COMMERCIAL REMOTE SENSING AND SPATIAL INFORMATION TECHNOLOGIES APPLICATION TO TRANSPORTATION

A PARTNERSHIP

FOR ADVANCING

TRANSPORTATION

PRACTICE

A Collaborative Research Program

Progess Report, January 2002

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

REMOTE SENSING AND SPATIAL INFORMATION TECHNOLOGIES APPLICATION TO TRANSPORTATION

INTEGRATED PROGRAM MANAGEMENT

U.S. Department of Transportation

Research and Special Programs Administration
Office of Innovation, Research and Education
400 7th Street, SW, Room 8417
Washington, DC 20590-0001
Dr. K. Thirumalai, Chief Engineer, 202-366-0375
e-mail: K.Thirumalai@rspa.dot.gov

National Aeronautics and Space Administration

Earth science Applications Directorate
NASA Stennis Space Center
Building 1210, Mail Code MA00
Stennis Space Center, MS 39529-6000
Dr. Michael Thomas, Division Director, 228-688-2401
e-mail: mthomas@ssc.nasa.gov

DOT/NASA PROGRAM OVERSIGHT COMMITTEE

DR. ASHISH SEN, Director, Bureau of Transportation Statistics, Committee Chairman

USDOT

MS. ELLEN ENGELMAN, RSPA Administrator

MR. RICHARD BITER, Deputy Director
DOT Intermodalism Office

MR. TIMOTHY KLEIN, Associate Administrator
RSPA

DR. K. THIRUMALAI, RSPA (Executive Secretary)

MR. THOMAS MARCHESSAULT, Office of the Secretary, Policy

NASA

MR. COURTNEY STADD, NASA Chief of Staff and White House Liaison

DR. GHASSEM ASRAR, Associate Administrator NASA Earth Science Enterprise (ESE)

DR. MICHAEL THOMAS, Director, Earth Science Applications Directorate, NASA Stennis Space Center

DR. CHARLES HUTCHINSON, Acting Director, Applications Division, NASA, ESE

MR. EDWIN SHEFFNER, Program Manager, Applications Division Earth Science Enterprise

USDOT

Bureau of Transportation Statistics
Federal Aviation Administration
Federal Highway Administration
Federal Motor Carrier Safety Administration
Federal Railroad Administration
Federal Transit Administration
Maritime Administration
National Highway Traffic Safety Administration
Research and Special Programs Administration

NASA

Ames Research Center
Dryden Flight Research Center
Glenn Research Center at Lewis Field
Jet Propulsion Laboratory
Johnson Space Center
Kennedy Space Center
Langley Research Center
George C. Marshall Space Flight Center
Goddard Space Flight Center
John C. Stennis Space Center

The DOT-NASA Joint Partnership Program
is delivering results *for* Application to Transportation Practice

The U.S. Department of Transportation (U.S. DOT) initiated the Commercial Remote Sensing and Spatial Information Technology Application to Transportation program in 1999 in collaboration with the National Aeronautics and Space Administration (NASA) in accordance with Section 5113 of the Transportation Equity Act for the 21st Century. The joint program is the first program of its type that focuses on transportation application of commercial remote sensing technologies.

The Research and Special Programs Administration of the U.S. DOT administers the program, as part of multi modal R&D with well defined goals of ensuring transportation safety and security, enhancing mobility, reducing environmental impact and promoting economic growth by increasing transportation efficiency and reducing the service cost. The collaborating NASA program office of the Earth Science Applications Division is part of NASA's Earth Science Enterprise and focuses on turning Earth science results into tools for solving practical problems at national and regional levels. The joint program utilizes the best available scientific and technology resources from both agencies for application to transportation.

A far-reaching R&D strategy was developed and implemented for the program. The program focuses on unique and cost-effective application of remote sensing and spatial information technologies for achieving transportation research goals. The program was implemented in partnership with service providers, industries, transportation agencies and the academia. The program strategy focuses on near-term products application to transportation practice through partnership with transportation service providers, industries and state transportation agencies. The long-term technology development, and transportation professional building are carried out through partnership with four major university consortia consisting of fourteen collaborating institutions. The consortia develop the technology base and provide one-stop technology assistance to users in state and local agencies.

Education and outreach to state agencies and professional building of the transportation workforce are an important part of the program strategy for enabling the application of emerging products and results from the program to transportation practice. The program in cooperation with AASHTO and the Transportation Research Board, provides outreach and training for state and local agency users on using remotely sensed technologies to address priority service problems.

The brochure outlines significant results emerging from the first program years. During the third program year (2002/2003), the joint program will continue its focus to produce results and products for applying remote sensing technologies to transportation practice in the following areas:

- Innovative applications for ensuring infrastructure security and safety, and operational assurance during disasters.
- Streamlining environmental impact assessment and providing cost-effective corridor planning and assessment tools for developing options on transportation system changes.
- Applying commercial remote sensing tools and technologies to supplement ITS for improving regional traffic and intermodal flow and passage at border crossings and beyond.
- Application of new approaches to lower cost of routine transportation infrastructure inventorying, monitoring and management.
- Global outreach to market U.S. remote sensing technology and product services for transportation planning and operations.

ENVIRONMENTAL

Assessment, Integration and Streamlining

NCRST-Environment focuses research on the goal of providing cost effective corridor planning and assessment tools:

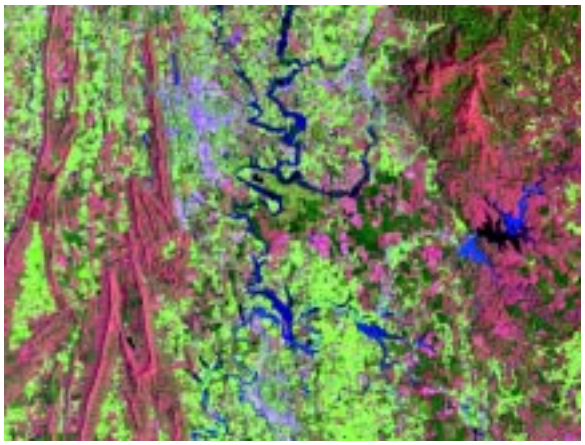
- Developing innovative remote sensing technology solutions for use in transportation environmental assessment and planning; in particular, applying the capabilities of new high resolution, multispectral and hyperspectral instruments;
- Developing the tools necessary to extract environmental information efficiently from remote observations;
- Streamlining and standardizing data processing for information necessary to meet NEPA environmental assessment requirements; and
- Expanding awareness and understanding of the value of remote sensing technology to transportation environmental professionals.

Remote sensing allows for the synoptic observation and analysis of urban growth. Satellite images with moderate resolution (10 to 30 meters) have for decades facilitated scientific research activities at landscape and regional scales. Recent improvements in remote sensing technologies allow satellite- and aerial-based imaging systems to provide spatial resolutions of 1m or better, yielding improved site-specific information. Additionally, hyperspectral sensors provide increased spectral resolution that can be used to further the analyses of environmental conditions.

NCRST-E applies remote sensing imagery to the analysis of transportation impacts on the environment, both human and man-made. The areas include needs assessment for remote sensing information in transportation environmental assessment; land cover classification and change detection; wetlands mapping and assessment; air quality measurement, analysis, and modeling; watershed assessment and characterization; habitat assessment; cultural feature identification; and digital geospatial libraries for environmental assessment and planning in transportation.

Landsat 7 image of the the I-10 Coastal Corridor enhanced by Intermap Global Terrain (GT) elevation data.

Needs Assessment. The consortium's research, technology application and education programs respond to the evaluated environmental assessment geospatial information needs of transportation stakeholders. These information needs were compiled through workshops, surveys of transportation agencies, and literature reviews. The NCRST-E needs assessment process and results and publications can be found at the consortium web site: *http://www.ncrste.msstate.edu/publications*

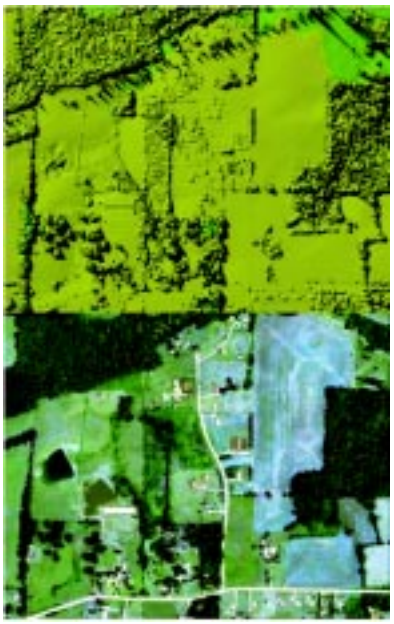


Enhanced Thematic Mapper Plus image from a region northeast of Atlanta, GA showing a mix of managed forests, agricultural and developed land in a region of complex physiography.

