
The Center for Transportation and the Environment
North Carolina State University

**NATIONAL TELECONFERENCE SERIES**

Program No. TC-30:

# Environmental Information Management and Decision Support System for Transportation: The Results of NCHRP 25-23

June 24, 2004
1:00 - 4:00 p.m., EDT

Broadcast Live From
Agency for Public Telecommunications
Raleigh, North Carolina

**CTE is a USDOT university transportation center located at:**
The Institute for Transportation Research and Education
North Carolina State University, Centennial Campus
Box 8601, Raleigh, NC 27695-8601
Phone: (919) 515-8899
Fax: (919) 515-8898
http://www.itre.ncsu.edu/cte

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## CTE National Broadcast on
## *Environmental Information Management and Decision Support System for Transportation Agencies: The Results of NCHRP 25-23*

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| 1:00 - 1:05 | **Welcome & Introduction of Moderator** | Katie McDermott, CTE (Host) |
| 1:05 - 1:10 | **Panel Introduction** | Wayne Kober, Consultant (Moderator) |
| 1:10 - 1:20 | **NCHRP 25-23 Project Overview:** Purpose, objectives, and deliverables | Wayne Kober, Consultant |
| 1:20 – 1:35 | **The EIM & DSS Framework:** What it is. What it can do for transportation agencies. How to get started now. | Bill Hyman, ARA, Inc. |
| 1:35 – 1:45 | **Case Study #1:** Applying the EIM/DSS Concept to *Project Development* – Washington State's GIS Workbench | Elizabeth Lanzer, Washington State DOT |
| 1:45 – 2:00 | **Panel Discussion:** EIM & DSS: What's The Big Picture? | Entire Panel |
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| 2:25 – 2:35 | **Case Study #3:** Applying the EIM/DSS Concept to *Operations and Maintenance* – PennDOT's Facilities Management System | Jack Christensen, Pennsylvania DOT |
| 2:35 – 2:45 | **Next Phase of NCHRP 25-23:** Software development and selection of state DOT pilot sites | Bill Robert, Cambridge Systematics, Inc. |
| 2:45 – 3:00 | **Panel Discussion:** Opportunities and Challenges Related to Implementing EIM & DSS | Entire Panel |
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| 3:10 - 3:55 | **Audience Q&A** | Panel & National Audience |
| 3:50 - 3:55 | **Closing Summary** | Wayne Kober, Consultant |
| 3:55 - 4:00 | **Wrap-Up** | Katie McDermott, CTE |

The supplemental handout containing the presenters' PowerPoint slides can be downloaded from CTE's Web site at: **www.itre.ncsu.edu/cte/2004teleconferences.html#Jun24**

# PANELIST PROFILES

## Mr. Wayne W. Kober (Moderator)

*President, Wayne W. Kober, Inc., Transportation and Environmental Management Consulting (Dillsburg, PA)*

Wayne Kober has over 30 years of multi-modal transportation and environmental management experience for both the public and private sectors. He has a B.S. in environmental resource management from Penn State University. He is nationally recognized as an innovative leader in the field of transportation program delivery and environmental management. His broad span of experience at successfully integrating environmental analysis, agency/public involvement and context-sensitive design aspects into a systematic decision-making process has enabled him to play a prominent role in advancing state and federal multi-modal transportation improvement programs. Mr. Kober has worked at the Mid Atlantic States and national levels in leading the development of the environmental streamlining and stewardship legislation, policies and practices. He led the development of the PENNDOT Strategic Environmental Management Program, which has resulted in ISO 14001 Certification. He managed the organization of the 2003 State Transportation Agency Environmental Management System Conference for the American Association of State Highway and Transportation Officials Center for Environmental Excellence. He is in private practice and currently provides environmental management services to a wide range of public and transportation sector clients. He currently chairs the panel for NCHRP 25-23(2), Software for an Environmental Information Management and Decision Support System, and the panel for NCHRP 25-22(2), Technologies to Improve Consideration of Environmental Concerns in Transportation Decisions. Mr. Kober is an emeritus member of the Transportation Research Board Committee on Environmental Analysis and the Academy of Board Certified Environmental Professionals.

## Mr. Jack Christensen

*Acting Chief, Facilities Management Division, Pennsylvania DOT (Harrisburg, PA)*

Jack Christensen is currently employed at PENNDOT as the acting chief of the Facilities Management Division/Bureau of Office Services, managing the technical support unit, administrative support section, and field operations for the Facilities Management Division. These areas handle a variety of issues including architectural design for road side rests and welcome centers, leasing of new facilities for PENNDOT, electrical system expertise, parking, security, code and hazmat issues, administrative support to field staff, pool car administration, specification development, project management and budget support. Prior to assuming this facilities role, Jack provided facilities support for engineering District 3-0, Montoursville, managing contractors and construction projects. Prior to serving the Commonwealth, Jack was a millwright, installing and servicing industrial machinery and facilities, a plant/facility manager for Olivetti Supplies, Service/Facility Manager for Besco Systems, and an entrepreneur owning two businesses. These positions are supported by a certified inspection mechanics license, certification as an asbestos inspector and supervisor, licensed lead based paint risk assessor, commercial driver license, certification as a commercial driver examiner trainer (AAMVA), emergency medical technician (EMT) and an associate degree in business administration.

## Mr. William Hyman

*ERES Consultants Division, Applied Research Associates, Inc. (Elkridge, MD)*
Bill Hyman has 30 years experience working in the environmental and transportation areas. He began his career at the Wisconsin Department of Transportation where he was involved in innovative environmental analysis of plans and programs including the State Rail Plan and the Six Year Highway Investment Program. Since then he has worked on or managed many environmental related projects for the Urban Institute, Cambridge Systematics, Booz Allen Hamilton, and Applied Research Associates. His environmental work includes two recent NCHRP Projects: (1) Technology to Enhance the Consideration of Environmental Factors in Transportation Decision Making and (2) the subject of this presentation, Environmental Information Management and Decision Support System, for which he was co-principal Investigator.

