

PROPOSAL FOR RESEARCH
[clarifications prepared April 11, 2003]

**ANALYTICAL SUPPORT FOR THE STATEWIDE MULTIMODAL LONG-RANGE
TRANSPORTATION PLAN**

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INTRODUCTION

The following is a proposal for research to provide systems analytical support for the statewide multimodal long-range transportation plan. The proposal is in the following parts: Problem Statement, Purpose and Scope, Methods, Expected Benefits, Schedule, Budget, Deliverables, References, and Contractor Qualifications.

PROBLEM STATEMENT

In accord with the vision of VTrans2025 “*to build a world-class multimodal transportation system*”, there is the need for analytical methods to improve the communication and cooperation among the various modal transportation agencies of the Commonwealth of Virginia. Subsequent to developing a comparison tool for VDOT road improvement projects, the PI of this proposal has collaborated with the VTrans 2025 Technical Committee (comprised of agency representatives of VDOT, DOAV, VDRPT, and VPA) since August 2002. The PI participated in monthly meetings of the Committee and separately briefed a Committee subgroup, the latest in April 2003. The need for systems analytical support for multimodal transportation planning has several dimensions as follow.

The VTRANS 2025 Committee is encouraged to address examples of *real projects* and systems, in addition to a focus on developing the process of statewide multimodal planning. Systems *integration* of multi-agency planning should rely on the concurrent processes (i) bottom up, from the project level, and (ii) top down, from the recognition of statewide needs and the identification of candidate multimodal solutions. Early yet reliable *gross forecasts* of costs and impacts are needed for the evaluation and trading off among candidate multimodal systems. Inter-agency *notification* of current and future needs for multimodal participation and coordination can and should take place in a regular and defined process. While performance metrics of transportation projects are not always common across modes (e.g., crash reduction by road projects may not be comparable to safety gains brought about by aviation or port projects), the process of *metrification* across modes and the accompanying technical terms can be made consistent to better support multimodal coordination. The *scheduling* considerations are primary in the coordination of projects across multiple agencies. The consideration of the impacts of current decisions to future planning options is a case in point. Communication and coordination of state agencies with *other states, local and federal authorities, and with private interests* must be assured. The prominence of (i) autonomous (not directed by Virginia agencies) airport

authorities in the aviation sector of Virginia, (ii) local transit authorities in the public transportation sector, and the (iii) importance of harmonizing interstate rail corridors, to name two examples, make clear the need for participation of extra-state entities in the multimodal planning process. Relatively *few projects* will need the extra support of multimodal systems analytical methods, as most intra-agency projects will not require multi-modal or inter-agency coordination. The share of agency projects needing multimodal attention will vary from mode to mode, perhaps being a higher share in ports and transit than of the 1500 road projects in the roadway six-year plan at any one time. The VTRANS 2025 Committee, whose work is due to be completed in July 2004, is benefiting from the work of its *predecessors* in inter-agency transportation planning, most recently a working group that tendered its report to the Virginia General Assembly in 1997.

In summary, the VTRANS 2025 will benefit from systems-analytical methods to improve coordination among the several state transportation agencies and other entities and to enable the effective allocation of funds (identifying cost savings) in planning of a multimodal transportation infrastructure.

PURPOSE AND SCOPE

The goal of the proposed effort is to develop and apply systems analytical methodology that supports coordination among Virginia state transportation agencies in planning transportation projects with multimodal significance. In particular, the methodology will contribute in assigning priorities to projects in the building out of multimodal networks and systems, as illustrated in Figure 1. The objectives of the effort are: (1) Review the relevant literature and the experience of federal agencies, other states, and other countries; (2) Understand multimodal system requirements and participation by the various state transportation agencies; (3) Specify analytical methods and data needs for multimodal systems planning; (4) Transfer the developed methodology to the transportation agencies, in part through the development of case studies of real projects. The VTRANS 2025 committee will provide a steering committee for the effort.

METHODS

The effort will consist of the following tasks:

Task 1: Review of Literature

A review and evaluation of research programs, studies, theory and methodology, and associated databases that support the proposed effort will be performed. Focus of the review will be on the following aspects of multimodal systems:

- planning process
- investment process
- coordination and communication requirements

A sample of reference sources is given in the last section of this proposal.