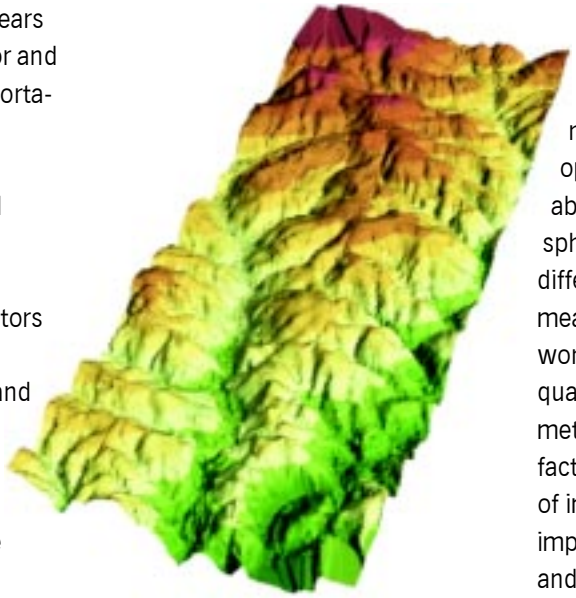
Land Cover Classification and Change Detection. For the Mississippi Gulf Coast I-10 and Coastal Corridor and for an area in the Appalachian Region, the NCRST-E's land cover classification and change detection efforts are producing significant results. Within the Appalachian region, 55 counties of northeastern Alabama, northwestern Georgia, and south-central Tennessee are included in a regional environmental assessment. The Mississippi Gulf Coast I-10 and Coastal Corridor project applies results of land use changes

recorded over the previous 30 years in the Mississippi coastal corridor and investigates its impact on transportation infrastructure for the area.

Wetlands Identification and Mapping. Technology outreach between researchers, "on-the-ground" practitioners, and regulators is critical to the development of acceptable approaches for wetland identification and mapping that employ remote sensing products. NCRST-E is developing guidelines for the use of remote sensing data for wetlands identification and mapping in transportation projects. Initial results from North Carolina and Iowa studies indicate that the best uses will likely involve using high-resolution image and elevation data to create information products for early screening and detection of potential wetlands for alignment alternates assessment and in providing field guides to wetlands biologists who must eventually "walk the line" and map wetlands for selected transportation alignments. Additional studies in Virginia and Alabama are under way to further refine these best practices. The development of cost-effective, acceptable approaches for the use of remotely sensed data in wetlands identification and mapping will provide improved screening and selection of alignments and in the minimization of related wetlands section 404 actions. Additional studies are being conducted to assess the use of similar data for watershed assessment.



Shaded relief surface model from LIDAR data and hyperspectral image data used to classify wetland vegetation in North Carolina.



Terrain surfaces from LIDAR data will be useful for delineating watersheds boundaries and mapping of hydrologic features such as wetlands, and providing improved maps of map flood prone areas.

Air Quality Measurement, Analysis, and Modeling. Efforts to directly determine the impact of transportation on air quality have had varied success, but the use of remote sensing technology is providing important results in this area. DIfferential Absorption LIDAR (DIAL) has been used with success to monitor atmospheric pollutants, such as Nitrogen Oxides, Sulfur Dioxide, Hydrocarbons, Ozone, and Mercury vapors. DIAL uses laser pulses to transmit and receive electromagnetic radiation. Non-invasive remote sensing DIAL systems operate on the principle that the absorption of light by the atmosphere and air pollutants varies at different wavelengths. DIAL air quality measurements and coordinated field work allow the correlation of air quality levels with vehicle traffic, meteorological conditions, and other factors to assist in the development of improved models for assessing the impact of transportation on air quality and the environment.

Habitat Assessment, Cultural Feature Identification, and Digital Geospatial Libraries. New project efforts are underway in habitat assessment, cultural feature identification, and digital geospatial libraries, all of which are being conducted in partnership with transportation agencies.

NCRST - ENVIRONMENT

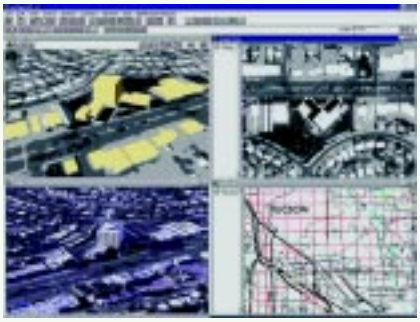
www.ncrste.msstate.edu

Mississippi State University
University of Alabama in Huntsville
University of Mississippi
Auburn University
Universities Space Research Association
NASA Marshall Space Flight Center
Digital Globe
Intermap Technologies Corporation
Earth Data Technologies, LLC
ITRES Corporation

Dr. Roger King
Consortium Manager
rking@erc.msstate.edu

Dr. Charles 'Chuck' O'Hara
Consortium Coordinator
cgohara@erc.msstate.edu

Veridian Systems Division This project focuses on the development of a regional database for southern Mississippi for use in transportation planning. Beginning with a regional database originally developed for the Gulf Regional Planning Commission (GRPC), Veridian will use remotely sensed imagery to update existing vector data layers. Transportation planning can benefit significantly from the use of regional environmental data. Among the most significant benefits are the ability to assess impacts due to changes in alignment configuration. The database will be shared via an Internet Map Server (IMS) for use across the Internet.

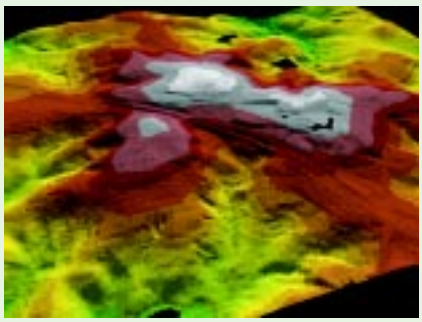


Example of Transportation Planning Tool Screen.

The Washington State DOT and the Oak Ridge National Laboratory, with support from ERDAS, the Wisconsin DOT and the EPA, are demonstrating the use of commercial software and remotely sensed data to produce information products that streamline the environmental analysis process in transportation project planning. The project will demonstrate opportunities to streamline the environmental analysis process for transportation project planning. The highly urbanized corridor of Interstate 405 is one of several transportation improvement programmatic environmental analyses either in-process or planned for the Puget Sound metropolitan area. The regional transportation planning process has identified the I-405 corridor as being a high priority for congestion relief. The environmental analysis process for major projects has become long and costly, often significantly delaying the delivery of transportation improve-

ICF Consulting with the assistance of Veridian studied the viability of using remotely sensed data for conducting environmental analyses in support of transportation corridor analyses. This project, conducted in cooperation with the Virginia Department of Transportation, determined the role of remote sensing for a wide variety of transportation applications. High-spatial-resolution imagery from the Space Imaging Ikonos satellite was used to determine if high-resolution imagery could provide greater versatility and precision for land-cover mapping and feature extraction. After data collection was completed, images were processed to characterize land cover features and to identify environmental features of interest under the National Environmental Policy Act (NEPA). NEPA guidelines require that a comparison among potential alternatives be conducted to determine the potential impact of a proposed project and its alternatives

EarthData International in partnership with the North Carolina DOT, applied photogrammetry and airborne remote sensing to accelerate and streamline the NEPA permitting process. The project demonstrates the use of remote sensing in accelerating the cumbersome decision process, by



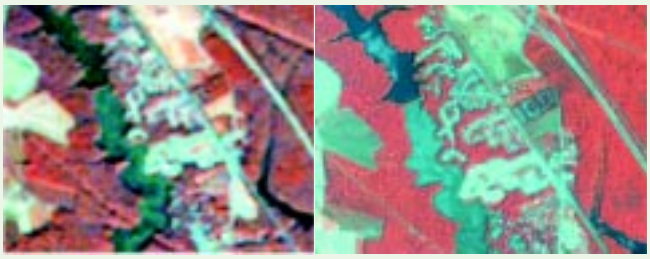
providing detailed and current topographic and land cover data more quickly than previously possible. The technologies employed include airborne GPS and inertial measurement to georeference digital aerial photography, LIDAR for topographic mapping and hyperspectral sensing for identification of wetlands and

Virginia DOT will demonstrate that remotely sensed wetlands data, introduced early in the planning process, along with other available GIS data layers provides a good preliminary indication of potential impact as well as an accurate guide to field reconnaissance and survey. The "as is" planning process follows the "*1987 Corps of Engineers Wetlands Delineation Manual*" with supplemental information from the National Wetlands Inventory data, soil survey data (USDA-NRCS), aerial photography, and field reconnaissance. The investigation includes plans to review VDOT wetland identification processes for projects, review completed processes for Route 17, acquire Erdas Sub-pixel software, identify and acquire imagery, establish reflectance ranges for vegetation types, refine wetland classification routines, and output wetland poly-

Another portion of the study involves analysis and comparison of various digital elevation data sources. Existing USGS products along with products derived from remote sensing analyses will be compared to ground truth data to meet the needs of transportation planners. In addition, a transportation planning tool will be developed to assist engineers and environmental scientists with evaluation of environmental impacts. This GIS-based tool will allow the user to specify an alignment and right-of-way requirements. Using this information, the tool will query the database for specific environmental features, calculate the impacts for each feature and develop an impact matrix. Finally the tool will allow the user to develop "strip maps" along the corridor at a specified scale. These maps can be printed and taken to the field for use.
Contact: John Albasini
john.albasini@veridian.com

ments. This study will evaluate the benefit of using remote sensing technologies to develop environmental data supporting the programmatic analysis of corridor programs. Key products will include: data supporting the National Environmental Policy Act process; techniques, procedures and methods to integrate multiple data resources to derive land use / land cover information; and a cost benefit analysis comparing the remote sensing and traditional approaches.
Contact: Elizabeth Lanzer
lanzere@wsdot.wa.gov

One meter color photography for I-405 and SR-167. Wetlands along lower left edge of image are key environmental factors.