## Mr. Robert G. Kaiser

*Senior Project Manager, Michael Baker Jr., Inc. (Glen Burnie, MD)*
Bob Kaiser leads the efforts of Michael Baker Jr., Inc. (Baker) on regional mobile source air quality issues. His focus is on transportation and air quality planning and analysis, including transportation impacts analyses, transportation – air quality conformity, state implementation plan development, highway mobile source emissions inventories, control measure analyses, and cost benefit and feasibility analysis. His 25 years of experience include extensive activities under ISTEA, TEA-21, and the Clean Air Act for federal and state and local clients. He has designed and implemented a systematized method of collecting and analyzing data for decision making, regulatory submittals and control measure implementation regarding mobile source air pollution issues. The system uses parallel sub-approaches to address needs in areas with and without travel demand models. Since 1992 for the Pennsylvania Department of Transportation Mr. Kaiser has led the design and implementation of a system that addresses the CAA requirements on mobile sources. This includes conformity, inventory, and control measure analyses in the state's 45 one-hour and 37 eight-hour ozone standard non-attainment counties. This encompasses 13 MPOs and 8 rural areas. This is now expanding to encompass the new PM2.5 NAAQS. For the Maryland Department of Transportation, Mr. Kaiser implemented a data and conformity system for large urbanized areas, and implemented a parallel system that addresses the needs of several smaller non attainment areas and 1 Early Action Compact area, and designed a system to meet federal requirements regarding "latest planning assumptions." Similar efforts were conducted for New Jersey, Illinois, Utah and Virginia. For the FHWA, Mr. Kaiser led the update of the FHWA TDM Employer Guide, including new foci on employer motivations and opportunities provided by technology, and he also leads a national ITS technical assistance program.

## Ms. Elizabeth Lanzer

*Environmental GIS Manager, Washington State DOT (Olympia, WA)*
Elizabeth Lanzer joined Washington State DOT in 1999 to lead the agency's environmental GIS program after working for 10 years in Washington State environmental and natural resources agencies. Her program supports the environmental information needs for statewide project development, maintenance, and planning purposes. She represents the DOT on inter-agency data management committees, and manages inter-agency contracts for developing high-priority data for environmental decision-making. She has co-authored several papers in professional GIS and remote sensing related conference proceedings, and an article in *GIS Solutions In Natural Resource Management* (Stan Moran, ed., 1999). Recently, she was the project manager on a USDOT research project titled "Remote Sensing Applications for Environmental Analysis In Transportation Planning: Application To The Washington State I-405 Corridor."

## Mr. Bill Robert

*Principal, Cambridge Systematics, Inc. (Cambridge, MA)*

Bill Robert specializes in transportation software application development. He has extensive experience in transportation asset management encompassing planning, project development, programming, design, construction, operations, and maintenance decision processes. Recently, he managed the development of the Executive Support System for the Ministry of Transportation of Ontario, a what-if analysis tool designed to support analysis of needs and performance across asset types as part of the Ministry's Asset Management Business Framework initiative. Currently, Mr. Robert manages Cambridge Systematics' work on the Pontis Bridge Management System for the American Association of State Highway and Transportation Officials (AASHTO). Pontis is a comprehensive system that systematically addresses the bridge management functions of information gathering, interpretation, prediction, cost accounting, decision-making, budgeting, and planning. In addition, he has managed Pontis training, customization, and implementation efforts for over 20 agencies. Mr. Robert manages the development and implementation of National Bridge Investment Analysis System developed by Cambridge Systematics for the Federal Highway Administration (FHWA). In addition, he manages Cambridge Systematics' work developing and supporting the Planopt system, a what-if analysis system for predicting bridge conditions developed for the Swedish National Road Administration (SNRA). Mr. Robert has performed additional software assessment, design, and development work related to pavement, bridge, maintenance and other asset management systems. Previously, Mr. Robert specialized in the assessment of noise and vibration caused by transportation sources, including highways, transit, rail and aircraft at Harris Miller Miller and Hanson Inc. In this position, he participated in the development of Version 1.0 of the FHWA Traffic Noise Model. Mr. Robert received both a master's degree in civil and environmental engineering and a bachelor's degree in physics from MIT.

## ADDRESS INFORMATION


### Mr. Wayne Kober (Moderator)
President, Wayne W. Kober, Inc.
Transportation and Environmental Consulting
65 Brittany Lane
Dillsburg, PA 17019-9620
(717) 502-0179
wwkpa@earthlink.net

### Mr. Jack Christensen
Acting Chief
Facilities Management Division
Pennsylvania DOT
5th Floor, Commonwealth Keystone Building
400 North Street
Harrisburg, PA 17120-0041
(717) 787-0466
jchristens@state.pa.us

### Mr. William Hyman
ERES Consultants Division
Applied Research Associates, Inc.
7184 Troy Hill Drive, Suite N
Elkridge, MD 21075
(410) 540-9949
Bill.Hyman@ara.com

### Mr. Robert Kaiser
Senior Project Manager
Michael Baker Jr., Inc.
801 Cromwell Park Drive, Suite 110
Glen Burnie, MD 21061
(410) 424-2210
rkaiser@mbakercorp.com

### Ms. Elizabeth Lanzer
Environmental GIS Program Manager
Office of Environmental Services
Washington State DOT
P.O. Box 47331
Olympia, WA 98504-7331
(360) 705-7476
LanzerE@wsdot.wa.gov

### Mr. William Robert
Principal
Cambridge Systematics, Inc.
100 CambridgePark Drive, Suite 400
Cambridge, MA 02140
(617) 354-0167
wrobert@camsys.com

# QUESTION / COMMENT SHEET

Phone: 1-888-288-6736 (Toll Free) Fax: 1-919-715-3569

Or you can email your questions/comments to: **cte_email@ncsu.edu** (please type "TC-30" in subject header)

***Please check whether this is a comment or a question for the panelist(s).***

- ❑ Comment
- ❑ Question for: _____

Would you like to state your question or comment on the air? ___YES ___NO
(If "YES," please write your phone number below and CTE will attempt to include you in the broadcast.)

