Contains one record for each alternative. Users can define one or more alternatives for each asset, project, or plan. For instance, users can define an alternative maintenance strategy for an asset, an alternative project, or an alternative long-term plan.
commitments	Contains one record for each commitment associated with a plan, project, or asset. For instance, a project might include commitments to local residents to restore wetlands.
commitment_actions	Contains one record for each action associated with a commitment. Each commitment can be associated with zero or more actions.
requirement_sets	Contains one record for each requirement or best practice set. The sets could include environmental, economic, and/or safety requirements or best practices. Each alternative can be associated with one set, while a set can be associated with one or more alternatives.
requirements	Contains one record for each requirement or best practice in a set. Each requirement/best practice must be associated with a set.
analyses	Contains one record for each analysis associated with an alternative. Each analysis must be associated with an alternative, while each alternative can include zero or more analyses. For instance, a project alternative may be associated with air quality, wetlands, noise, and/or other analyses.

(continued)

TABLE 1 (Continued)

Table Name	Description
impacts	Contains one record for each impact associated with an analysis. Each impact must be associated with an analysis, while an analysis may include zero or more impacts.
pub_process_steps	Contains one record for each public process step associated with an alternative. Public process steps include conducting public meetings, responding to public queries, and/or public process elements. Each step must be associated with an alternative, while an alternative may be associated with zero or more public process steps.
pub_process_actions	Contains one record for each action related to a public process step. Each action must be associated with a public process action, while a public process step may include zero or more actions.
mapdata	Contains one record for each geographic data record associated with an asset.
multimedia	Contains one record for each multimedia document associated with any of the records in the other entities in the database. The document can be represented as a file location or a URL.
entities	Contains one record for each entity represented in the conceptual data model, including assets, projects, plans, alternatives, commitments, commitment_actions, requirement_sets, requirements, analyses, impacts, pub_process_actions, and pub_process_steps.
entity_attribute_descriptors	Contains one record for each attribute of each entity in the entities table. System administrators can flexibly define the attributes for each entity.
entity_attribute_values	Contains one record for each instance of each attribute for all entities for which attributes have been defined by the system administrator.
System Tables	
config_options	Contains one record for each configurable option in the EIMS.
config_codes	Contains one record for each code value defined for fields that can only take on a predefined set of values.
users	Contains one record for each user defined in the EIMS. Each user must be assigned to a user role.
user_roles	Contains one record for each user role defined in the EIMS database.
user_role_access_rights	Contains one record for each access right assigned to a user role. Each user role access right must be assigned to a use case.
use_cases	Contains one record for each use case defined for the EIMS. Each use case must be assigned to a geographical user interface (GUI) module.
gui_modules	Contains one record for each GUI module.
session	Contains one record for each session initiated by a user.
session_log	Contains one record for each event logged for each session.

The EIMS prototype software includes installation details, a sample database, and preconfigured sample reports. An agency typically will want to establish its own set of attributes for plans, projects, assets, and other items stored in the EIMS database. Although the EIMS prototype software is available free of charge, it requires the following commercially available software to be available on appropriately configured server hardware:

- Windows Server 2003
- Microsoft SQL Server
- Microsoft Internet Explorer
- Adobe Acrobat Reader
- TransCAD Maptitude
- Crystal Reports Developer XI

The basic installation and configuration steps are as follows:

1. Install the prerequisite software packages.
2. Install the EIMS.
3. Configure the EIMS database.
4. Import agency data into the EIMS database.
5. Import geospatial data files into TransCAD and configure TransCAD to customize the map views in the EIMS.
6. Customize the reports using Crystal Reports.
7. Configure system and database security.

SECTION 3: EIMS USE AND EXTENSIONS

In the testing of the initial EIMS prototype with MoDOT and NCDOT, agency personnel reported generally that the EIMS is flexible, easy to use, and applicable to a variety of analysis situations. Environmental specialists could input and retrieve data quickly and found that little training is needed to use the system. The system could be managed by district personnel. The EIMS, as a single integrated system, would likely enhance environmental management. As a result of recommendations made by testers, the research team added features such as online help and navigation enhancements to improve the EIMS functionality. However, the EIMS remains a prototype system, the product of a broad-based research effort. Additional steps could be taken to facilitate the transition of the EIMS from a prototype system to a production system that can advance the state of practice in environmental management in transportation agencies.