Landsat 7 (left) and Ikonos (right) multispectral images of the study area. Urban features (cyan) appear blurry and difficult to interpret in 30 m Landsat. They are more precise and easy to interpret in Ikonos (4 m) image.

upon the local environment. The results achieved 88% accuracy using the remotely sensed data to identify environmental features when compared to ground measurement in the transportation corridor. This suggests that there is significant promise for using high-spatial-resolution remotely sensed imagery for detection and mapping of environmental features for transportation planning projects.
Contact: Gary Erenrich
gerenrich@icfconsulting.com

other vegetative land cover classes crucial to permitting. The results were verified by NCDOT using existing data gathered by conventional means. NCDOT engineers and wetlands biologists evaluated the impact of these new data types on existing workflows to demonstrate time savings or improved quality of results, which both lead to streamlining of the environmental permitting process required by NEPA. The final product will be a blueprint for integrating these technologies into mainstream practice. Implementation guidelines will be accompanied by sample data containing the data products created. Agencies can use these to customize specific mapping and engineering workflows. Decision makers can use the findings as a basis for dialogue with NEPA agencies such that practices that enhance and streamline the permitting process can be implemented in policy.
Contact: Karen Schuckman
kschuckman@earthdata.com

gons to compare with existing GIS data such as soil type and NWI data. The areas classified as wetlands will be compared to existing field reconnaissance data. The derived wetland polygon data will be made available in the VDOT GIS and integrated with other enterprise GIS data.

Distribution of data will be enabled by use of Oracle, ESRI/SDE, and ArcIMS software.
Contact: Dan Widner
widner_dk@vdot.state.va.us

Image data for the Virginia Route 17 wetlands identification project.

Transportation
INFRASTRUCTURE
Management

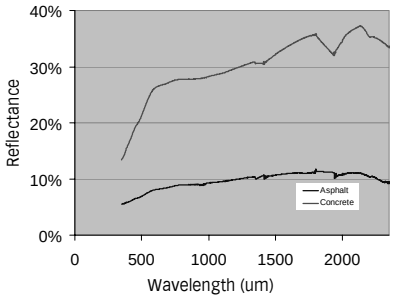
NCRST-Infrastructure focuses on common goals of physical infrastructure management for transportation systems, including surveillance, asset management, condition assessment and infrastructure planning. Infrastructure management includes planning, design, construction, maintenance, operation, monitoring and renewal of pavement, bridges, pipelines, rail, harbors and airports.

Remote sensing and geospatial information technologies play a significant role in streamlining the infrastructure management process, making it more efficient and accountable. The outputs from remote sensing and image processing must be combined with other sources of data, facilitated by appropriate models and data delivery mechanisms, to produce useful information products that translate into informed decision making. Cost, quality, benefit and timeliness of solutions are important.

The research program addresses the location of assets, planning models, surveillance, condition monitoring and change detection.

Centerline extraction. Centerline maps are the basis of location referencing for asset management. They are critical data for accident and incident reporting, Intelligent Transportation Systems (ITS), real-time routing for the logistics industry, and everyday address finding services such as *MapQuest*®. With GPS now a popular accessory in numerous systems, a need is emerging for a new generation of centerline databases that are more detailed, accurate, up-to-date and universal in coverage than current products. In August 2001 the consortium hosted a gathering of international experts on centerlines. The forum concluded that centerlines fulfill such a variety of roles, with accuracy demands from centimeters to tens of meters, that imagery is best viewed in concert with other technologies. The area in which it holds the greatest edge is the development of global transportation databases and disaster relief.

Centerline geometry extracted from aerial photograph.



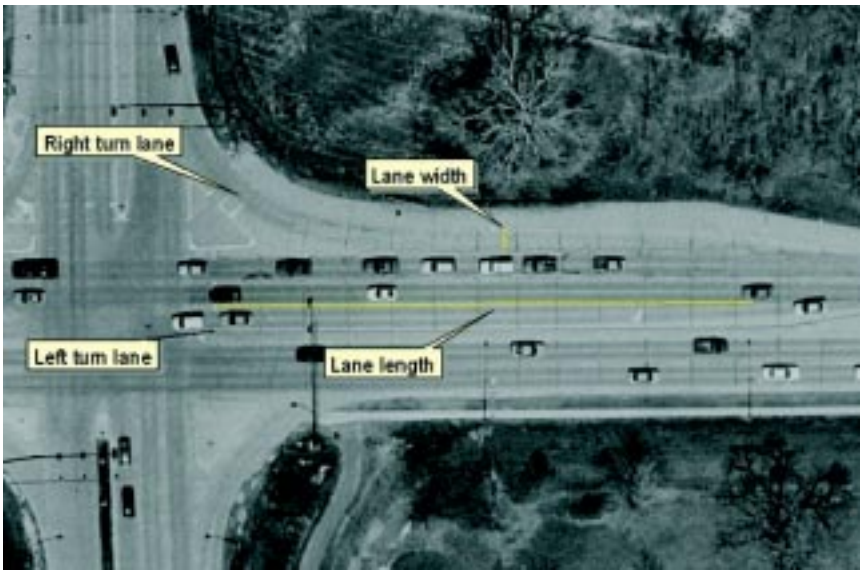
Concrete and asphalt are easily distinguished in hyperspectral imagery

The approach to centerline detection is based on both manual digitizing (see graphic) and semi-automated extraction from hyperspectral imagery. In the course of the hyperspectral work, different pavement surfaces were characterized, and it became evident that the technology holds promise as a rudimentary classifier of road material (e.g. concrete vs asphalt — see graph), age and perhaps condition.

Bridge location. The National Bridge Inventory requires states to maintain accurate records on bridge location. Current databases are in some cases rudimentary, stating location in cryptic terms. When these descriptions are translated into map locations, they can be in error by hundreds of meters. An *ArcView*® extension was developed to assist DOTs with the task of improving bridge location records. *BridgeView* uses imagery at various scales from state to local. At the largest scale, orthophotos are overlaid with road

centerlines and bridge locations from existing records, errors are detected and adjustments made. The utility of *BridgeView* can extend to DOT assets across all transportation modes, such as trans-shipment facilities, bus stops and pedestrian crossings.

Asset mapping and safety. This project examines a number of road features for asset mapping — centerlines, medians and curbs, turning lane length, lane width — and compares the cost and effectiveness of different scales of imagery. Safe design of urban arterials requires that road features and characteristics such as medians and lane width be surveyed accurately, to about 1–5 meters. The cost of field survey is a deterrent; remote sensing has the potential to reduce survey cost and to increase the frequency of update. The accuracy with which assets can be identified and mapped from different scales of imagery is being investigated. Low level photography with 5 cm pixels clearly affords the best discrimination and accuracy, but is most costly. Coarser 1 m imagery is adequate for some applications.



Roadway characteristics measured off aerial imagery.

Airport surveys. Federal law requires airports to have comprehensive layout plans and 3-D approach plans. Layout plans include 3-D models of airport buildings and structures, that enable analysis of runway visibility from the control tower. LIDAR is a promising technology. Fusing digital camera photography with LIDAR data, 3D Airport Layout Plans (3DALP) for the airport at Plant City FL were constructed. The same data are also used to analyze the airspace and to identify potential obstructions to flight paths.

Outreach program. The consortium is developing a growing set of resources on the web in support of GIS-T and remote sensing. There is an extensive bibliography with about 700 entries. A curriculum in GIS-T and Remote Sensing is being prepared in conjunction with the National Center for Geographic Information and Analysis (NCGIA) core curriculum in GIScience and the Remote Sensing Core Curriculum. Regional meetings are being organized with state DOTs and local government agencies, promoting remote sensing technology, offering technical advice and facilitating local initiatives.


Orthophoto of Plant City FL, derived from LIDAR and digital photography.

NCRST - INFRASTRUCTURE

www.ncgia.ucsb.edu/ncrst

University of California, Santa Barbara
University of Wisconsin-Madison
Iowa State University
University of Florida
Digital Geographic Research Corporation
Geographic Paradigm Computing Inc

Dr. Michael Goodchild
Principal Investigator
good@geog.ucsb.edu

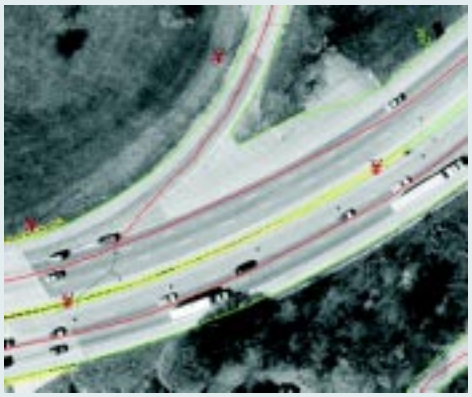
Dr. Val Noronha
Project Director
noronha@dgrc.ca

Tetra Tech Inc The project focus is to develop remote sensing tools for analysis of federal intermodal connectors to the federal highway system. The test locale is the Alameda Corridor area of southern Los Angeles County, a $2.8 billion freight rail system connecting the Ports of Los Angeles and Long Beach with the intercontinental rail system. The project is analyzing two intermodal connectors. The primary technical work is being conducted at Pasadena's Jet Propulsion Laboratory (JPL). The team is assessing the application of multiple remote sensing imagery types, including IKONOS, Landsat and AVIRIS data. The data are being cross-referenced with digital ortho-photography and integrated with a GIS platform. National transportation and census databases will be integrated into the data to create analytical tools. The project results are being evaluated by a team of industry experts led by the NAFTA Corridor Institute and American Transportation Management, who will apply the tools to industry-specific needs. These include (1) corridor planning along the intermodal connectors for expansion and optimization of goods

Orbital Imaging Corporation (ORBIMAGE) and its partners, Parsons Brinckerhoff and Bentley Systems, are investigating and demonstrating the application of remotely sensed data to planning projects involving five transportation types: roads, railroads, airports, water ports and transmission systems. The application of road data will be interactive with Bentley's MicroStation software. The demonstration incorporates various forms of imagery and GIS data, emphasizing nearly automated techniques for the delivery of remotely sensed digital imagery to desktops. Northern Virginia is the geographic focus for this project in cooperation with Virginia DOT. The Project Team

Northern Virginia Route-1 project plan with digital one-foot resolution orthophoto and parcel information. Instant Imagery Access button is shown.