***Provide the following information.***

Name: _____ Title: _____

Agency: _____

Site (City/State): _____ Phone (Current Location): _____

Fax: _____ Email: _____

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# CTE TELECONFERENCE EVALUATION

Please take a moment to complete this evaluation and return it to your downlink site coordinator. Your comments and suggestions are important to us. [NOTE: If you participated in this program *via the Internet*, please use the electronic evaluation form located on the CTE Web site at http://www.itre.ncsu.edu/cte/CTEWebcastEvalForm.html] Thank you for your cooperation!

**Downlink Site Location:** (City)_____ (State)_____

**Select the category which best describes your current place of work:**
a. Federal b. State c. Local/MPO d. University e. Private f. Other

*Circle the letter(s) that apply and provide additional comments when possible.*

**1. Did the program content meet your expectations? (If you select C or D, please explain.)**
a. Excellent b. Good c. Fair d. Poor

**2. Was the information presented well organized? (If you select C or D, please explain.)**
a. Excellent b. Good c. Fair d. Poor

**3. The information I received from the teleconference will be:**
a. Extremely useful in my current job b. Somewhat useful c. Not useful at all

**4. The best part(s) of this teleconference was:**
a. Panelist(s)' knowledge, experience, delivery
b. Printed materials and handouts
c. Visual aids
d. Interaction between panel and national audience
e. Use of real-world examples, case studies

**5. The most needed improvement(s) to this teleconference are:**
a. Panelist(s)' knowledge, experience, delivery
b. Printed materials and handouts (Explain:_____)
c. Visual aids
d. Interaction between panel and national audience
e. Use of real-world examples, case studies

**6. Was the downlink facility appropriate/comfortable for the teleconference?**
a. Excellent b. Good c. Fair d. Poor

**7. What topics would you like to see developed for future teleconferences?**

**8. What overall suggestion(s) or comment(s) can you provide about this teleconference?**

# BIBLIOGRAPHY:

## CTE National Teleconference (TC30): Environmental Information Management and Decision Support System for Transportation

*The following bibliography represents a sampling of the published literature and web sites relating to the program topic and to environmental management systems in general. The bibliographic references and abstracts were identified through a keyword search of several online databases. We hope you find these resources helpful. Publication source and ordering information are provided where available.*

### Web Resources Specific to EIM/DSS/EMS

NCHRP 25-23: Environmental Information Management and Decision Support System for Transportation. http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+25-23

NCHRP 25-23(2): Software for an Environmental Information Management and Decision Support System. http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+25-23(2)

Environmental Management Systems. AASHTO Center for Environmental Excellence. http://environment.transportation.org/environmental_issues/environmental_management_systems/overview.htm

Environmental Management Systems. U.S. Environmental Protection Agency. http://www.epa.gov/ems/

National Database on Environmental Management Systems. U.S. Environmental Protection Agency. http://www.eli.org/isopilots.htm

Environmental Management Systems. Office of the Federal Environmental Executive. http://www.ofee.gov/ems/ems.htm

ISO 14000/14001 Information Center. http://www.iso14000.org/

### Published Literature

On the following pages, CTE provides a bibliography of published literature on the program topic. The resources listed show a broad range of EMS and IT applications in transportation, from planning through construction, operations, and maintenance.

For a more comprehensive bibliography, please refer to ***NCHRP Report 481: Environmental Information and Decision Support System – Implementation Handbook***. http://gulliver.trb.org/publications/nchrp/nchrp_rpt_481.pdf

ALFELOR, R., HYMAN, W., AND NIEMI, G., (1999) "Customer-Oriented Maintenance Decision Support System: Developing a Prototype." *Transportation Research Record 1672*, Transportation Research Board, 1–10.
Performance of highway maintenance units has been traditionally measured by output or production rates. Today, more and more highway agencies are incorporating customer-oriented performance measures to evaluate their maintenance management processes. The Minnesota Department of Transportation (MnDOT) has been adapting and applying private-sector business practices to the management of its maintenance functions. The department initiated a maintenance business planning (MBP) project several years ago to focus on rethinking highway maintenance from the customer's perspective. A prototype decision support system (DSS) was developed that builds on the MBP by modeling performance measurement parameters and implementing analytical processes that can support MnDOT's maintenance managers in responding to customer needs. The DSS uses input, output, outcome, environment, and customer data from existing databases to measure efficiency and effectiveness of maintenance activities, as defined by the customer. The pilot system focuses on two of seven groups of maintenance products and services--clear roads and attractive roadsides. Clear roadway products and services include activities that ensure unobstructed roadways (i.e., free from obstruction) and bare pavements (i.e., not covered with snow or ice). Attractive roadside products and services include activities that control the amount of litter, noxious weeds, and vegetation on the side of the roads. The prototype DSS displays data in formats useful for evaluating maintenance work processes, benchmarking work units' performance, evaluating efficiency and effectiveness in meeting customer needs, and deploying resources. Models that calculate the value added to customers in terms of road-user costs (i.e., travel time and accident costs) and customer willingness to pay for attractive roadside products were developed and incorporated in the DSS. If fully implemented, the DSS can be a powerful tool for maintenance decision