Based on the testing and other experience gained in developing the prototype EIMS software, the research team proposed several system enhancements for development in the future:

- **Establishment of user roles and permissions.** The prototype EIMS uses a simple security model: users can be given permission either to view data in the system or to both view and update data. The production version of the system should be enhanced to support increased security based on definition of user roles.
- **Improved map interface.** The map interface in the prototype system allows the user to display a selected set of assets, projects, or plans on the map; to select assets using the map; and to show on the map additional layers of environmental features. Support might be added for a range of map viewers and for other ways of viewing data from the map, such as pop-up windows with information on selected environmental features, color-coding of roads and bridges by functional class, and map-based queries.
- **Quick user access for common tasks.** The user interface for the prototype EIMS is very flexible and well suited to gaining access to all of the data stored in the system. However, most users will have a specific set of tasks to perform and may prefer to have a user interface tailored to provide access to the particular data they need and the work flow they follow.
- **Tools for customizing list views.** By default, the EIMS shows lists of all of the data of a given type (e.g., all projects, all documents). The system could be enhanced to include filters allowing the user to narrow the set of items on a list view and to customize what data items are shown in those views.
- **Email notification.** An administrator can configure the system to define specific types of events (e.g., generation of new comments or updates to particular data items) as triggers for system-generated emails. The system could be enhanced to allow users to edit their email preferences to avoid receiving unwanted emails.
- **Data import/export functionality.** In the prototype system, data must be imported and exported through the Microsoft SQL Server database environment; there are no data import/export tools built into the user interface. The system could be enhanced to import and export common data formats, including Extensible Markup Language (XML) files coded

using the evolving AASHTO TransXML schema, Highway Performance Monitoring System (HPMS) data, National Bridge Inventory (NBI) data, and other common formats.

- **Support for additional asset types.** The prototype EIMS supports three asset types: roads, bridges, and facilities/other assets. These three types might be extended to include additional agency-defined asset categories, such as roadside facilities, rights-of-way, culverts, signs, retaining walls, catch basins, guard rails, median barriers, barrier walls, lighting, and signal systems.
- **Environmental performance assessment.** The system could be enhanced to allow agency managers to compare observations from water-quality monitoring, fish survival surveys, noise measurements, plant establishment success, and other field observations and projections to agency goals and commitments.
- **Additional technical documentation.** Agencies implementing the EIMS could develop technical documentation to supplement the prototype user guide from this research, detailing items such as how to customize the EIMS database and how to integrate the system with other agency databases.

While enhancements are important to the long-term value of the prototype EIMS software, more crucial is the matter of stewardship, ensuring that updated versions of the EIMS remain available to DOTs and other users and facilitating joint effort by users to develop priority enhancements and share experience on system maintenance and applications. The research team considered what activities such stewardship might entail and options for how stewardship might be provided.

Stewardship of the prototype EIMS could be provided by any of a number of organizations—such as the American Association of State Highway and Transportation Officials (AASHTO), FHWA, or a university. Regardless of which organization ends up managing the EIMs, the organization would likely be called on to provide at least the following services:

- **Maintenance and support for the EIMS software.** Any piece of software must be maintained and supported if it is to be used over time. Because the EIMS is a highly configurable web-based system, the level of maintenance and support needed for successful implementation is relatively high. To be successful, the EIMS steward will need to have the resources and expertise to maintain and support the system, including expertise in web-based systems, relational databases, and GIS.
- **Enhancement of the EIMS.** In addition to the enhancements suggested in this research, there are likely to be others that users will request in the future. The exact nature and extent of the enhancements made to the system will necessarily depend on users' interests, priorities, and available resources. The organization that assumes stewardship responsibility for the EIMS will have to mediate among the possibly diverse priorities of multiple users, as well as mobilize and allocate the resources and expertise to enhance the software.
- **Pursuit of the goals that motivated the prototype EIMS development.** The primary goal of NCHRP Project 25-23 was to develop an EIMS that supports environmental management for transportation system management for all modes at all levels of decision making. The EIMS was envisioned as a tool to help transportation agencies pursue environmental goals and comply with environmental regulations. The organization that stewards the EIMS should continue to pursue the original goal and vision.

The research team and NCHRP project panel considered several options for how these stewardship functions might be provided:

- **Option 1: Manage the EIMS through the AASHTO Cooperative Software Development Program.** Under this program (also referred to as the "AASHTOWare Program"), AASHTO designates specific pieces of software as "AASHTOWare" and organizes a task force to guide development and support of the software. The task force is directed by AASHTO's Special Committee on Joint Development (SCOJD). A solicitation for initial funding for the new AASHTOWare project is sent to each AASHTO member, and a minimum number of members (typically 10) must agree to fund the project at the requested level of support to enable the project to proceed. If the software project relies on previously developed code, the agency that owns the preexisting code must grant ownership of any further development rights to AASHTO. Once a piece of software has been devel-

oped, AASHTO licenses the software to its members on an annual basis. License revenues are used to manage the ongoing effort, provide maintenance and support services, and fund further enhancements. The AASHTOWare program has been used successfully for several software products, including the Trns·Port suite of construction management tools, the Pontis Bridge Management System, and DARWin Pavement Analysis and Design System.