Florida DOT Transportation Statistics Office and its project partners, the Oak Ridge National Laboratory (ORNL), Southern Resources Mapping of Miami (SRMM), and Transmap of Ohio are teaming up on a project entitled "Highway Feature and Characteristics Database Development Using Commercial Remote Sensing Technologies, Combined with Mobile Mapping, GIS and GPS." The objective is to determine the feasibility of using commercial remote sensing technologies, combined with GIS, mobile mapping and GPS, to develop accurate and comprehensive databases of roadway features and characteristics. The project will first use remotely sensed data — specifically, airborne and satellite high-



Road feature map generated for the RCI.

University of Massachusetts. The Central Artery/Tunnel Project is about mobility, the environment, and economic growth for Boston and all of New England. This project provides one method for measuring improvements in mobility and quality of life. With a project as large as CA/T, particularly with infrastructure that has impacted a region over several decades, changes may be dramatic or subtle, and difficult to quantify. New methods are now available for measuring and evaluating changes occurring around infrastructure projects. Three activities will measure change to highway infrastructure, transit infrastructure, land use and/or coverage. The ultimate goal is to provide MassPike with tools to assess change. *Product 1* will use historic and current imagery to detect and to analyze changes in the highway infrastructure, preceding the Central Artery in the 1950s to the current stage of construction of I-90 and I-93. Public transportation activities are a key feature of the overall transportation infrastructure. Several transit facilities are either a

movement, (2) assessment of truck operations in areas surrounding the intermodal connectors, and (3) identification of container depots in the neighborhood of intermodal connectors. The project results will advance remote sensing application to intermodal transportation systems planning.

Contact: William Lyte
bill.lyte@ttisg.com

Carson intermodal connection yards. Simulated 1 meter resolution produced through convolution of 4m Ikonos RGB and 1m panchromatic.

is developing software applications and interacting with transportation planning users through technical exchange meetings and demonstrations. The team has focused application efforts on the Virginia DOT's Route 1 Location Study. Using Arc View parcel data shape files combined with black and white and 24-bit color digital orthorectified images, the team is demonstrating the ability to obtain remote-sensed data from geographically diverse server locations, integrated with infrastructure and demographic data, and displaying it at the desktop. Vector data are automatically matched to underlying imagery; relevant imagery is auto-selected from the remote server based upon the coordinate box. Implementation will initially serve MicroStation software environments. This architecture benefits users by eliminating on-site storage of massive image libraries, removing image maintenance responsibilities from regional DOT personnel, and matching the location and resolution of accessible images to the vector map display view.

Contact: M. Gregory Hammann
Hammann.Gregory@orbimage.com

resolution images — to extract highway networks (centerlines, edges and medians), measure highway width and length, count traffic lanes, identify pavement types and road conditions, and obtain 3-D representation of highway systems. The project will also fuse remotely sensed data with commercial mobile mapping capabilities to map detailed roadway features and characteristics such as traffic signs, traffic control devices, shoulder types, pavement conditions, road names and other roadway features. Existing GIS databases will be referenced for data comparison and feature attributes. Field GPS surveys will be performed to acquire ground truth data for validation. The project will select a section of I-10 between Jacksonville and Tallahassee and some local road segments, for an operational test. The project aims to generate an accurate and comprehensive Roadway Characteristics Inventory (RCI) for selected road sections that meets DOT requirements, and an assessment of technologies with respect to cost, accuracy, fitness and ease of implementation.

Contact: Anita Vandervalk
anita.vandervalk@dot.state.fl.us

part of, or are directly impacted by the CA/T. *Product 2* will analyze changes in the transit infrastructure from the mid-60s to the current stage of construction. *Product 3* will use historic land use maps and current GIS land use databases to analyze transportation-related land uses over time. To provide a meaningful level (Level IV, L4-USGS) of evaluation for land use, an overlay of a spatial land use classification layer (see graphic) will be used.

Contact: Kathleen Hancock
hancock@ecs.umass.edu

Land use around Boston's Big Dig.

TRAFFIC

Surveillance, Monitoring and Management

NCRST-Flows focuses research on applying remote sensing technology to improve the efficiency of regional traffic flow, intermodal freight and passage at border crossings and beyond. Improving the efficiency of transportation systems for the 21st Century will rely heavily on our ability to monitor and manage traffic flow and movement of freight in surface transportation. For increasing the capacity of surface transportation within limited physical space for movement of vehicles, transportation engineers seek more precision in managing flow for transportation decision-making and that requires

Figure 1

increased monitoring and the continued development of advanced management tools. The research focuses on flow monitoring and flow management. A strong component of methodological research is tool development for application . Examples of the research work completed by NCRST-F in each of the areas are outlined below. The full texts of the annual research reports of completed research are available at *www.ncrst.org/ncrst-f.*

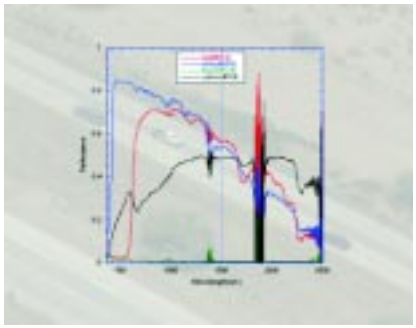


Figure 2

Traffic Flow Monitoring. The use of remote sensing can enhance the efficiency of many of the present practices used to determine the level of service, vehicle miles traveled (VMT), average annual daily traffic (AADT), and vehicle classifications and counts. Figure 1 is an example of the high-resolution imagery available today that enables the automatic classification and counting of vehicles from satellite imagery. Figure 2

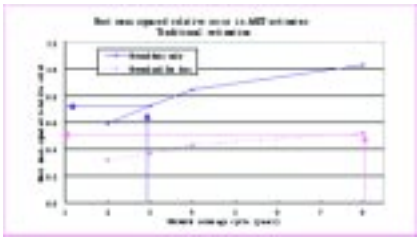


Figure 3

illustrates the use of spectral signatures to identify vehicles by color, make and model that is possible using hyper spectral imagery, and Figure 3 graphs the improvement in results of AADT and VMT estimates when imagery is combined with traditional ground count data. Each of these results improves the efficiency of current transportation engineering practice.

Traffic Flow Management. Remote sensing platforms can be used to assess highway speeds, improve real time and static origin/ destination estimates, and measure queue lengths at congestion points for real time traffic control and off-line traffic planning. Figure 4 is one example of the use of imagery to assess highway speeds. Several

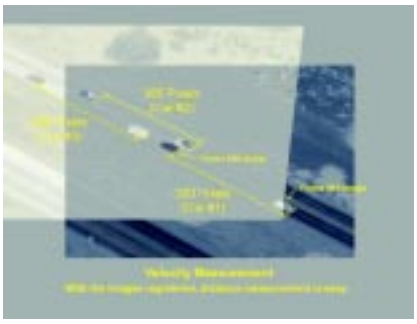


Figure 4

additional methods are under investigation to identify vehicles and compute speeds that are possible as offshoots of other investigations using remotely sensed imagery. The figures in Figure 5 enable researchers to detect and estimate queue formation, platoon progression, and turning fractions and thus serve as aids in managing intersection controls, ramp metering, incident detection, and traveler guidance systems. Improved estimation of origin/ destination data is also obtained.

Figure 5

Intermodal Flow Activities. The determination of passenger and freight flows at intermodal centers (park and ride, ports, TOFC/COFC, air/rail/bus/ferry terminals), and the identification of congestion points and patterns are facilitated by remotely sensed imagery. A time series of remotely sensed imagery provides a macro view of land use and transportation network change in the vicinity of intermodal facilities, enables the quantification of the impacts of freight movements at ports and intermodal facilities, provides critical planning information, and supports the tracking of freight movement on a regional transportation network. The fusion of multi-sensor databases can further improve the spatial accuracy and the visualization of intermodal traffic flows and support hypothesis generation about activities around intermodal centers. Figure 6 portrays imagery of an intermodal facility serving as a case study site for consortium researchers.