ALVAREZ, R., GUERRA, J., AND KUMAR, G. (1999). *Miami-Dade County Integrated Transportation Management System*. Conference Paper from Transportation Frontiers for the Next Millennium: 69th Annual Meeting of the Institute of Transportation Engineers.
The 1991 Intermodal Surface Transportation Efficiency Act mandated the development of six management systems and one monitoring system: bridge management system, congestion management system (CMS), intermodal management system (IMS), pavement management system (PMS), public transportation management system (PTMS), safety management system (SMS), and traffic monitoring system for highways (TMS/H). In 1996, the Miami-Dade County Metropolitan Planning Organization (MPO) completed the development of its Mobility Management Process/CMS (MMP/CMS). This process focuses on the concept of mobility of people and goods, rather than just congestion. The MMP/CMS process and other similar efforts around the nation have affirmed that a comprehensive transportation planning and decisionmaking process requires input from all management systems. The Miami-Dade County's MMP/CMS process has been cited several times as a prime example demonstrating the concept of mobility and congestion management. As a logical next step to the development of the MMP/CMS, the MPO commissioned the development of an integrated transportation management system (ITMS), which would integrate the MMP/CMS, IMS, PMS, PTMS, SMS, and TMS/H. The flexible design of the ITMS allows for the addition of new management systems in the future. The ITMS provides an automated centralized platform for sharing and analyzing data. This system functions as a decision support tool for providing the public officials improved access to transportation information within the Miami-Dade County area. The emphasis of this effort was to create the ITMS using available data. Over time, additional data would make all components more complete.

BEDRAN, M., KAYSI, I., AND SADEK, S. (1999) "GIS Platform for Multicriteria Evaluation of Route Alignments." *Journal of Transportation Engineering*, American Society of Civil Engineers.
The selection of an appropriate alignment for a proposed highway is determined largely by relating topographic, urban, and environmental features to geometric design controls. Typically, aerial photographs and topographic, geologic, and soil maps are reviewed. In this paper, a geographic information system (GIS) platform that incorporates the main coverages needed for evaluating route alignments is described. Using the GIS and a geographically referenced database, a decision-aid tool for multicriteria evaluation of route alignments is developed. Possible alignments are evaluated based on community disruption and environmental, geotechnical, and geometric design criteria. The developed decision-aid tool integrates

slope stability and roadway design packages and specifically written codes with GIS packages ARC/INFO and ArcView, the latter acting as the system engine and interface. A case study is presented that applies the developed platform to the testing of potential alignments for a proposed 12-km highway to the south of the city of Beirut, Lebanon. Results of the case study demonstrate the advantages of the decision-aid tool and highlight its potential in providing a quick, multicriteria screening evaluation of possible route alignments. Since road traffic in Europe is forecast to increase in the future, articulated strategies are needed in order to keep transportation sector growth within the bounds imposed by a sustainable development. Scientific research is contributing to the pursuit of this aim through a large number of projects dealing with transportation-environment interactions. This paper reviews international research activities in this field, focusing particularly on technological innovations and air and noise pollution prediction models, as well as on existing tools for socio-economic evaluation of traffic impacts on the environment. In particular, research projects of the Second Special Project on Transportation (PFT2) of the Italian National Research Council (CNR) are outlined. The aim of this paper is to underline the most relevant research topics on which it is necessary to concentrate the efforts if it is to be expected that community welfare will be achieved.

BEJLERI, I.; ZWICK, P.; LYONS, A. **"**Integrated approach for identifying potential environmental issues of proposed transportation corridors." (2002) *Transportation Research Record, 1792.* pp 93-100. ISBN: 0309077184. ISSN: 03611981.
Transportation projects often have delays, unnecessary duplication of efforts, and especially a lack of coordination among the involved agencies, leading to extra costs associated with the environmental review and approval process. The Florida Department of Transportation and University of Florida researchers are exploring several strategies for developing software tools to address such concerns. The goal is to identify major issues of the proposed transportation projects early in the planning phase so appropriate stakeholders can consult and resolve those issues before additional resources are invested in the project. Proposed is a methodological framework and a conceptual system design for building these software tools. The methodology for analyzing the impact is conceptualized as object-oriented, modular, and highly customizable. This approach offers analysis consistency and great flexibility for applications anywhere in the United States, provided that spatial databases are available. The system design strategy proposed for implementing the methodology takes an integrated approach between geographic information systems and relational database management systems. A prototype application developed based on the proposed framework proved effective in confirming the primary impact issues in a road extension pilot study in Florida. The tool quickly analyzed each of the proposed alignments and compared the levels of impact. Future directions will include expanding the focus from impact assessment to decision support with capabilities for selecting optimal road alignments.

BROWN, A.L. and J.K AFFUM. "A GIS-based environmental modelling system for transportation planners." (2002) *Computers, Environment and Urban Systems*. Vol. 26, pp. 577-590.
http://www.geog.ntu.edu.tw/course/gislucc/GIS_Paper%5Ctransportation.pdf
This paper describes a GIS-based environmental modelling system, termed TRAEMS, for use by transport planners in assessing the environmental e.ects of road tra.c plans. The system utilises capabilities of GIS to integrate the output from a transport planning activity with land use information to model the environmental impacts of di.erent road tra.c scenarios. TRAEMS enables planners to test transport related environmental impacts at the same time as they are testing the tra.c carrying e.ciencies of network plans. The suitability of this type of environmental modelling for planning purposes is illustrated using a case study.

CARSTEN, S. AND MATTRISCH, G., (2000). *A Systematic Approach on Rising Complexities in Urban Environments.* 6th International Conference on Urban Transport and the Environment for the 21st Century. WIT Press.
The paper highlights the need for an integrated approach in urban planning. Overall, economical, political, societal, and many more issues have to be dealt with in the urban decision processes. It is evident to handle both, various influential factors and the interrelation between these factors. Urban stakeholders - politicians, city planners, managers, institutions/organizations - are especially affected by these conditions. This paper presents the sensitivity analysis as a tool that enables the integration of qualitative and

quantitative data, the derivation of alternative scenarios, and the development of consistent and plausible implications.

CASSADA, R., MORRIS, W., NANDA, W., AND PAPIERNIK, D. (2000). "Data Warehouse Strategy to Enable Performance Analysis." *Transportation Research Record 1719*, Transportation Research Board.
The Virginia Department of Transportation (VDOT) has engaged to implement an enterprise data warehouse as part of a strategic investment in its information technology (IT) infrastructure. Data warehousing provides an information architecture that serves as the enterprisewide source of data for performance analysis and organizational reporting. To assist VDOT in achieving its strategic outcome area objectives, a programming and scheduling (P&S) data mart is being developed to track preconstruction project activities. This data mart and subsequent data marts function as departmental decision support platforms, enabling VDOT's operating divisions to perform their own enhanced analytical processing, visualization, and data mining for more informed business decision capabilities. Presented is a case study based on the enterprise data warehouse and P&S data mart being developed and implemented for VDOT by TransCore. Explicitly described is how one VDOT division, Programming and Scheduling, will benefit by investing in IT to achieve its strategic goals. The design approach, methodology, and implementation procedure for the P&S decision support data mart are detailed. The methodology for capturing the performance measures that have been defined by the Programming and Scheduling division in the context of its strategic outcome areas is highlighted. Recommended future direction and the technologies that the agency should adopt to continue to maximize their IT investment are outlined.

CHEN, C., et. al., (1999). "Decision Support System for Total Maximum Daily Load."
*Journal of Environmental Engineering*. Volume 125, Number 7, American Society of Civil Engineers, 653–659.
A decision support system (DSS) was developed to calculate total maximum daily loads (TMDLs) of various pollutants for water quality limited sections (WQLS) within a river basin. The DSS includes a watershed simulation model, a database, a consensus building module, and a TMDL module that provides a worksheet for the calculations. The system can generate multiple combinations of waste load allocation and nonpoint-load allocation to meet the water quality criteria for the intended uses of the WQLS. Considering various possible solutions, the regulatory agency and local stakeholders can negotiate an option most agreeable to all parties. The methodology is demonstrated with an example application in the Catawba River Basin, which extends from North Carolina to South Carolina.

COLORNI, A., et. al., (1997). *Decision Support Systems for Environmental Impact Assessment of Transport Infrastructures.* 1997 Transportation Systems Conference, Volume 3, Elsevier Science, Ltd., 1001–06.
Decision Support Systems for Environmental Impact Assessment of transport infrastructures are considered in this paper. Some indications which should be followed in practical applications are pointed out and SILVIA, a Decision Support System, is presented. SILVIA covers the four parts of an Environmental Impact Assessment study: the preparatory or orientation phase, the land analysis phase, the impacts estimate phase, and the decision phase. Finally, two directions for further developments are focused upon: sensitivity analysis and group decision.

FROHWEIN, H., et. al., (1999). "Multi Criteria Framework to Aid Comparison of Roadway Improvement Projects." *Journal of Transportation Engineering*. Volume 125, Number 3. American Society of Civil Engineers, 224–230.
This paper reports on an effort to assist the Virginia Department of Transportation in improving the comparison of potential roadway improvement projects in the planning phase. A multicriteria decisionmaking framework to aid the selection of roadway improvement projects is developed, based on the needs of the state highway agency. Three major factors--crash-risk reduction, performance improvement, and project cost--are addressed in a multicriteria tool that enables the comparison of even very diverse projects on a common ground and provides information on the tradeoffs that come with the selection of one or the other project. The contribution is unique in that no overall scores need to be generated, acknowledging that although decision support can be provided, project selection will be made by human decision makers, who should be able to incorporate additional information, such as

environmental or aesthetic impacts, not necessarily available to the analyst. The use of this framework primarily is seen at an early stage of planning, which generally is characterized by the absence of detailed information for the potential projects. A real-world application of the proposed methodology is demonstrated, and various potential applications and decisionmaking contexts in which the use of this tool could be beneficial are highlighted.

GREENSTEIN, J. AND EHRLICH, M., (1994). "Institutional Aspects of Environmental Management in Road Development." *Transportation Research Record 1434*, Transportation Research Board, 92–96.
Environmental protection and remediation are integrated activities of road administration. International lending agencies such as the Inter-American Development Bank and the World Bank and the lawmakers of both developed and developing countries insist that all projects be environmentally sound. To achieve this goal, road departments need adequate institutional capacity to address and resolve all the environmental issues in a timely and cost-effective manner to reduce or avoid remedial costs. Experience with the administration of environmental units within road departments is detailed in this paper. The principal responsibilities of such a unit are the administration of environmental impact assessments; research, development, and adaptation of new technologies; and education and training of the department's managerial and technical staff. This kind of environmental management is set within a defined legal and regulatory framework and requires interinstitutional cooperation and coordination. In order for this program to succeed, institutional strengthening is required for the development of human resources, improvement of the organizational set-up, implementation of environmental policies related to road administration, and improvement of the administration of environmental impact assessments. A typical institutional set-up and its responsibilities are presented.

*Guidance for Estimating the Indirect Effects of Proposed Transportation Projects, NCHRP Report B25-10*. Transportation Research Board. (1998).
This report contains guidance and a framework for practitioners in defining "indirect effects" of proposed transportation projects, identifying tools for estimating these effects, and analyzing these effects. The report should be of interest to state departments of transportation, metropolitan planning organizations, transit agencies, and other transportation project sponsors. It should also provide a valuable resource for transportation planners and engineers, environmental practitioners, and others responsible for project development and environmental impact analysis.

HAMILTON, BOOZ ALLEN AND MICHAEL BAKER JR. INC. (2003). *Environmental Information Management and Decision Support System – Implementation Handbook.* Transportation Research Board, NCHRP Report 481.
http://gulliver.trb.org/publications/nchrp/nchrp_rpt_481.pdf

HEANUE, K., (1997). *History of Data Collection.* Information Needs to Support State and Local Transportation Decision Making into the 21st Century Conference, Irvine California, March 2, 1997 to March 5, 1997, Conference Proceedings 14, Transportation Research Board, 53–57.
This conference paper presents a brief history of data collection in the field of transportation. The history is presented in terms of time, the evolution of transportation technology, and some of the applications of data, mostly in the highway program. The last half of the paper focuses on transportation planning, especially urban transportation planning, and the movement from data-based studies to simulations using small sample surveys. The paper concludes with comments on reauthorization of the Intermodal Surface Transportation Efficiency Act, a more effective dialogue with Congress, a planning process that is not geared to intelligent transportation systems, the "disconnect" between environmental analysis and project development, reaching for international answers, and a Transportation Research Board report on sustainability.

HELLINGA, B.; MCNALLY, R. A. "Method for quantitatively prioritising transportation projects on the basis of sustainability." (2003) *The Transportation Factor 2003. Annual Conference and Exhibition of*

*the Transportation Association of Canada. (Congres et Exposition Annuels de l'Association des transport du Canada).* 19p.
There is currently a great deal of interest in and discussion of the concept of sustainable transportation. A large number of factors, such as global warming, the Kyoto agreement, increased frequency, and severity of poor air quality that have provided the impetus for this increased interest. The scope of both discussions and research have, up until now, focused primarily on developing macroscopic measures of performance (or indicators) that are useful for application to regional areas. While these indicators are helpful for broad policy level evaluations, they are not always suitable for network or project level application. Consequently, transportation professionals and politicians at the municipal level have few if any tools available that enable them to quantitatively and objectively include sustainability when prioritizing potential transport projects. This paper addresses this issue, specifically offering several sustainability measures of performance and gives a framework within which the indicators can be used to evaluate potential transportation projects. Sample transport projects are used to illustrate the proposed method.

HYMAN, W. "Environmental information management: Resource paper." (2002) *Conference Proceedings 28, Environmental Research Needs in Transportation*. pp 87-92 ISBN: 030907715X; ISSN: 10731652
This paper recommends research regarding environmental information management. The approach taken is (1) identify the key components of environmental management systems, (2) emphasize those elements that pertain to environmental data and information management, and (3) identify current and future research needs. The following two approaches to environmental management systems are identified and discussed: (1) An environmental management system compliant with the International Standards Organization standard 14001; and (2) The concept for an Environmental Information Management and Decision Support System developed under National Cooperative Highway Research Program Project 25-23.

JHA, M.K. "Criteria-based decision support system for selecting highway alignments." *Journal of Transportation Engineering*. Vol.129, No.1. 01/2003, pp 33-41. ISSN: 0733947X
At the planning stages of a highway development process, a number of candidate highway alignments are explored. While computerized highway optimization models can seek optimized horizontal and vertical alignments by minimizing aspects of total highway cost, selection of final alignments is often affected by environmental impact assessment and public and political participation. To ensure that there are no adverse impacts on the environment and the living conditions of the residential community, the Federal Highway Administration has initiated a context-sensitive design approach to highway design. A criteria-based decision support system is developed in this paper for selecting highway alignments using genetic algorithms and geographic information systems, which can assist in estimating trade-offs among alignment-sensitive cost, alignment circuity, floodplain and wetland impacts, and intersections with existing highways. A procedure for selecting notably different alignments is proposed by evaluating alignments obtained at intermediate search generations by genetic algorithms. A set of different alignments can provide enough leeway to explore trade-offs among cost and environmental and roadway impacts. An example using Maryland's geographic database is presented.

KLUNGBOONKRONG, P.; TAYLOR, M.A.P. "The experiences in evaluating the multicriteria traffic environmental impacts in urban road networks using SIMESEPT." (2002) *Eighth International Conference on Urban Transport and the Environment in the 21st Century.* pp 311-334. ISBN: 1853129054. ISSN: 1462608X.
The estimation and assessment of safety, amenity, and environmental degradation caused by road traffic in traffic is difficult and complex. Spatial Intelligent Multicriteria Environmental Sensitivity Planning Tool (SIMESEPT) is a microcomputer-based decision support system that was developed to evaluate traffic environmental impacts of urban road network. SIMESEPT integrates various advanced information technologies and some traffic environmental impact evaluation models. This paper applies SIMESET to investigate and evaluate the environmental impacts characteristic of the Khon Kaen road network in Thailand, and is organized to present the following: fundamental structure of SIMESEPT; environmental sensitivity method; the Khon Kaen case study; future development; and the conclusions.

LALIOTIS, L., PROTONOTARIOS, M., AND TZAFESTAS, S., (1999). *Decision Support and Artificial Intelligence in GIS: Overview and Applications.* Proceedings volume from the IFAC workshop, Ethnikon Metsovion Polytechneion.
This paper provides an overview of decision support systems (DSS) and artificial intelligence (AI) concepts as they are applied to and can enhance geographical information systems (GIS). Four case studies are discussed. These include: 1) a real-time traffic congestion system in Athens, Greece; 2) planning a best route facility; 3) a route cost comparison system; and, 4) a traffic pre-emption system.

LANE, L., et. al., (1998). "Environmental Justice Evaluation: Wilmington Bypass, Wilmington, North Carolina." *Transportation Research Record 1626.* Transportation Research Board, 131–139.
Among the common mandates of agency guidelines implementing Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, is the determination of whether the subject action or project will cause disproportionately high and adverse human health or environmental effects on minority or low-income populations. This determination is often troublesome because it requires the analyst to know or define disproportionate impacts. A method is provided for defining disproportionate within the context of an environmental justice evaluation that was conducted for the Wilmington Bypass environmental impact statement. In response to strong local opposition to one of the alignment alternatives of the Wilmington Bypass and to address the perception that this community's residents were not involved in the planning process, the Wilmington Bypass public involvement program was augmented to include a citizens' informational workshop, project development meetings, and community liaison meetings. A brief history is provided of the Wilmington Bypass project, highlighting the public involvement surrounding the environmental justice evaluation. Discussions of the scoping process and delineation of the study area are followed by discussions of the reference population development for the minority and low-income populations. Particular emphasis is given to the use of available census demographic and socioeconomic data and graphical display of these data with the use of a geographic information system. Impact evaluations and mitigative responses for issues determined relevant for the environmental justice analysis conclude the discussion. Conclusions and recommendations for further study are provided.