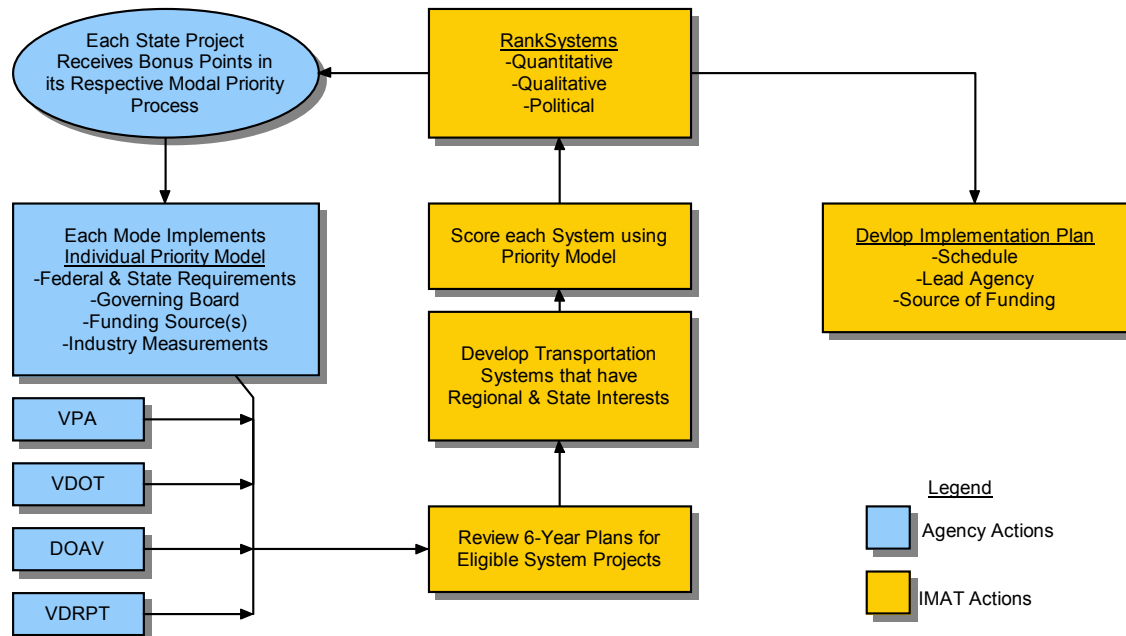


Figure 1. Multimodal statewide planning process (Source: VTrans 2002)

Task 2. Modal Project Case Studies

Case studies of the VTrans 2025 "needs assessments" from various modal agencies will be conducted with an existing comparison tool developed by the PIs. The case studies will provide insights towards implementing analytical tools and techniques to multimodal networks of projects. In particular, the case studies will show how projects of different modes can be compared using both quantitative and categorical information. The case studies will also explore how such comparison can be streamlined through the development of software and databases. Figures 2 and 3 highlight a common approach to the characterization of agency project portfolios and the associated integration of multimodal networks. Figure 2 depicts metrics useful to compare and contrast project portfolios from various agencies. Figure 3 illustrates that multimodal systems can be compared in terms of the relevant agency projects, with a focus on a distribution of costs and potential impacts. [A sample of these results was presented to the VTrans Technical Committee in January and February. New effort on this task will be minimal and focused on documentation of past efforts. The results of this task may facilitate multimodal analyses and interpretation of the several modal "needs assessments" that are due to be completed by the modal agencies in August 2003. Our past efforts on this task relied in part on existing and older versions of the modal "needs assessments".]