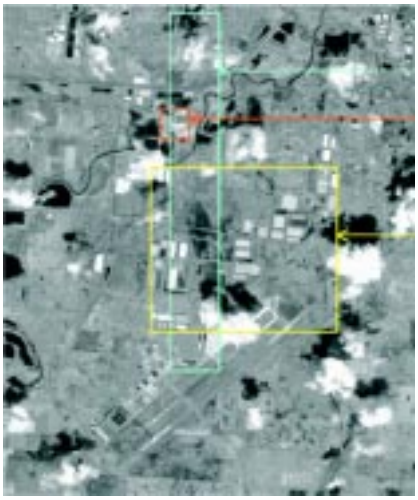


Figure 6

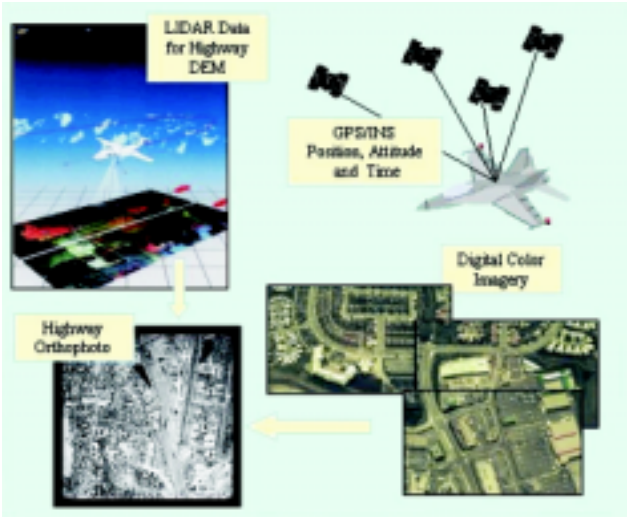


Figure 7

Methodological Improvements. A framework for fusing sensor and ground-based data improves the automatic interpretation and geo-referencing of transportation features making the creation of transportation databases more useful and accessible. Figure 7 illustrates one such framework that is returning data of significance to transportation planners and engineers.

Outreach. NCRST-F scientists are regular participants at numerous flow-based conferences, and present research findings at venues across the United States. An international symposium on the use of remote sensing in transportation is being planned with colleagues in Central Europe to take place in Budapest in 2002.

NCRST - FLOWS

www.ncrst.org/ncrst-f

The Ohio State University
George Mason University
University of Arizona

Dr. Joel L. Morrison
Consortium Director
morrison66@osu.edu

Dr. Mark McCord
Consortium Research Coordinator
mccord2@osu.edu

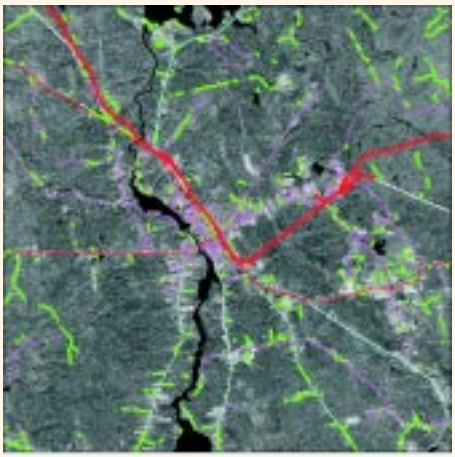
Bridgewater State's Moakley Center for Technological Applications developed an uninhabited aerial vehicle (UAV) as a platform for 35 mm aerial photography, with real-time digital video down link for assistance in flying the aircraft and acquiring imagery. The UAV is hand-launched, has an auto-pilot and emergency parachute recovery. The UAV imagery was applied to evaluate the effectiveness of commuter rail park and ride lots as well as the safety and efficiency of inter-modal strategies, including pedestrian-rail crossings

and traffic monitoring around intermodal facilities. The project also used GPS based vehicle location systems and transit data, integrated with high-resolution digital orthophotos, to evaluate transit shuttle operations. The UAV application used low-cost components to create a platform that was affordable and could meet the demands of high spatial resolution (1 inch recognizable objects) and high temporal resolution (10 minutes). Imagery analysis applications for the security of transit capital infrastructure and transit operations are now being documented.

Contact: Lawrence J. Harman
lharman@bridgew.edu

Technology Service Corporation (TSC) demonstrated the application of imagery to highway traffic management. One project was automatic road identification for Ellsworth ME. Techniques were developed that exploit Ikonos imagery for automatic identification of road networks, in cooperation with Maine DOT. The second project developed and demonstrated a road corridor planning tool for the extension of Interstate 395 near Bangor ME. Software was developed that employs imagery and spatial data to select optimal corridors. The software utilizes a variety of land cover, terrain elevation or road network data. It features user-selectable models for land acquisition, road upgrade, road intersection and earthwork costs as well as road and bridge construction cost. The automatic road identification and corridor selection tools are now available to assist other state and federal DOTs exploit remote sensing data for their ongoing projects.

Contact: Steve Jaroszewski
sjaroszewski@tsc.com



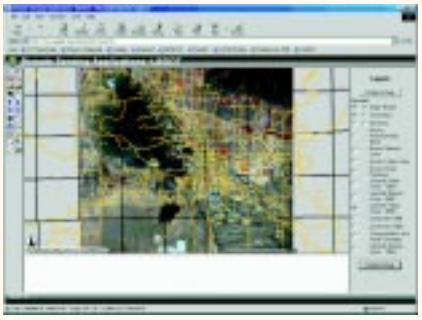
The Automatic Road Identification software extracts roads from Ikonos imagery and performs raster-to-vector conversion. The green lines in this figure indicate areas where new construction has occurred since the last update.

Grafton Technologies, in conjunction with Brown University and GIS/T Man Inc, will design, develop and deploy a web-based tool kit to support the planning needs of airports and their stakeholders. It will identify the types, specifications and sources of data they will likely require. Airport expansion projects are often in growing metropolitan areas. Spatial data technologies, specifically remote sensing, offer a unique source of information that can help planners communicate, understand and analyze complex and often

interrelated issues. The project offers a standard database design and interface, providing users with the ability to communicate, analyze and resolve issues. The Portland International Jetport in Maine will be the focus of initial development efforts. The tool kit developed in this project will be applied at Anchorage International Airport to evaluate how well the completed product can be deployed at other airports.

Contact: Randall Murphy
rmurphy@graftontech.com

Veridian and its project partners (Michigan DOT, Pima County (AZ) DOT, Pima Association of Governments, ERDAS, Space Imaging, ESRI, and ICARD) developed enhanced capabilities to map and extract transportation-related features from satellite imagery including Landsat 7 ETM and Space Imaging's IKONOS systems. Change Vector Analysis (CVA) and Automated Feature Extraction algorithms were implemented in Veridian's Classification and Feature Extraction for Transportation (CAFÉ-T), a module for ERDAS Imagine.

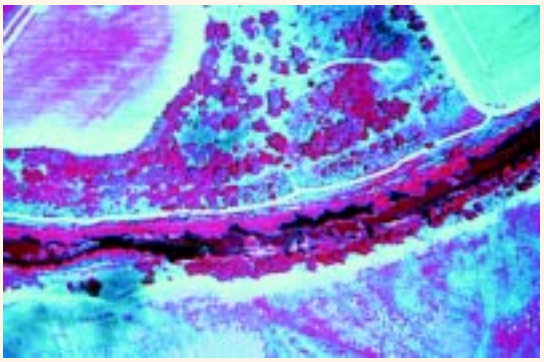


Interactive Mapping Site, hosted by Pima Association of Government's Regional Data Center, showcases project results.

Veridian has provided CAFÉ-T software at no cost to participating universities and state and regional DOTs. In addition the project develops materials to facilitate the use of these tools, and methods to develop and maintain regional transportation databases. These materials, including background on remote sensing and satellite imagery, image processing tools, and project planning and implementation guidelines, were presented in a series of workshops across the country.

Contact: Chris Chiesa
chiesa@erim-int.com

TerraMetrics Inc in coooperation with the Kansas Applied Remote Sensing (KARS) Program, is developing a tool for mapping and monitoring aquatic plant obstructions to transportation in navigable waterways. Aquatic plant infestations impede commercial and recreational traffic through navigable waterways and exert dangerous damaging pressure upon infrastructure. The project will evaluate the ability of satellite and airborne remotely sensed imagery to map and monitor invasive emergent aquatic plant infestations in waterways. The pilot project will focus on



water hyacinth (Eichornia crassipes) cover in the lower Rio Grande River near Brownsville TX, where project partner AquaSolutions LC is currently engaged in aquatic plant control. The project will determine the relationship between aquatic plant cover and spectral reflectance; evaluate the ability of high and moderate resolution satellite multispectral imagery to map and estimate aquatic plant cover; evaluate the ability of imagery to assess the effectiveness of aquatic plant control efforts in waterways; and evaluate the cost-effectiveness of the imagery used in the project.

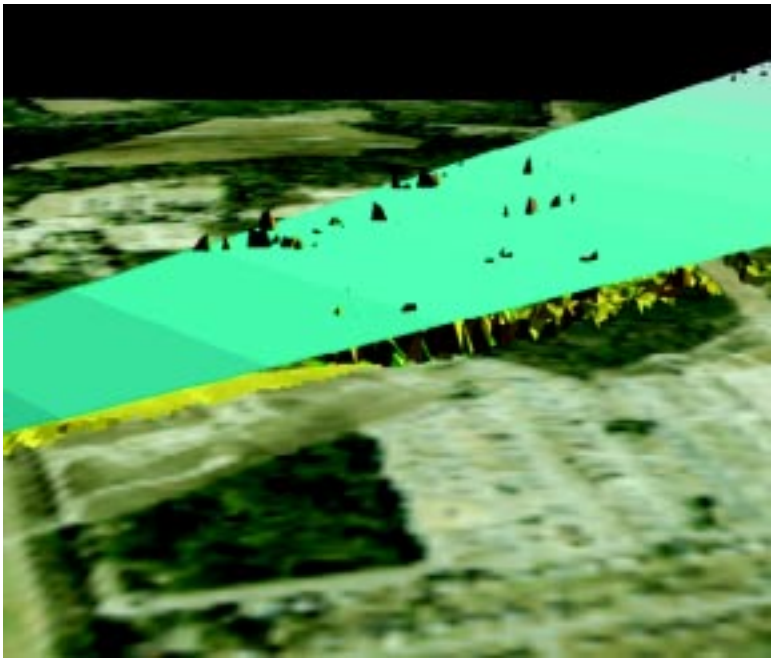
Contact: Mark Jakubauskas
mjakub@ukans.edu

Geodata Systems, Inc and its partners DBR & Associates will use an unmanned airborne data acquisition system (ADAS) for traffic surveillance, monitoring, and management. This lightweight system can fly for more than 2 hours with a sensor payload up to 20 lbs. The ADAS has multiple interchangeable sensor packages to support diverse applications. These include a flexible high-resolution video system, hyperspectral, multispectral, thermal infrared, and synthetic aperture radar sensors. The system provides the user with high-resolution imagery data that is georeferenced and overlaid with information relevant to a specific application. The project will compare this innovative data collection technique with conventional methods in terms of cost, accuracy and timeliness; and determine areas in which the ADAS can be applied effectively and efficiently. The imagery will enable collection of peak hour volumes per direction, vehicle classification counts, turning volume counts at intersections and interchanges, and vehicle speeds.