LAUTSO, K., AND TOIVANEN, S., (1999). *SPARTACUS System for Analyzing Urban Sustainability.* Presented at the *Ann. Meeting of the Transportation Research Board,* Washington, DC.
http://www.ltcon.fi/spartacus/default.htm
SPARTACUS (System for Planning and Research in Towns and Cities for Urban Sustainability) is a strategic urban planning system based on a state-of-the-art land use/transport model (MEPLAN) combined with a set of urban sustainability indicators, the geographic information system-based Raster method to calculate values for some of the indicators, the MEPLUS database and presentation module, as well as the decision-support tool USE-IT. The USE-IT system is used for evaluating the results of policy options based on weighted indicator values representing social, environmental, and economic effects of the policies. The SPARTACUS system has been used for assessing policy options in a systematic way in three cities: Helsinki, Bilbao, and Naples. More than 30 policy elements (i.e., individual policy measures) have been analyzed. The policy elements represent different pricing, regulatory, land use, transport planning, and investment measures. Based on the results, policies and policy combinations comprising several promising policy elements have been defined and analyzed. The results show that the level of sustainability can be increased in the test cities in a cost-effective way by using a variety of policies, especially pricing and regulatory policies and their combinations. Negative side effects of individual policies can be mitigated by combining policies, and innovative policy combinations can be found. Recommendations for sustainable urban policies and future research are given, based on the above studies.

MARTIN, J. AND EDGLEY, G., (1998). *Environmental Management Systems: A Guide for Planning, Development, and Implementation*. Government Institutes.
The authors of this book discuss the strategic factors that determine the success of an environmental management system (EMS): performance standards, realistic cost-benefit analysis, consideration of market practices, best management practices, risk assessment, and life cycles. The title explores trends, such as

environmental business processes, evaluation of the process, types of programs in a successful EMS, and the integration of the environment function into the business function.
The book includes extensive graphs, tables, forms, and flow diagrams. A 12-page chart compares four management standards and guidelines, and helps readers decide which one or ones to follow: ISO 14001, Malcolm Baldridge, EMAS, and ICC Principles.

MICHENER, W., et. al., (1994). *Environmental Information Management Analysis: Ecosystem to Global Scales*. Taylor & Francis.
Most environmental studies are based upon data collected at fine spatial scales plots, sediments, cores, etc. Furthermore, temporal scales of these studies have been relatively short (days, weeks, months) and few studies have exceeded three years duration the typical funding cycle. Despite this history, environmental scientists are now being called upon to extrapolate findings from 'plot-level' studies to broader spatial scales and from short-term studies to longer temporal scales, up to decades for questions related to long-term processes such as global warming and the rise in sea level. The complex questions being addressed internationally require that scientists take advantage of new technologies including remote sensing, geographic information systems GIS, and powerful climatic and environmental simulation models. As more environmental scientists begin to work at these broader spatial and temporal scales, and to utilize many of the newer technologies, they are recognising a whole new class of problems. This book aims to address the most pertinent issues, and includes a comprehensive review of selected topics, case studies, and theoretical discussions, divided into seven sections each preceded by a brief introduction.

MUKHERJEE, S. AND OZBAY, K. (2000). "Web-Based Expert Geographical Information System for Advanced Transportation Management Systems." *Transportation Research Record 1719*, Transportation Research Board, 200–208.
The Internet is fast becoming the standard environment for client-server applications that involve multiple users. The proliferation of Internet-based application development tools opens new doors to transportation researchers who work in real-time decision support system (DSS) development. In the 1990s, one of the most important problems in advanced transportation management systems research was the development of better incident management systems. Although the incident management process has been well studied, the development of real-time DSSs that can be used by all the involved agencies remains a challenging area of transportation engineering research. Existing incident management systems are developed on various traditional computing platforms, including UNIX and Windows. However, with the advent of the World Wide Web and Internet-based programming tools such as Java, it is possible to develop platform independent decision support tools for the incident management agencies. Web-based support tools offer an invaluable opportunity to develop next-generation online decision support tools for real-time traffic management. The applicability of Web-based tools to the development of online DSSs for incident management is explored and demonstrated, and a prototype incident management DSS that has most of the capabilities of similar UNIX-based DSSs is developed and tested. Briefly described are the implementation and development of a prototype wide-area incident management system using Web-based tools.

REPAKA, S.R.; O'HARA, C.G.; TRUAX, D.D. "Analysis of remotely sensed data for planning transportation networks". (2002) *Integrating Remote Sensing at the Global, Regional and Local Scale*. Pecora 15/Land Satellite Information IV Conference.10p.
http://www.isprs.org/commission1/proceedings/paper/00003.pdf
Analysis of remotely sensed and hyperspectral data has significant potential application in the areas of planning of, and better decision support for, transportation networks. With increased demand for better transportation facilities and rapid urbanization, there has been large scale modification of land cover systems. This paper discusses an environmental assessment that will be conducted to study the impacts of relocating segments of the CSX railroad out of significant population growth areas along the environmentally sensitive Mississippi Gulf Coast. The environmental assessment project is intended to make broad use of remote sensing and geospatial technologies. Using the CSX railroad relocation as a test case, an analysis framework is proposed for using remote sensing and geospatial information to support the environmental assessment and planning tasks for a transportation network.

SADEK, S., et. al., (1999). "GIS Platform for Multicriteria Evaluation of Route Alignments." *Journal of Transportation Engineering*. Volume 125, Number 2, American Society of Civil Engineers, 144–151.
The selection of an appropriate alignment for a proposed highway is determined largely by relating topographic, urban, and environmental features to geometric design controls. Typically, aerial photographs and topographic, geologic, and soil maps are reviewed. In this paper, a geographic information system (GIS) platform that incorporates the main coverages needed for evaluating route alignments is described. Using the GIS and a geographically referenced database, a decision-aid tool for multicriteria evaluation of route alignments is developed. Possible alignments are evaluated based on community disruption and environmental, geotechnical, and geometric design criteria. The developed decision-aid tool integrates slope stability and roadway design packages and specifically written codes with GIS packages ARC/INFO and ArcView, the latter acting as the system engine and interface. A case study is presented that applies the developed platform to the testing of potential alignments for a proposed 12-km highway to the south of the city of Beirut, Lebanon. Results of the case study demonstrate the advantages of the decision-aid tool and highlight its potential in providing a quick, multicriteria screening evaluation of possible route alignments.

SCHMOLDT D., AND RAUSCHER, M. (1996). *Building Knowledge-based Systems for Natural Resource Management*. Chapman & Hall.
This is the first book to provide a detailed process for planning, designing, implementing, and testing knowledge-based systems for natural resource management. It presents material on all these major aspects of building a deliverable system. Equipped with these techniques, managers and scientists will improve their ability to solve complex resource problems that are multidisciplinary in scope and for which mathematical approaches prove insufficient. Fully describing the various components of these systems, this important work includes discussions on system design, knowledge acquisition, prototyping, knowledge verification and validation, implementation, and system delivery. To further illuminate the material presented, it contains a tutorial on the knowledge-based programming environment PROLOG as well as many examples of expert system development, including one for forest management. *Building Knowledge-Based Systems for Natural Resource Management* demonstrates how knowledge can be effectively organized and administered, enabling natural resource professionals to respond intelligently to natural resource problems. This book also provides researchers and students with an essential resource for understanding this useful technology.

SMITH, L., et. al., (1995). *TRANSIMS: Transportation Analysis and Simulation System.* Fifth National Conference on Transportation Planning Methods Applications—Volume II: A Compendium of Papers Based on a Conference Held in Seattle, Washington in April 1995. Transportation Research Board.
This paper, which appears in a compendium of conference papers, describes the TRansportation ANalysis and SIMulation System (TRANSIMS) Project, the system's major modules, and the projects's near-term plans. TRANSIMS employs advanced computational and analytical techniques to create an integrated regional transportation systems analysis environment. The simulation environment includes a regional population of individual travelers and freight loads with travel activities and plans, whose individual interactions are simulated on the transportation system, and whose environmental impact is determined. An interim operational capability (IOC) for each major TRANSIMS module will be developed during the 5-year program. When the IOC is ready, a specific case study to confirm the IOC features, applicability, and readiness will be completed.

SOUTHWORTH, F., (1995). *A Technical Review of Urban Land Use: Transportation Models as Tools for Evaluating Vehicle Travel Reduction Strategies*. ORNL-6881. Oak Ridge National Laboratory.
The continued growth of highway traffic in the United States has led to unwanted urban traffic congestion as well as to noticeable urban air quality problems. These problems include emissions covered by the 1990 Clean Air Act Amendments (CAAA) and 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), as well as carbon dioxide and related "greenhouse gas" emissions. Urban travel also creates a major demand for oil. Therefore, for economic as well as environmental reasons, transportation planning agencies at both the state and metropolitan area level are focusing a good deal of attention on urban travel reduction policies. The purpose of this review is to evaluate the ability of current analytic methods and models to support both the evaluation and possibly the design of such vehicle travel reduction strategies,

including those strategies involving reorganization and use of urban land. The review is divided into three sections. Section 1 describes the nature of the problem we are trying to model, Section 2 reviews the state of the art in operational urban land use/transportation simulation models, and Section 3 provides a critical assessment of such models as useful urban transportation planning tools.
http://ntl.bts.gov/DOCS/ornl.html

VOELLINGER, L. AND OAKES, C., (1996). "Regional Place-Systems Analysis Applied to Long-Range Transportation Planning." *Transportation Research Record 1518*, Transportation Research Board, 19–21.
The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires the integration of environmental considerations into transportation planning. Although previous legislation has required the consideration of environmental elements during project planning, ISTEA necessitates a different approach. During project-specific planning, each environmental element is researched to determine baseline conditions, and project plans are superimposed to determine potential impacts and the need for mitigative measures. This approach is appropriate for project-specific planning, but it presents only a snapshot of existing conditions because environmental data are changing constantly. The integration of environmental considerations into long-range plans requires a much broader focus. It must allow dynamic systems to change without affecting the plan's validity. A case study is presented of the Oklahoma statewide intermodal transportation plan, which uses recent geographic theory to integrate planning and human activity at varying scales. This theoretical framework is based on ecological and societal units of interaction called "bioregions" or "place-systems". The environmental baseline and analysis for Oklahoma begin with the identification of place-systems in the state: areas of biophysical and cultural similarity and context. The delimitation of such regional place-systems is sufficiently generalized and flexible to accommodate many data types and sources, yet rigid enough to be useful for planning. Both quantitative data and descriptive information are included in an analytical framework suitable to relational data bases and geographic information systems applications. These are used to create a series of map and data overlays to project potential environmental impacts and constraints, as well as opportunities for developing future transportation projects.

WEILAND, U. AND HILTY, L., (1998). *Sustainable Urban Management: Opportunities and Risks of Information Technology. Sustainable Development and the Future of Cities*. Intermediate Technology Publications Ltd.
In order to develop sustainable urban areas, we need concepts, techniques, and measures that allow us to combine environmental policies with social and economic policies. This paper describes existing computer-supported methodologies: Environmental Impact Assessment, Life Cycle Assessment, Eco-logistics, and Material Flux Analysis. These instruments require completion and integration. Even if integrated in a holistic and consistent framework, they are not sufficient to bring about the paradigm shift from conventional urban planning to sustainable urban management. New ideas, such as the concept of fractal urban form, the sequential interindustry model, and the dynamic economic-ecological models, need to be developed and utilized. Sustainable urban management requires a deeper understanding of the evolution of ecological, social, and economic structures and, based on this understanding, the construction of instruments that help to approach sustainability. For both steps, information technology can offer various forms of support.