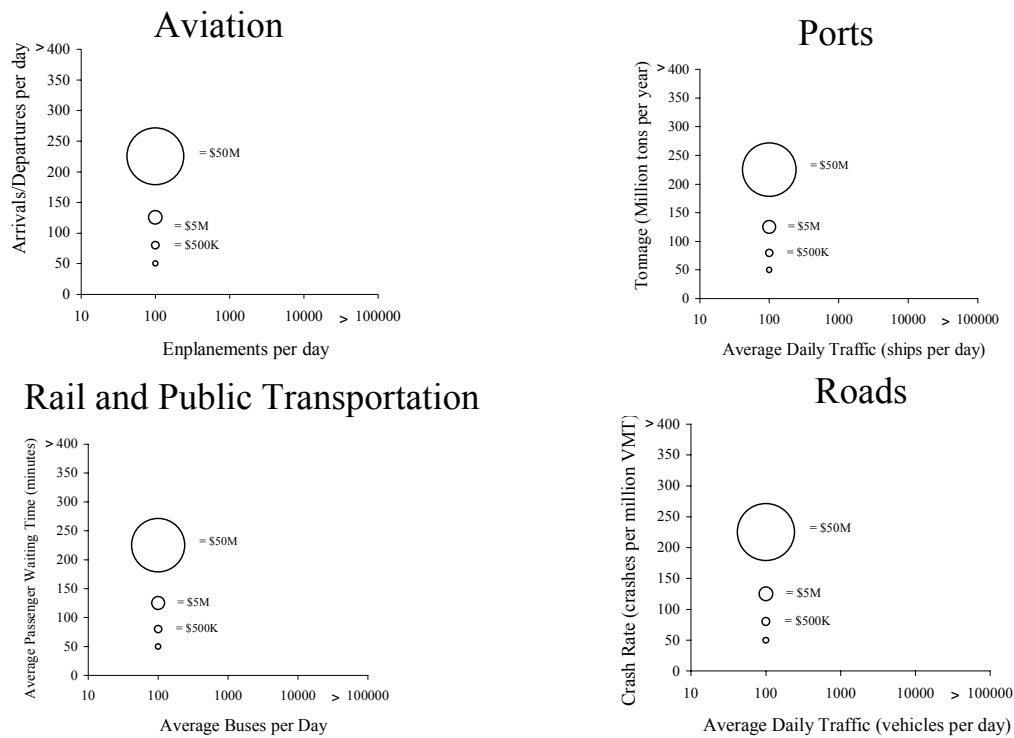


Figure 2a. Applications of a graphical project-portfolio comparison tool across transportation modes

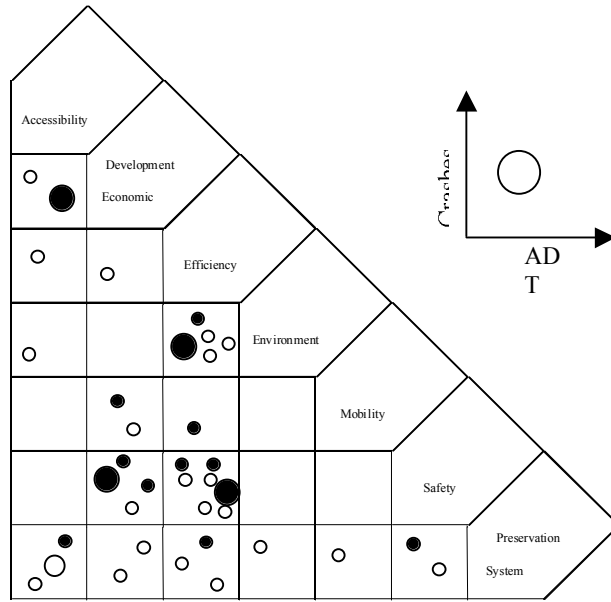


Figure 2b. Concept for combining quantitative and categorical evidence of potential impacts across a portfolio of projects