Contact: Ernest A. Carroll
ecarroll@geodatasystems.com

Safety HAZARDS and Disaster Assessment

NCRST-SHDA focuses on transportation safety assurance, and on preserving mobility and access options for accident and disaster management. The consortium's research focuses on developing analytical tools to identify, map and assess hazards, and to plan for disasters as they affect transportation lifelines. The consortium also strives to serve as the US DOT national point of contact for the application of remote sensing technology to safety, hazards, and disaster assessment. Transportation lifelines form the essential infrastructure that sustains all modern societies. Whether they are the highways, railroads, and rivers that transport the people and products of a nation, or the pipelines that distribute the energy that sustains it, these lifelines are subject to unplanned hazards and disasters that threaten human lives and property. The human and economic cost of natural and man-made disasters is a direct reflection of the extent to which these lifelines are disrupted. The development of remote sensing and other geospatial technologies to identify, assess, and assist in the mitigation of hazards and disasters as they affect these lifelines is the focus of NCRST-SHDA.



Airport Glidepath obstructions – Airborne LIDAR and traditional aerial stereophotogrammetry are used to identify obstructions in airport glidepaths.

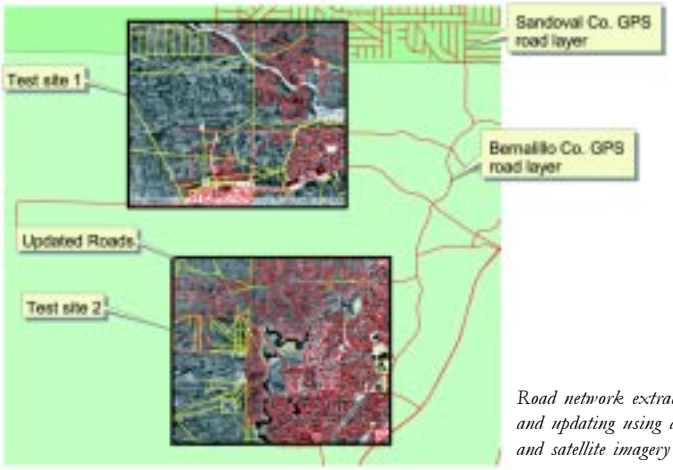
Merged satellite imagery and elevation data showing areas of subsidence near Las Vegas, Nevada. The colored fringe in the center left of the image shows subsidence resulting from draw down of subsurface water. Impacts from subsidence to roads and pipelines create hazardous conditions that require monitoring and mitigation. Satellite Interferometric Radar provides an effective means of precisely monitoring subsidence over large areas. Developed by NPA Group, Kent, UK and published in Professional Surveyor, October 1999.

The focus of the NCRST-SHDA efforts is the integration of remotely sensed data with issues concerning disaster assessment, safety, and hazards for transportation lifelines. The inclusion of remotely sensed data into the transportation and disaster information systems provides an objective and reliable source of pre- and post disaster information. Techniques allowing transportation specialists to assess and apply information derived from remotely sensed data are being developed by the consortium.

Examples of the results of NCRST-SHDA research are provided in a

Collapse of Interstate 880 from the 1989 Loma Prieta Earthquake that killed 67 people and caused an estimated 7 billion dollars in property damage, much of that to the transportation system. (NOAA)

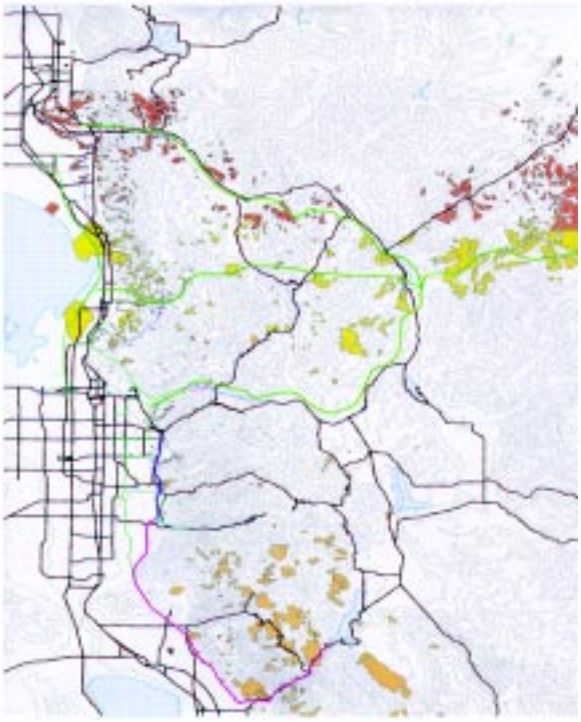
series of Cookbooks describing the applications and as software designed to facilitate integration of remote sensing and transportation. Professional and White Papers, Technical Notes, and Technology Application Briefs describing the research and its results make the technology and research accessible to all levels of the transportation community. Examples of research results include: Risk assessment incorporating satellite imagery and interferometric radar data allows the assessment of avalanche hazard vulnerability.



Road network extraction and updating using aerial and satellite imagery

Research on the automated extraction of road networks from digital imagery shows the cost effectiveness of aerial and satellite imagery for road network mapping and updating. Satellite and aerial imagery are integrated with near real-time weather data to assess hazardous road conditions. The incorporation of remotely sensed imagery in the Oak Ridge Evacuation Modeling System (OREMS) allows rapid updating of transportation infrastructures and improves the responsiveness of the model to changing road conditions.

Education and outreach activities are critical components to successfully integrating remote sensing technology with the needs of the transportation community. The NCRST Safety, Hazards, and Disaster Assessment Consortium outreach activities include efforts addressing these needs for local, regional, national, and international communities. Presentations and current activities include: organizing an international Remote Sensing in Transportation Conference to be held in China; presenting project results and applications at local, state, regional, and national professional meetings; and developing and maintaining a web page portal for information relating remote sensing technology to transportation safety hazards and disaster assessments.



Satellite imagery is used to identify avalanche areas and to assess potential risk to transportation lifelines.

NCRST - HAZARDS

www.trans-dash.org

University of New Mexico
University of Utah
Oak Ridge National Laboratory
George Washington University

Dr. Stanley Morain
Consortium Manager
smorain@edac.unm.edu

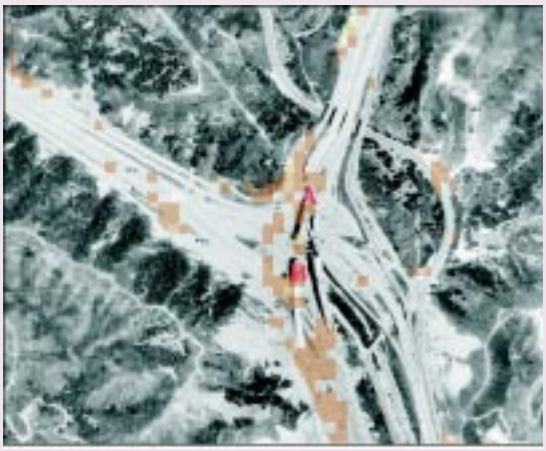
Dr. Richard P. Watson
Consortium Coordinator
rwatson@edac.unm.edu

AERIS Inc. The project focuses on the trial testing and implementation of airborne ground-penetrating radar to support monitoring of pipeline safety and performance. With support from the EPA and Oklahoma Corporation Commission, the project developed a simulated pipeline failure test site to support demonstration of radar system performance. The site, located near the Lake Oologah Oil Spill Site (30 miles north of Tulsa, Oklahoma), was developed by placing pipe on both dry and oil-saturated soils and burying the pipes with several depths of sandy soil. An advanced pulse-Doppler radar system was installed in a UH-1H helicopter. The system was configured for side-looking synthetic aperture radar (SAR) dual-polarization data collection at 150-450 MHz (with up to 512 frequency steps) with simultaneous X-band data collection at 9.8-10.0 GHz. The system was operated at 1,000 ft altitude and flown in a series of flight lines to investigate the impacts of viewing geometry and distance on detection and overall system performance. Flight opera-

Flight operations underway at Lake Oologah oil spill site.