- **Option 2: Manage the EIMS as an open source software product.** Under this option, the EIMS would be placed in the public domain. NCHRP would release the EIMS software code to all interested parties, ideally with an open source license. Several models for such licenses are available, such as the "GNU is Not Unix" (GNU) General Public License (GPL), the Berkeley Software Distribution (BSD) License, and the Mozilla Public License (MPL). Such a license would ensure that the EIMS source code is available free of charge to users and software developers and that the original source code for the system remains in the public domain. Depending on the details of the license, further enhancements to the original source code may be required to remain in the public domain. The open source model has been successfully employed for several different software products in recent years, perhaps most famously the Linux operating system.
- **Option 3: Offer and enhance the EIMS through further NCHRP research.** The prototype EIMS software can be downloaded for free from the TRB website at http://www.trb.org/news/blurb_detail.asp?id=7310. AASHTO's Subcommittee on Research (SCOR) could initiate a third phase of NCHRP Project 25-23 to perform additional research to enhance the prototype EIMS, thereby producing a new version of the system. The NCHRP project would not provide maintenance and support of the software.

The research team and project panel agreed that Option 1 represents the most viable strategy for stewardship of the EIMS. Managing the EIMS through the AASHTOWare program will ensure that the software is made available to its target market of users and that future enhancements are responsive to those users' demands.

APPENDIX: REPRESENTATIVE ENVIRONMENTAL MANAGEMENT INITIATIVES

The research team identified the examples in the following table of environmental information management system efforts undertaken by state DOTs.

Agency	Description
Arkansas State Highway and Transportation Department	**Participates in a multiagency wetland planning team** that conducts a state wetland inventory, using a wetland prioritization model based on GIS, a wetland classification and characterization database, a wetland planning database, and functional assessment models. These tools support the DOT in improved wetland planning, management, and monitoring. **Developed an environmental GIS,** including information on engineering constraints, alternative alignments, and natural and social environmental analysis. **Developed a historic bridge management system** using GIS to manage the state's Historic Bridge Inventory. The system centralizes all historic bridge data and facilitates data sharing and evaluation processes with the Arkansas Historic Preservation Program.
Caltrans	**Co-sponsored a statewide effort to identity and prioritize conservation areas for habitat connectivity.** The effort identified and prioritized 232 critical habitat linkages. Caltrans is now incorporating the data and environmental analysis into region-level planning by comparing its long-range transportation plan with priority conservation areas.

(continued)

Agency	Description
	Is developing and organizing statewide information on environmental mitigation needs in conjunction with identification of mitigation or environmental enhancement opportunity areas. Summaries of integrated mitigation needs and plans will be developed by region, covering a 10-year period. The project will investigate past Caltrans mitigation projects to summarize outcomes and to compare costs. Existing programmatic agreements and mitigation/conservation banks available to Caltrans will be identified and linked to geo-referenced needs, and Caltrans' existing BioMitigation database will be improved. **Established division-level pilot projects for electronic document management supporting project work flow.** The pilot projects allow users to electronically search and use archived material, review documents in progress, and track comments. They also enable concurrent review, ensure that review time is spent on up-to-date documents, and can generate reports on the status of documents under review. Caltrans is now augmenting the pilot projects to add a document tracking capability that is anticipated to include existing biological reports, scanned and geo-referenced to enhance access. District 6 Project Management Division undertook one of the pilot projects to integrate the document management system with the work flow engine. **Identified environmental aspects of design, maintenance, and construction activities** (with a focus on storm water) as a part of the agency's practice guidelines for selecting best management practices. **Is implementing a directive for all Caltrans districts to maintain an environmental commitments record (ECR)** to ensure that the agency meets its environmental commitments by (1) recording each environmental mitigation, compensation, and enhancement commitment made for an individual project, (2) specifying how each commitment will be met, and (3) documenting the completion of each commitment. The ECR brings all relevant environmental compliance information together in a single place as a detailed reference throughout all project phases, both to identify and track commitments and to locate the most current, detailed source of information. The ECR review also facilitates quality control and continuity and is being integrated into a variety of other Caltrans processes. **Is developing an environmental IT solution.** Caltrans is currently developing an environmental analysis IT approach that will manage and integrate information at multiple levels in concert with other systems, incorporate management and metrics tools, and deliver products/information to stakeholders and decision makers while contributing to and drawing upon corporate knowledge. The system will consist of four integrated but independently functioning components: (1) environmental/production information flow, (2) process metrics and feedback, (3) communicated corporate knowledge, and (4) project management tracking.
Colorado DOT	**Developed an EMS in conjunction with the State Natural Heritage Program characterizing mitigation needs for the most populous eastern third of the state** by vegetation communities and species, to assist the agency in complying with Endangered Species Act Section 7 requirements and to help achieve ecosystem recovery goals for both listed and unlisted species. The EMS and a related agreement provided a programmatic consultation framework, improved conservation outcomes, and more efficient and cost-effective transportation project delivery.