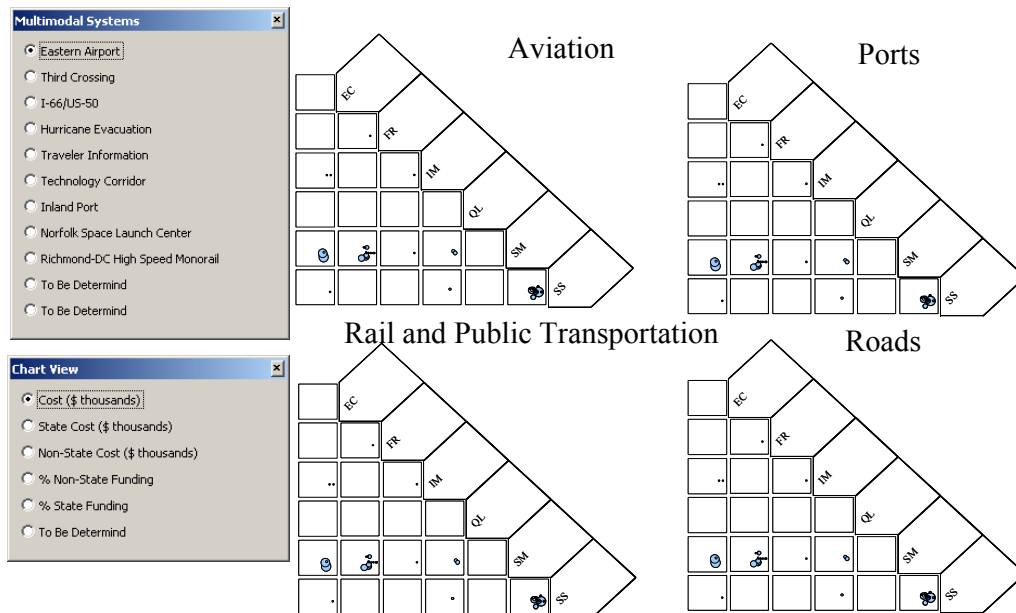


Figure 3. Prototype of a tool for visualizing the costs and impacts of multimodal networks and systems of modal agency projects

Task 3. Systems Analysis of Multimodal Networks

A *multimodal impact statement* will be developed for comparison of multimodal networks. The impact statement will facilitate the development, comparison, and prioritization of proposals for multimodal networks. The impact statement will facilitate deliberation of multimodal networks among modal agencies, non-Virginia agencies, MPOs and PDCs, and the private sector. The development of the impact statement will draw in part on principles of systems analysis described just below via an example. A prototype of such an impact statement developed by the PIs in April 2003 is given in the attachment.

A systems analysis of multimodal networks will be performed with emphasis on the coordination among the various modal transportation agencies of the Commonwealth of Virginia. Particularly, analytical tools to support the coordination process will be developed and the information needed for planning and integration of multimodal networks will be identified.

For example, a network model will be explored to highlight scheduling and planning of multimodal systems. Suppose there are nine projects in a particular multimodal system. Table 1 suggests a framework to identify project dependencies and estimated project duration.

Table 1. Example: Multi-agency project information of a multimodal system

Project ID	Description	Mode	Duration	Predecessor
A	Rehabilitate alternative roads	Highway	8	-
B	Re-zoning	Aviation	20	-
C	Widening of road	Highway	33	-
D	Grading of median	Rail	18	A
E	Construction of by-pass	Highway	20	A
F	Purchase land	Aviation	9	B
G	Rehabilitation of port	Port	10	C
H	Construction of rail-road tracks	Rail	8	D
I	Extension of air port	Aviation	4	E, F

In application of PERT-CPM as in Table 2, the earliest start, earliest finish, latest start, and latest finish for each project are identified. Furthermore, the duration for the entire multimodal system of project can be determined by identifying the scheduling critical path.

Table 2. Start and finish times of multimodal network resulting from PERT-CPM

Project ID	Earliest Start	Earliest Finish	Latest Start	Latest Finish
A	0	8	9	17
B	0	20	10	30
C	0	33	0	33
D	8	26	17	35
E	8	28	19	39
F	20	29	30	39
G	33	43	33	43

H	26	34	35	43
I	29	33	39	43

The project dependencies can be also be presented graphically, as shown in Figure 4.

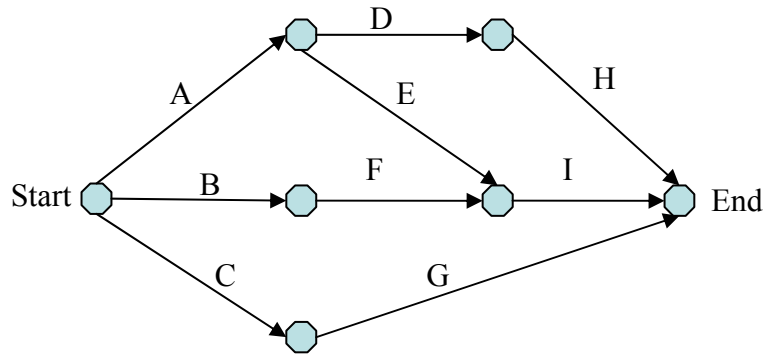


Figure 4. Network model of multimodal projects showing the start and end of the network and the precedence of the individual projects

The above example is representative but not encompassing of an analytical approach to the planning of multimodal systems. The choice of example highlights the centrality and importance of schedule considerations to multi-agency coordination.