DigitalGlobe (formerly EarthWatch Incorporated) and partners Pacific Gas and Electric Company Technical and Environmental Services (PG&E), Lawrence Livermore National Laboratory (LLNL) and Chevron Information Technology Company (CITC) are collaborating on a project using high spatial resolution imagery and RADAR interferometry from satellite and airborne platforms to quantify and characterize surface land movement on a section of natural gas pipeline in California. PG&E and Chevron both are responsible for monitoring many hundreds of miles of pipeline in the U.S. Subtle land deformations which exist, but are not always visible during routine windshield or aerial surveys of a pipeline corridor, may potentially lead to pipeline stress and failure. To address this, PG&E has made modifications to one of its operational software packages, the goal being to develop a more specialized analysis of high-spatial resolution imagery. The project will provide more detailed information about surface land movement using sophisticated textural and edge analysis and change detection algorithms. LLNL is producing RADAR interferograms for the study site using pairs of images from different dates to pinpoint the location and magnitude of land surface changes. The project also involves interpretation and classification of high-resolution digital imagery using conventional methods and COTS image processing software. These information sources will be combined to produce a risk model. The project will focus on pipeline corridors in areas where small landslides and surface deformation are common. Mapping and monitoring using this new technology will

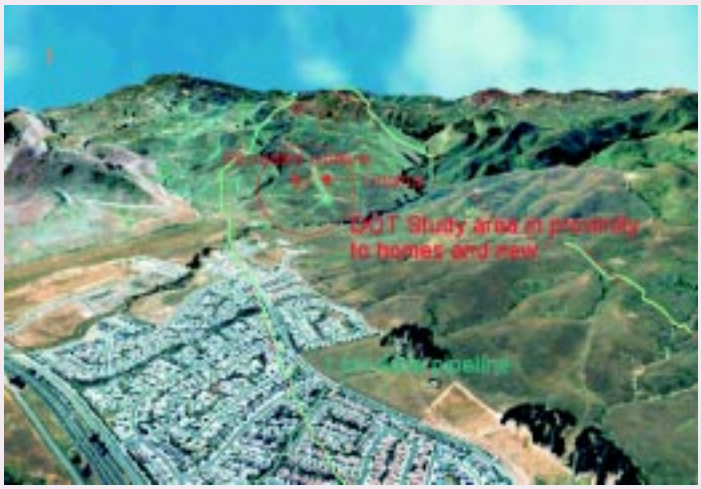
ImageCat Inc. in Long Beach, California and its project partners, the University of California at Irvine, the University of Nevada at Reno and the California Department of Transportation (CALTRANS) are demonstrating the capabilities of remote sensing technologies, in particular synthetic aperture radar (SAR) and high resolution optical images, in quantifying the scope and magnitude of damage to transportation elements after major natural disasters. For purposes of demonstration and validation, the project team is using earthquake as the demonstration hazard. By the end of this study, the project will provide a validated methodology for detecting changes (damage) to transportation systems after major disasters. Ultimately, this methodology would be used by transportation agencies and emergency response organizations to detect post-event damage to bridges and highways in near real-time, thus improving



Change Detection Map overlaid onto USGS Aerial Photo – I-5/14 Interchange. 1994 Northridge Earthquake.

tions and data collection were conducted on September 8-11, 2001. Data reduction, processing, image production and results analysis tasks are underway. AERIS also performed a study to investigate the capabilities and benefits of hyperspectral imaging (HSI) to support the monitoring of pipeline safety and performance. The efforts focused on using HSI to enhance current capabilities for surface and subsurface leak detection, particularly for pipelines that cannot accommodate internal inspection devices. It was found that HSI can play valuable roles in locating leaks, both for emergencies and periodic pipeline inspection. HSI can also provide valuable information for environmental management, pipeline routing optimization, and support to acquisition and due diligence activities. HSI may have the potential to detect natural gas leaks as well. In addition to exposed spills, the study found promising techniques for using HSI to detect subsurface spills. The study demonstrated the advantages of automated processing of HSI data. In the past, the large, complex data sets produced by HSI have been difficult, time-consuming and costly to process. Recent developments in advanced, automated processing tools have made the application of HSI technology much more viable. These tools allow rapid processing of data sets covering large areas, a key requirement for applications of interest to transportation and other industries.

Contact: Robert W. Davis
AERISRWD@aol.com



provide the means for proactive responses to prevent pipeline failure caused by land surface movement. The progress of the project was delayed several months due to the difficulty of acquiring suitable imagery data. With the successful launch of DigitalGlobe's QuickBird satellite the project will soon have a consistent source of high-resolution satellite image data.

Contact: Lynn Francis
lfrancis@digitalglobe.com

response and recovery. The graphic shows a change detection map created from an examination of pre- and post-earthquake images. This change detection map has been overlaid onto a USGS aerial photo taken in June of 1994, roughly five (5) months after the earthquake. Reconstruction on several of the overpasses is evident in the graphic. Damage to this interchange was significant, the most spectacular being the collapse of several spans. These failures occurred as a result of the spans becoming unseated from the connecting piers. Two spans collapsed (approximately 300 feet) from the North Connector Overcrossing and an additional three spans collapsed (over 500 feet) onto the I-5 freeway. The brown areas in the illustration correspond to areas showing the greatest change between the two images (SPOT band3, 1993 and SPOT band3, 1994) after normalizing for changes in brightness between the two images. These brown areas directly correspond to the locations of the collapsed spans. The project will explore how these damage detection methodologies based on remote sensing technologies can be used to improve our ability to quantify impacts in large earthquakes. The focus will be on major transportation elements, such as bridges and major roadways, demonstrating the efficacy of the methodology. The project will explore in detail how the methodology can be applied to other natural hazards including flooding, hurricane wind and tornado hazards.

Contact: Ronald T. Eguchi
rte@imagecatinc.com

COMMERCIAL REMOTE SENSING AND SPATIAL INFORMATION TECHNOLOGIES APPLICATION TO TRANSPORTATION

MANAGEMENT TEAM

Department of Transportation

Dr. K. Thirumalai
U.S. Department of Transportation
Research and Special Programs Administration
Office of Innovation, Research & Education, DIR-1
400 7th Street SW, Rm. 8417
Washington, DC 20590
Tel: (202) 366-0375; Fax: (202) 366-0375
E-mail: k.thirumalai@rspa.dot.gov

Mr. Warren Osterberg
U.S. Department of Transportation
Research and Special Programs Administration
400 7th Street SW, Rm. 7108, DMA-30
Washington, DC 20590
Tel: (202) 366-6942; Fax: (202) 366-7974
E-mail: warren.osterberg@rspa.dot.gov

Mr. Ron Boenau
U.S. Department of Transportation
Federal Transit Administration, Rm. 9402C
400 7th St., SW
Washington, DC 20590
Tel: (202) 366-4995; Fax: (202) 366-3765
E-mail: ronald.boenau@fta.dot.gov

Mr. Tom Marchessault
U.S. Department of Transportation
Office of the Secretary, P-110
400 7th St., SW, Rm. 10305
Washington, DC 20590
Tel: (202) 366-5422
E-mail: tom.marchessault@ost.dot.gov

Mr. Roger Petzold
U.S. Department of Transportation
Federal Highway Administration
HEPS-20, Rm. 3301
400 7th St., SW
Washington, DC 20590
Tel: (202) 366-4074; Fax: (202) 366-2198
E-mail: roger.petzold@fhwa.dot.gov

Mr. Bruce Spear
U.S. Department of Transportation
Federal Highway Administration
400 7th St., SW, Rm. 3222
Washington, DC 20590
Tel: (202) 366-8870; Fax: (202) 366-3640
E-mail: bruce.spear@fhwa.dot.gov

Mr. Lloyd Ulrich
U.S. Department of Transportation
Research and Special Programs Administration
400 7th Street SW, Rm. 7128
Washington, DC 20590
Tel: (202) 366-4556
E-mail: lloyd.ulrich@rspa.dot.gov

Mr. Chip Wood
U.S. Department of Transportation
Office of the Secretary, S-3
400 7th Street SW, Rm. 10126
Washington, DC 20590
Tel: (202) 366-5911; Fax: (202) 366-0263
E-mail: chip.wood@ost.dot.gov

Dr. Aviva Brecher
U.S. Department of Transportation
Volpe Center, Kendall Square
55 Broadway
Cambridge, M2142-1093
Tel: (617) 494-3470; Fax: (617) 494-3633
E-mail: brecher@volpe.dot.gov

Ms. Carol Brandt
U.S. Department of Transportation
Bureau of Transportation Statistics
400 7th Street SW, Rm. 3430
Washington, DC 20590
Tel: (202) 366-6662; Fax: (202) 366-3640
E-mail: carol.brandt@bts.dot.gov

Mr. Alex Landsburg
U.S. Department of Transportation
Maritime Administration, MAR-250
400 7th Street SW, Rm. 7302
Washington, DC 20590
Tel: (202) 366-1923; Fax: (202) 493-2288
E-mail: alex.landsburg@marad.dot.gov

Mr. David Gibson
U.S. Department of Transportation
Federal Highway Administration, HRDO-4
6300 Georgetown Pike, Rm. T204
McLean, VA 22101
Tel: (202) 493-3271; Fax: (202) 493-3419
E-mail: david.gibson@fhwa.dot.gov

Mr. Peter Sparacino
U.S. Department of Transportation
Federal Aviation Administration
William J. Hughes Technical Center
AAR-411, Building 296
Atlantic City International Airport
Atlantic City, NJ 08405
Tel: (609) 485-5430; Fax: (609) 485-4845
E-mail: peter.sparacino@tc.faa.gov