Agency	Description
	Developed a commitment tracking system for the NorthWest Parkway and the multimodal Transportation Expansion Project on the main highway through the metro area, building on a spreadsheet model. **Developing an EMS** to reduce pollutants and trash loads for maintenance facilities as part of a storm water consent decree.
Florida DOT	**Developed the Efficient Transportation Decision Making (ETDM) process** to support early and efficient environmental screening, comment, and decision making for transportation projects in the long-range plan and in the Statewide Transportation Improvement Program. The process also facilitates linkages between land use, transportation, and environmental resource planning initiatives through early, interactive agency involvement and increasing environmental screening on the MPO level. The process includes: • A web-based, interagency analysis and comment system. • A public information website that provides public access to information about proposed transportation projects, their status, and interactive environmental maps through the Florida Geographic Data Library. • Project management tools to support project implementation once a project is accepted for programming. Functions include electronic class-of-action determination and support for environmental analysis (EA) and environmental impact statement (EIS) development. • Performance tracking of interagency environmental technical advisory teams for decision support and continuous improvement in administration of DOT-funded positions. **Supported development of wildlife occurrence and habitat GIS database for use in roadway alignment analysis, impact assessment, and identification of priority areas for conservation and habitat connectivity improvements.** The Florida DOT is participating in the interagency Greenways Program partnership to guide land acquisition activity. **Developed a GIS model for road improvement projects, including an interactive CD-ROM that allows the user to perform multiple scenarios and analyze impacts** related to wildlife crossings, road mortality, habitat connectivity, and other environmental impacts. (This model was developed in conjunction with the Florida Fish and Wildlife Conservation Commission.)
Illinois DOT (IDOT)	**Developed the Project Monitoring Application database** to track the status of biological and cultural resource surveys, including: • **Electronic environmental survey request forms** that have standardized data elements and are completed online by district offices and can be accessed by external users. Windows for biological and cultural resource surveys in the system include fields to enter various commitments. Wetlands and special waste screens have been added. • **Commitments window,** a central "one-stop-shop" for all project commitments to be listed. • **Ability to run annual reports and track internal compliance.** • **Integration with IDOT project management databases** through common project and contract numbers.

(continued)

Agency	Description
Indiana DOT (INDOT)	**Developed a GIS application for use during NEPA project development and long-range planning.** The tool includes 170 geospatial data layers pertaining to southwestern Indiana, with plans to expand the system for statewide use. **Developed criteria for prioritizing work on maintenance facilities,** including proximity to public surface water intake, other high-quality waters, and natural areas as part of an EMS approach. **Developed a mitigation commitment summary, from an electronic project tracking system,** which INDOT incorporates into NEPA document and project plans. Incorporating the summary into the tracking system has increased the effectiveness of the summary and resulted in more complete implementation of environmental commitments. **Developed a "Scope/Environmental Compliance Certification/Permit Application Certification" checkpoint** at four different design stages to ensure that the design has incorporated all environmental commitments. This tool certifies that the requisite permits have been acquired and the associated conditions/requirements have been included in the plans, specifications, and estimates.
Kentucky Transportation Cabinet (KYTC)	**Developed an online commitment tracking approach called "Communicating All Promises" (CAP) that posts and tracks all agency commitments through all phases of project development** and implementation. Produces CAP reports that are incorporated into bid and contract documents and that provide the basis for project engineering plans to fulfill commitments. KYTC developed an associated guidance accountability form checklist, which is used by consultants and reviewed by KYTC to communicate mitigation of tasks in all phases of the transportation development process. During project implementation, KYTC uses its project impact profile form as a communication tool to summarize the impacts of a project and the related mitigation. KYTC's CAP is an SQL add-on to the agency's existing Oracle-based preconstruction management program. KYTC created pages within this existing system for project managers to input the commitments. The agency is in the process of converting to a web-based system.
Maryland State Highway Administration (MDSHA)	**Established environmental stewardship as a key performance area** for the agency. Environmental stewardship goals, objectives, and performance measures are included. **Participates in statewide efforts to identify and preserve ecologically significant resources and link conservation areas.** The agency uses State Green Print databases and watershed plans to assist in meeting watershed and wetland mitigation goals. **Developed an information management system to inventory, rank, and track hydraulic and water quality control structures,** facilitating National Pollutant Discharge Elimination System (NPDES) compliance, asset management, environmental enhancements, and efficient administration. System data are used for online NPDES permits, storm water system evaluation, and maintenance work and assignments. A GIS helps staff determine the location of systems, track maintenance activities, and address public complaints. Ultimately, the system will be capable of hydrologic analysis of the drainage systems for estimating assessments of storm water runoff from MDSHA right-of-way.

Agency	Description
	Prepares environmental compliance/consideration checklists for all major projects. MDSHA is working to create both a statewide system for all NEPA EA and EIS projects and a system to support tracking and achievement of environmental stewardship goals. **Tracks interagency concurrence points** in the transportation development process. **Developed a desktop permit tracking system,** to which it is adding commitment tracking capabilities, focused on project development and design. MDSHA's desktop permit tracking system was developed in Oracle and Microsoft Visual Basic programming language, with plans to make the tool web-based. Using existing systems and databases, the system imports current projects and schedules and tracks all projects and permits. MDSHA is extending the system to track conditions and commitments. The MDSHA project management system uses Microsoft Project, and both the project management system and the desktop permit tracking system run on Oracle, on the same server, to be able to accommodate databases from other legacy systems. Common project numbers and geographic coordinates for projects facilitate linkage to the agency's cash flow system for capital forecasting and also GIS. **Is integrating data management projects.** Under the direction of Planning, all MDSHA data management projects are being pulled into one GIS platform using Oracle. MDSHA is now able to track environmental information on all projects, major and minor, supplementing the major project efforts described below. **Used a commitment tracking system for large and environmentally controversial projects.** For projects such as the Woodrow Wilson Bridge, MDSHA used a commitment tracking system in Microsoft Access. Compliance was documented in concert with daily inspections, and actual versus projected impacts were tabulated/estimated separately from the database for reporting purposes. While this existing system is not web-accessible, a model to be developed for the Intercounty Connector will be web-based. **Prepares environmental compliance/consideration checklists** for all major projects and summarizes all environmental mitigation and project commitments to ensure that environmental commitments are not lost through value engineering or other plan revisions.
Massachusetts Highway Department	**Developed an EMS for agency maintenance facilities focusing on six compliance program areas:** hazardous waste, wetlands, hazardous materials, underground storage tanks, water quality, and solid waste. A management system improvement and implementation plan was established for each area.
Maine DOT	**Developed and is implementing environmental management systems for all Maine DOT maintenance facilities.** Maine DOT developed manuals and reference guides targeted to appropriate managers and field personnel. The agency is now conducting annual audits of facilities to review effectiveness of policies and procedures. An environmental management committee has delegated responsibility for tracking and timely closure of audit findings.

(continued)

Agency	Description
Michigan DOT	**Developed the Michigan DOT Electronic Document Management System** to provide an integrated tool for project website collaboration, imaging, process workflow automation, electronic forms, shared document access, documentation security control, versioning control, and document life-cycle management. The system applies to five focus areas: transportation planning environmental review, real estate property disposal engineering review, CAD file management, website collaboration, and executive correspondence response and tracking. **Developed the Southeast Michigan Snow and Ice Management Partnership** with four road maintenance agencies and a regional transit authority to coordinate winter maintenance vehicles in the region. The system includes snowplow sensor systems, a communications system, and central management systems. The communications system transmits environmental and status data from in-vehicle devices to a transit management center, which transmits data to maintenance managers and transit dispatchers.
Minnesota DOT	**Is piloting an effort to manage design and environmental information electronically and to provide decision support in the field.** GIS wetland information is leveraged for construction by creating links to graphics, permits, and construction equipment guidance systems. Existing environmental data layers and computer-aided design (CAD) information is made available to designers in a cohesive, standardized format. Electronic design files are available at the construction site, and changes to the data are entered in the field through handheld computers.
Nevada DOT	**Developed the online Reno Transportation Rail Access Corridor (ReTRAC) mitigation monitoring program report system,** which provides the public with real-time reports on the project's compliance with Nevada DOT's environmental commitments and streamlines note taking and report writing. The system replaces manual field note taking with electronic field-based recording using handheld devices and data upload via wireless connections. Reno city officials estimated that ReTRAC.info saves each monitor 45 minutes each day per report filed. ReTRAC also served as a document management system containing compliance reports, notices to the contractor, feedback from resource agencies (with controlled access), and access to sensitive cultural resource data. The system streamlines reporting, enhances quality control, improves compliance monitoring, and supports improved public communications. ReTRAC.info is nonproprietary and can be adapted to solicit comments from the public when reviewing NEPA documents.
New Hampshire DOT	**Established an EMS in the Bureau of Traffic, initially focused on painting and signing** operations, with the goal of expanding the program into other units. The system was implemented in accordance with ISO 14001 guidelines (though is not yet certified). **Developed and implemented Risk Assessment for Site Contamination and Appraisal of Land and Inventory of Managed Properties—**a system of integrated handheld computers and web-based data management to support a contaminated property valuation policy for prospective and currently owned properties.
New Jersey DOT	**Developed the New Jersey DOT Environmental Policy Statement and Stewardship Action Plan.**

Agency	Description
New York State DOT (NYSDOT)	**Established the Environmental Commitment and Obligations Package for Construction (ECOPAC),** which records and tracks environmental compliance of construction projects. ECOPAC is a PDF checklist that the design group fills out and gives to construction. Construction uses the form for followup, awareness, and field inspection. **Automated the New York State Department of Environmental Conservation's State Environmental Audit System to report environmental initiative activities and self-report violations.** This Oracle-based system focuses on facilities (e.g., rest stops and maintenance shops) and is used to track noncompliance and to develop remediation plans. The system also could be used to identify patterns, improve overall processes, and initiate training. **Developed ETRACK database to track projects and major milestones** and to establish consistency in statewide environmental information management. ETRACK is an environmental permit tracking database in Microsoft Access that is being used in all NYSDOT regions. NYSDOT currently has an IT proposal to make the database web-based and to potentially link it to ECOPAC because the agency would like to add commitment tracking capabilities. Providing a linkage to the ECOPAC checklist would be a first step in this regard. ETRACK is used for project scoping and permit tracking, but not for any environmental terms or conditions. ETRACK has the potential to offer standardized reports and the ability to make queries, track items of interest, track the number of permits in process and time required for completion, and other factors. Each region has a stand-alone system; statewide queries are not supported. **Is undertaking a comprehensive process improvement program** in planning, design, construction, maintenance, and operation of transportation facilities, including development of environmental quality assurance/control procedures, project tracking and management, and establishment of performance measures. The program is part of NYSDOT's Environmental Ethic Initiative.
NCDOT	**Established the Ecosystem Enhancement Program (EEP) with the North Carolina Department of Environment and Natural Resources to conduct planning and mitigation on watershed levels** to streamline the project delivery process and to improve ecological outcomes. An EMS enables comparison of problems and assets of local watersheds based on GIS data analysis of five broad categories of information: baseline watershed conditions, watershed resources or attributes, watershed problems, potential threats and stressors, and other factors. The system includes a screening methodology to identify target areas for restoration and tracks performance by comparing actual impacts of implemented projects against targeted goals for wetland and riparian functions. EEP is developing a system for assessment of wetland and ecosystem functions, and it will be linked to the mitigation credit and need accounting system. **Includes assessments of some environmental conditions and deficiencies in the maintenance management system's inventory of sample sections of roadway.** **Is developing an environmental strategic plan for the agency.**

(continued)

Agency	Description
Oregon DOT (ODOT)	**Established the Collaborative Environmental and Transportation Agreement for Streamlining (CETAS),** an interagency environmental coordination body, to implement stewardship agenda. **Established a programmatic agreement** with the Oregon Department of Fish and Wildlife for culvert retrofit and replacement. **Developed a GIS-based sensitive resource inventory along nearly 6,000 miles of state highway** as part of the Salmon Resources and Sensitive Area Mapping Project. The inventory is used to support planning, scoping, and appropriate maintenance activities. ODOT is currently developing an Internet-based application to enable wider desktop access to data and to facilitate data sharing and communications with resource agencies. **Established a programmatic approach to the Endangered Species Act (ESA) for routine road maintenance without review of individual actions,** based on jointly developed resource and restricted activity zone maps. **Developed a bridges Internet GIS to support repair or replacement of more than 360 state and 125 local bridges over 10 years,** through a strategic, corridor-based approach. The initiative includes a comprehensive program of bridge site assessment and programmatic agreements with regulatory agencies to streamline environmental permitting. Extensive information on each bridge site is provided through an interactive, graphics-based Internet map server. **Initiated efforts to estimate and track environmental costs.** ODOT is in the process of adding elements to its accounting system for expanded tracking. **Initiated development of a data management system for inventory of 20,000 drainage facilities,** enabling ODOT to track, prioritize, schedule, and budget maintenance and repair of facilities. **Is evaluating use of real-time GPS connection to maintenance vehicles.** **Is in the process of developing a global asset management system.** The ODOT Transportation Management System (OTMS) will integrate management of highway pavement, bridges, highway safety, traffic congestion, public transportation facilities and equipment, intermodal transportation facilities and systems, and traffic monitoring. OTMS will ultimately incorporate other systems that track environmental assets.
Pennsylvania DOT (PennDOT)	**Developed a computerized CE expert system** that was then expanded to environmental assessments. An online system to support CE and EA evaluations was launched in November 2002, replacing a paper-based process. The PennDOT CE/EA Expert System has been expanded to support electronic review and approval, including online public review of documents and responses to comments, and permit applications and tracking. **Developed a strategic environmental management program** that identified environmental aspects of work agencywide. A pilot ISO 14001-certified EMS, which includes performance measures, was developed for erosion control and winter maintenance operations in Engineering District 10. PennDOT plans to expand this system to other districts. **Developed a statewide fish database of all species** to enable users to conduct rapid, in-house reviews for project impacts on fish species of concern.

Agency	Description
	Developed a cultural resource document tracking system, enabling automated environmental reviews, support to design processes, and expedited alternatives analysis. PennDOT plans to integrate this system with GIS in the future. **Supports Penn State University's Pennsylvania Direct and Gravel Roads Center** and an online system to identify and rank erosion control problem areas along roadsides. **Developed a salt stockpile management, stockpile academy, and quality assurance (QA) program using a 50-element QA review.** The program enables PennDOT to track and compare application rates against targets.
Pennsylvania Turnpike Commission	**Developed computerized spreadsheet/database tracking systems** that identify and monitor right-of-way requirements (not in NEPA document), changes in environmental impacts, and fulfillment of mitigation commitments during construction.
Texas DOT (TXDOT)	**Developed a comprehensive environmental tracking system (ETS) to track projects during project development,** focusing on management of NEPA and environmental permitting requirements prior to construction. ETS, the main database, records when a project is received, who is reviewing it, and what agency coordination is occurring. ETS: • Tracks NEPA and permit status and process time for environmental clearance. • Enables electronic circulation of all project documents. • Provides e-notifications to reviewers. • Estimates process time for each phase. • Determines whether all environmental permits, issues, and commitments (EPIC) are addressed in the project plans. EPIC is an ETS function that lists permits, issues, and commitments. Reports or checklists on commitments can be generated at the end of the project, then attached to the plan and incorporated into specifications. Engineers are required to review EPIC screens and ensure that plan sheets include commitments. • Enables remote project entry and project status queries by district environmental coordinators. • Automatically flags projects that have surpassed predetermined circulation periods within the environmental division. • Generates a monthly report, identifying all transportation projects entered within a certain month or within a given period or exceeding their circulation period, as well as a "Clear Environmental" report, identifying all projects cleared by the division within a certain month or within a given period. A project circulation report identifies projects that have exceeded the assigned circulation period at FHWA or other federal or state agencies. • Is available online to FHWA. There are plans to share the system with other agencies to facilitate comments in an ETDM-like environment in the future.

(continued)

Agency	Description
	ETS was built in PowerBuilder Version 9, which allowed conversion of all old data into a new database with growth potential. The ETS is based on a two-tier architecture (client, database server). TXDOT plans on moving ETS to the web, using Microsoft SQL Server and Microsoft .NET (with C# as the programming language). **Implemented an environmental commitment checklist.** All TXDOT districts use a checklist to monitor construction, maintenance, and facilities projects. Contractors use the checklist to verify compliance with environmental commitments and permit conditions. The checklist is also used by the Texas Department of Environmental Compliance for compliance review. **Developed tracking software and a web-based environmental process manual.** TXDOT plans to add functionality, including a centralized repository, and Internet links to resource agencies' policies. **Developed a pollution prevention and abatement and audit program for maintenance facilities.** **Developed an approach to environmental screening using the best available data over a more than 1,000-mile project corridor (Interstate 69).**
Washington State DOT (WSDOT)	**Developed an online environmental procedure manual** for the agency, consultants, and contractors, with links to all appropriate regulations. **Developed a watershed-based approach to assess how improved ecological benefits could be achieved from mitigation** at reduced mitigation costs. WSDOT developed and applied criteria and EMS tools to assess and rank alternative mitigation sites and processes, including capability to identify priority recovery areas for individual targeted resources and priority areas for multiple-objective mitigation. The analysis includes a functional assessment and social, economic, and environmental cost benefit analysis for candidate sites. **Designed an environmental GIS workbench** program with 125 GIS data layers to provide technical support to project planning and delivery, including desktop access to 60 layers of environmental and natural resource management data. The system is supported by WSDOT's Environmental Information Program, which coordinates with federal, state, and local agencies to ensure current and accurate data. **Manages WSDOT's GeoData Catalog,** which allows the public to view GIS metadata and example maps and to download agency GIS data. **Initiated a project to analyze the costs and benefits of using remote-sensing-based approaches** compared with the costs and benefits of using other methods for environmental analysis. **Developed a decision support system for evaluating and addressing slope failure areas** and chronic environmental deficiencies. **Is developing an EMS** to integrate environmental issues with program and project delivery. The initial focus is on construction, parts of maintenance and operations, and the State Ferry System, with an emphasis on ensuring and demonstrating compliance.

Agency	Description
	Developed a commitment tracking system that: • Tracks all formal commitments (environmental, design, and right-of-way) from inception through construction to completion or handoff to maintenance and operations offices. • Ensures that permit conditions are adequately incorporated into contract documents. If permit language is not appropriate as contract language for the final plans, specifications, and estimates (PS&E), the system facilitates finding/crosswalking to relevant contract language. If no appropriate contract language exists, the user may draft new language. • Allows commitments to be matched with standard specifications, general special provisions, and standard plans. WSDOT is building environmental procedures into the agency's construction manual and standard specifications, drawing from the NCHRP 25-25(4) Environmental Stewardship Practices Guide. • Will provide "job-aids" to help ensure that all environmental commitments and permit conditions (e.g., project inspection checklists, compliance binders for site inspectors, and summarized notification requirements) are implemented. • Generates reports showing whether all environmental commitments have been met prior to completion of the project and whether the maintenance and operations office has received and confirmed understanding of all long-term compliance expectations for the site. • Incorporates programmatic permit or consultation conditions; however, prompts are not automated in the system. The user has to be aware that a programmatic agreement exists and apply the agreement to the project to incorporate the commitments therein. The commitment tracking system does not include document management or storage functions. Instead, WSDOT has focused on making project-related documentation available to the public through the agency's website. WSDOT has basic task scheduling functionality as part of the agency's project delivery information system. The system was custom built on a Microsoft SQL Server database using Microsoft .NET. All projects with project-specific commitments are now being entered, including CEs. In the long run, WSDOT intends to incorporate the different commitments into the database, to make the database mapable as a GIS layer in the GIS workbench, and to translate mileposts into GIS raster data. Ultimately, WSDOT is interested in incorporating performance measurement and reporting into the system as well. **Established a database for tracking construction site erosion and sedimentation control risk, requirements/commitments, and performance.** The database assesses trends and provides reports at the project, regional, and state levels. Reports also include data on the use frequency, correct application, maintenance, and overall effectiveness of 37 best management practices. All construction sites are evaluated and characterized based on inherent risk of erosion (size, timing and duration of work, soils, slopes, groundwater levels, need for in-water work). Runoff from 20% of projects that meet the risk criteria is tested during storm events and during critical

(continued)

Agency	Description
	periods of in-water work. Monitoring results are used to evaluate project performance and to validate results of the Temporary Erosion and Sediment Control (TESC) assessment database. The assessment program identifies (1) how well WSDOT is protecting water quality, (2) areas that need improvement, and (3) strategies to use in making improvements. **Is developing environmental cost assessment tools for project development** through the Environmental GIS Program. **Tracks some environmental conditions and deficiencies in the maintenance accountability process.**
Wisconsin DOT	**Developed and implemented a methodology to conduct system plan environmental evaluations** to meet state requirements. The methodology applies environmental criteria to evaluate and compare major system plan alternatives. The Wisconsin DOT developed worksheets to guide the user through the environmental screening process and to streamline EA and EIS development. Decision support software has not yet been developed. **Conducted an environmental cost study** to develop and refine a process to capture standardized financial data to track environmental costs on transportation projects. **Conducted an inventory of high-potential corridors for the presence of lupine and developed a right-of-way management plan to protect habitat** for the Karner Blue Butterfly. **Is using on-vehicle differential global positioning system (GPS) receivers and other sensors to collect environmental data, equipment status data, and material usage data** to track and manage winter maintenance activities, including use of winter operations performance measures. The system uses the GIS application "Wiscplow" to integrate vehicle data with manually entered data and spatial data.

These digests are issued in order to increase awareness of research results emanating from projects in the Cooperative Research Programs (CRP). Persons wanting to pursue the project subject matter in greater depth should contact the CRP Staff, Transportation Research Board of the National Academies, 500 Fifth Street, NW, Washington, DC 20001.

THE NATIONAL ACADEMIES™
Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.
www.national-academies.org

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