Task 4. Development of Prioritization Methods

A prototype list of performance metrics was developed by the PIs and provided to the VTrans Technical Committee in November 2002 [see attachment]. Work on revision of these metrics resumed and continues to be a primary focus of the committee in April 2003.

Prioritization tools and techniques, including performance metrics, for multimodal networks will be developed based on the needs and benefits reflective of the primary motivations for multimodal projects as defined by the Commonwealth of Virginia VTRANS 2025:

- *Economic Competitiveness*: Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency
- *Fiscal Responsibility*: Promote efficient system management and operation [may be removed per discussions in April 2003]
- *Quality of Life*: Protect and enhance the environment, promote energy conservation, and improve quality of life
- *Intermodalism and Mobility*: Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight
- *System Management*: Increase the accessibility and mobility options available to people and for freight

- *Safe and Secure Transportation*: Increase the safety and security of the transportation system for motorized and non-motorized users

Support for prioritization and comparison of modal projects, multimodal networks, and systems will be grounded in theory and methodology of multicriteria decision-aiding (MCDA).

Task 5. Demonstration with Virginia Multimodal Networks/Systems

The application of the multimodal impact statement developed in Task 3 will be demonstrated on several emerging multimodal networks of Virginia, including: (1) US 460 Transamerica Corridor, (2) Hampton Roads "Third Crossing", and (3) Dulles Airport Access Corridor. A sample list of other such networks will be developed working closely with the VTrans 2025 Technical Committee. The work on the 460 example began in April 2003, a sample of which is given in the attachment.

Prioritization tools and techniques, focusing on the application of the multimodal impact statement, will be developed and applied to a sample of competing multimodal transportation systems in Virginia. The demonstration will explore the suitability of tools and techniques in coordinating multimodal projects across agencies, with consideration to addressing the heterogeneity of projects.

Task 6. Recommendations

The effort will develop recommendations for implementation of systems analysis by the statewide committee on multimodal system needs VTRANS 2025. The recommendations will address:

- Factors that support or inhibit the development prioritization tool to support statewide multimodal transportation plans
- Framework for improved coordination amongst Virginia state transportation agencies in planning transportation projects with multimodal relevance

Task 7. Reports, Presentations, and Workshop

The principal investigator will prepare progress reports and a VTRC final report, develop and make presentations to the multimodal statewide committee, and present a workshop to educate selected personnel of the modal agencies in the multimodal planning process. Documentation and spreadsheets will as well be provided in electronic form and via an internet web site at the University of Virginia.

EXPECTED BENEFITS

The benefits of the proposed effort include:

- Improved coordination among Virginia state transportation agencies in planning transportation projects with multimodal significance
- Prioritization tool for projects that participate in multimodal networks and systems

- Improved understanding of an appropriate balance among costs, risk reduction, and other factors/metrics in the selection of multimodal system projects
- Specification of databases of parameters related to the justification for multimodal systems

SCHEDULE*

Tasks	Duration (months)	Start Date	End Date
1. Review of Literature	3	2/1/03	5/31/03
2. Modal Project Case Studies	7	ongoing	3/31/03
3. System Analysis of Multimodal Networks	8	2/1/03	9/30/03
4. Development of Prioritization Methods	3	4/1/03	6/30/03
5. Demonstration with Virginia Multimodal Networks	9	6/1/03	2/30/04
6. Recommendations	2	2/1/04	3/30/04
7. Reports, Presentations, and Workshop	14	1/1/03	3/30/04

*change start date to May 1

BUDGET

[submitted with formal proposal February 2003]

DELIVERABLES

The principal investigator will prepare progress reports and a VTRC final report, develop and make presentations to the VTRANS 2025 Committee, and present a workshop to educate the participating agencies and entities in the developed methodology. Documentation and spreadsheets will as well be provided in electronic form and via an internet web site at the University of Virginia. The deliverables of the project will be interim and final reports, presentations, and prototype spreadsheets to support allocation of resources to multimodal systems by the several transportation agencies of the Commonwealth and by the coordinating multimodal committee. The reports and presentations will include:

1. Review of systems analytic methods applied to multimodal planning
2. Framework for modal agencies coordination and collaboration
3. Systems tools for scheduling and planning of multimodal networks, including multimodal impact statement
4. Priority-setting tools for support of multimodal planning
5. Case studies and spreadsheets of the above tools and methods
6. Documentation of the spreadsheets, in paper and electronic form via an internet web site

During the contract period of performance, the PIs will be available to the VTrans 2025 Technical Committee to address emerging needs and will be amenable to modify the PI's statement of work that is specified in this proposal as directed by the committee and the Virginia Transportation Research Council.

REFERENCES

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Additional resources include the following.

AASHTO Journal, Accident Analysis and Prevention, Better Roads, Civil Engineering, Civil Engineering Practice, ITE Journal, Journal of Safety Research, Journal of Transportation Engineering, Public Works Management and Policy, TR News, Traffic Engineering and Control, Transport Policy, Transportation, Transportation Journal, Transportation Research Part A: Policy and Practice, Transportation Research Part B: Methodological, Transportation Research Part C: Emerging Technologies, Transportation Research Part D: Transport and Environment, Transportation Research Part E: Logistics and Transportation Review, Transportation Science

CONTRACTOR QUALIFICATIONS

The Center for Risk Management of Engineering Systems, University of Virginia, develops theory and methodology for the assessment of risk in a variety of civilian, defense, water resources, and other engineering systems. Industry and government sponsors of research at the Center work closely with faculty and students, contributing their unique strengths and interests to the Center and sharing in experience from a broad range of ongoing projects at the Center. Areas of expertise include (1) water resources, transportation, and technology management, (2) environmental impacts, (3) electronic, safety-critical systems, (4) computer-based systems, including hardware and software performance and reliability, (5) reliability modeling of multiple failure modes of complex systems, and (6) protection of critical infrastructure systems. The Center is unique for:

1. Its cross-disciplinary range of projects within and beyond engineering,
2. Its status as one of few groups to apply risk management to engineering and technology-based systems, and
3. Its experience since 1987--the Center is in a strategic position to evaluate and manage risk in a broad scope of technology-based systems.

Since 1987, research at the Center for Risk Management of Engineering Systems, University of Virginia, has provided an environment conducive to strong faculty-student learning and collaboration. Graduate students, along with fourth-year and occasionally third-year undergraduates, join in regularly scheduled brainstorming sessions on topical research areas. Over the last twelve years, the Center has supported more than fifty graduate students at the University of Virginia.

The Center brings together industry, government, and consulting organizations with faculty from the School of Engineering and Applied Science, the Darden Graduate School of Business Administration, the College of Arts and Sciences, and the School of Continuing Education for joint activities that include sponsored research; interaction with graduate students and faculty; attending tutorials and workshops; engaging in dialogue with industry competitors in a cooperative environment; visiting of staff and professionals at the University of Virginia; sharing technical reports, articles, publications; accessing software tools; and advancing the state of knowledge and the cutting edge of research for risk modeling, assessment, and management.

In recent years, the Center developed several major efforts with the Virginia Transportation Research Council and Virginia Department of Transportation. "A tool to aid the comparison of highway improvements" has resulted in a methodology and supporting software to improve the balance among avoided crashes, travel-time savings, and the costs in planning new construction. "Recovery of hurricane damage to highway signs, lights, and signals" seeks an appropriate balance between levels of equipment spares and the magnitude of the recovery needed following various categories of storms. "Hurricane preparedness and recovery for a highway agency" has developed a model and associated criteria to aid in prioritizing the recovery of hurricane damage to the road network of Tidewater, Virginia. "Risk-based management of guardrails" has developed a process and associated software for allocation of resources to guardrail needs across a region. "Protection of critical highway transportation infrastructure" has addressed the threat of terrorism. "Warrants for roadway lighting" has addressed the screening of needs for visibility

enhancement. "Maintenance management of highways" has addressed tool and methods for asset management across the agency. In addition, the Center, sponsored by the National Science Foundation (NSF) and General Motors (GM), developed reliability models for various failure modes of automated highway systems. Also with NSF and GM, the Center evaluated crash-avoidance technologies for highway vehicles. For combining 'intelligent' technologies with traditional structural approaches, the Center developed (i) a risk-based framework for the evaluation of flood warning and evacuation systems, and (ii) multiobjective analysis for design of lock walls, for the US Army Corps of Engineers.