National Aeronautics and Space Administration

Dr. Michael Thomas
NASA Stennis Space Center
Earth Sciences Applications Directorate
Mail Code MA00
Building 1210
Stennis Space Center, MS 39529-6000
Tel: (228) 668-2401; Fax (228) 688-7455
E-mail: mthomas@ssc.nasa.gov

Dr. Chuck Hutchinson
Acting Director, Applications Division
NASA Headquarters
Washington, DC 20546
Tel: (202) 358-0851; Fax: (202) 358-3098
E-mail: chutchin@hq.nasa.gov

Mr. Edwin Sheffner
Office of Earth Science
Applications Division, Code YO
NASA Headquarters
Washington, DC 20546
Tel: (202) 358-0239; Fax: (202) 358-3098
E-mail: esheffne@hq.nasa.gov

Professor Christopher Lee
California State University
Department of Geography
1250 Bellflower Blvd.
Long Beach, CA 90840-1101
Tel: (562) 985-2358; Fax: (562) 985-8993
E-mail: clee@csulb.edu

Professor Ram Narayanan
University of Nebraska-Lincoln
Department of Electrical Engineering
242 WSEC
Lincoln, NE 68588-0511
Tel: (402) 472-5141; Fax: (402) 472-4732
E-mail: rnarayanan@unl.edu

Ms. Elizabeth Pentecost
NASA/DOT Integration & Coordination Office
USRA
300 D Street SW, Suite 801
Washington, DC 20024
Tel: (202) 488-5152; Fax: (202) 479-2613
E-mail: lpenteco@usra.edu

Ms. Denise Dunn
NASA/DOT Integration & Coordination Office
USRA
300 D Street SW, Suite 801
Washington, DC 20024
Tel: (202) 488-5150; Fax: (202) 479-2613
E-mail: ddunn@usra.edu

NCRST-Environment

Dr. Roger King
Remote Sensing Technologies Center
Mississippi State University
P.O. Box 9652
Mississippi State, MS 39762
Tel: (662) 325-2189; Fax: (662) 325-9133
E-mail: rking@ece.msstate.edu

Dr. Charles O'Hara
Mississippi State University
2 Research Blvd., ERC, Rm 201
Box 9627
MS State, MS 39762
Tel: (662) 325-2067; Fax: (662) 325-7692
E-mail: cgohara@erc.msstate.edu

NCRST-Infrastructure

Dr. Michael Goodchild
Department of Geography
University of California, Santa Barbara
Santa Barbara, CA 93106-4060
Tel: (805) 893-8049; Fax: (805) 893-3146
E-mail: good@geog.ucsb.edu

Dr. Val Noronha
Department of Geography
University of California, Santa Barbara
Santa Barbara, CA 93106-4060
Tel: (805) 893-8992; Fax: (805) 893-8993
E-mail: noronha@geog.ucsb.edu

NCRST-Flows

Dr. Joel L. Morrison
Center for Mapping
The Ohio State University
1216 Kinnear Road
Columbus Ohio, OH 43212
Tel: (614) 292-1612; Fax: (614) 292-8062
E-mail: morrison66@osu.edu

Dr. Mark McCord
The Ohio State University
Dept Civil & Environ. Engr. & Geodetic Sci.
491D Hitchcock Hall
2070 Neil Avenue
Columbus, OH 43210
Tel: (614) 292 2388; Fax: (614) 292-3780
E-mail: mccord2@osu.edu

NCRST-Hazards

Dr. Stanley A. Morain
Director, Earth Data Analysis Center
Bandelier West, Room 111
University of New Mexico
Albuquerque, NM 87131-6031
Tel: (505) 277-3622; Fax: (505) 277-3614
E-mail: smorain@edac.unm.edu

Dr. Rick Watson
Earth Data Analysis Center
Bandelier West, Room 111
University of New Mexico
Albuquerque, NM 87131-6031
Tel: (505) 277-3622; Fax: (505) 277-3614
E-mail: rwatson@edac.unm.edu

Technology Applications Partners

Mr. Robert W. Davis, President & CEO
AERIS Inc.
11386 Seneca Knoll Drive
Great Falls, VA 22066-3035
Tel: (703) 444-3771; Fax: (703) 444-2749
E-mail: AERISRWD@aol.com

Contact Information

Mr. William Lyte
Tetra Tech Inc
328 East Foothill Blvd.
Pasadena, CA 91107
Tel: (626) 683-0066; Fax: (626) 683-0040
E-mail: bill.lyte@ttisg.com

Mr. Lawrence J. Harman
Geographics Laboratory
Moakley Center for Technological Applications, Rm M-211
Bridgewater State College
Bridgewater, MA 02325
Tel: (508) 531-6144; Fax: (508) 531-6121
E-mail: lharman@bridgew.edu

Mr. Gary Erenrich
ICF Consulting Inc.
9300 Lee Highway
Fairfax, VA 22031
Tel: (703) 934-3349; Fax: (703) 934-3740
E-mail: gerenrich@icfconsulting.com

Ms. Karen Schuckman, President
EarthData International of North Carolina, LLC
1912 Eastchester Drive
High Point, NC 27265
Tel: (336) 812-9121; Fax: (336) 812-9018
E-mail: kschuckman@earthdata.com

Ms. Lynn Francis
EarthWatch Inc.
1900 Pike Road
Longmont, CO 80501-6700
Tel: (303) 682-3875; Fax: (303) 682-3848
E-mail: lfrancis@digitalglobe.com

Mr. M. Gregory Hammann
Orbital Imaging Corporation
Director, Application Development
21700 Atlantic Blvd.
Dulles, VA 20166
Tel: (703) 406-5895; Fax: (703) 406-5461
E-mail: Hammann.Gregory@orbimage.com

Mr. Steve Jaroszewski
Technology Service Corporation
6515 Main Street
Trumbull, CT 06611
Tel: (203) 268-1249; Fax: (203) 452-0260
E-mail: sjaroszewski@tsc.com

Mr. Chris Chiesa, Manager, Southwest Operations
Veridian ERIM International Inc.
4400 East Broadway Blvd., Suite 118
Tucson, AZ 85711-3519
Tel: (520) 326-7005; Fax: (520) 322-9700
E-mail: chiesa@erim-int.com

Mr. John Albasini, Project Manager
Veridian Systems Division
Building 1100, Suite 11139
Stennis Space Center, MS 39529
Tel: (228) 688-1504; Fax: (228) 688-2044
E-mail: john.albasini@veridian.com

Ms. Elizabeth L. Lanzer
Washington State DOT
Environmental Affairs Office
310 Maple Park Drive, P.O. Box 47331
Olympia, WA 98504-7331
Tel: (360) 705-7476; Fax: (360) 705-6833
E-mail: lanzere@wsdot.wa.gov

Dr. Kathleen Hancock
Dept. of Civil & Environ. Engr.
University of Massachusetts
216 Marston Hall
Amherst, MA 01003
Tel: (413) 545-0228; Fax: (413) 545-9569
E-mail: hancock@ecs.umass.edu

Dr. Mark Jakubauskas
TerraMetrics Inc.
1321 Wakarusa Drive, Suite 2102
Lawrence, KS 66049
Tel: (785) 841-7120; Fax: (785) 841-7268
E-mail: mjakub@ukans.edu

Mr. Ronald T. Eguchi, President
ImageCat, Inc.
Union Bank of California Bldg.
400 Oceangate, Suite 305
Long Beach, CA 90802
Tel: (562) 628-1675; Fax: (562) 628-1676
E-mail: rte@imagecatinc.com

Mr. Randall Murphy
Grafton Technologies, Inc.
43 Federal Street
Newburyport, MA 01950
Tel: (978) 463-7820
E-mail: rmurphy@graftontech.com

Mr. Ernest A. Carroll
GeoData Systems, Inc.
10565 Lee Highway, Suite 100
Fairfax, VA 22030
Tel: (703) 273-8200; Fax: (703) 273-8162
E-mail: ecarroll@geodatasystems.com

Ms. Anita Vandervalk
Manager, Transportation Statistics Office
Florida Department of Transportation
605 Suwannee Street, MS27
Tallahassee, FL 32399-0450
Tel: (850) 414-4848; Fax (850) 488-4752
E-mail: anita.vandervalk@dot.state.fl.us

COMMERCIAL REMOTE SENSING AND SPATIAL INFORMATION TECHNOLOGIES
APPLICATION TO TRANSPORTATION

National Consortia

ENVIRONMENTAL IMPACT ASSESSMENT

Mississippi State University
University of Alabama in Huntsville
University of Mississippi
Auburn University
Universities Space Research Association
NASA Marshall Space Flight Center
Digital Globe
Intermap Technologies Corporation
Earth Data Technologies, LLC
ITRES Corporation

Virginia DOT
EarthData
ICF Consulting
Washington State DOT
Veridian Systems Division

INFRASTRUCTURE MANAGEMENT

University of California, Santa Barbara
University of Wisconsin-Madison
Iowa State University
University of Florida
Digital Geographic Research Corporation
Geographic Paradigm Computing Inc

Florida DOT
University of Massachusetts
Orbital Imaging Corporation
Tetra Tech Inc

REGIONAL TRAFFIC MONITORING

The Ohio State University
George Mason University
University of Arizona

GeoData Systems Inc
TerraMetrics Inc
Veridian
Grafton Technologies
Technology Service Corporation
Bridgewater State College

SAFETY HAZARDS AND DISASTER ASSESSMENT

University of New Mexico
University of Utah
Oak Ridge National Laboratory
George Washington University

ImageCat Inc
DigitalGlobe
AERIS Inc

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION