INTRODUCTION

TRANSPORTATION, & National Parks, Public Lands

Defining the Challenge, Fostering Research and Partnerships

CAROL A. ZIMMERMAN and KATHERINE F. TURNBULL

Most people may be resigned to congested freeways and streets during the daily commute, but no one wants to experience traffic congestion on visits to national parks, wildlife refuges, recreation areas, and other public lands. This issue of *TR News* highlights approaches to address transportation problems in these scenic and historic protected areas.

Park roads, railroads, touring coaches, boats, horses, and hiking trails have played important roles in the development of national parks and public lands. These means and modes continue to serve visitors to and within parks and support the visitor experience. Transportation, national parks, and public lands are intrinsically linked.

The National Park System includes 388 sites covering more than 84 million acres and receives 300 million visitors annually. The National Wildlife Refuge System attracts 39 million annual visitors to 570 refuges and wetlands totaling 96 million acres. Even without adding the statistics for the Bureau of Land Management, the Forest Service, and other public lands to these totals, the magnitude of the transportation challenge is evident.

The federal land management agencies, the U.S. Department of Transportation, state governments, communities, foundations, businesses, regional organizations, and other groups are exploring and implementing innovative approaches to transportation issues in national parks and public lands. The accompanying articles, assembled by TRB's Transportation Needs of National Parks and Public Lands Task Force, seek to advance discussion of these issues and the potential solutions.

The task force provides a forum for transportation issues, research, and outreach activities associated with national parks, wildlife refuges, recreation areas, and other public lands. Task force-sponsored sessions at TRB Annual Meetings have addressed a range of topics, with paper presentations and invited speakers. The number of annual meeting papers in the subject area has increased, producing a more robust body of knowledge. The task force is sponsoring its first workshop, on transportation and the visitor experience, at the 2005 Annual Meeting.

The task force also is developing problem statements for the National Cooperative Highway Research Program (NCHRP), the Transit Cooperative Research Program, and other research sponsors. NCHRP Synthesis 329, *Integrating Tourism and Recreational Travel with Transportation Planning and Project Development*, stemmed from a task force-developed topic. The task force is drafting problem statements on the influence of changing demographics on park transportation needs, multimodal and intermodal approaches to park transportation, transportation in low-volume parks, and quality of service measures for parks and public lands.

The task force will continue to encourage collaborative efforts—such as those presented in the following pages—to examine and address transportation needs in national parks and public lands.

Zimmerman is Chair, TRB Task Force on Transportation Needs for National Parks and Public Lands, and Vice President, Battelle, Washington, D.C. Turnbull is Chair, TRB Policy and Organization Group, and Associate Director, Texas Transportation Institute, College Station.

Transportation Technologies Take to the Parks

Context-Sensitive Innovations Improve Aesthetics, Communications, and Safety

GARY L. BROWN, MONICA GOURDINE, BRADLEY J. ROBERTS, ROGER W. SURDAHL, AND J. HEATHER WOLL

The authors are with the Federal Highway Administration's Office of Federal Lands Highway: Brown is Technology Coordinator, Eastern Division, Sterling, Virginia; Gourdine is Technology Programs Engineer in the headquarters office, Washington, D.C.; Roberts is Technology Deployment Systems Coordinator, Western Division, Vancouver, Washington; and Surdahl and Woll are Technology Development Engineers, Central Division, Lakewood, Colorado.

From coast to coast, national parks are successfully deploying innovative, transportation-related technologies through a partnership between the U.S. Department of Transportation's Federal Highway Administration (FHWA) and the U.S. Department of the Interior's National Park Service (NPS).

"The partnership works very well," observes John Gentry, division chief of maintenance and engineering at the NPS' Blue Ridge Parkway in North Carolina and Virginia. "It would be tough for my team to maintain and manage 500 miles [805 kilometers] of parkway without the partnership with FHWA. I have park engineers here, but FHWA has the geotech experts, the structural and bridge engineers, and the highway planners and engineers, and we capitalize on their expertise."

For example, after Acadia National Park in Maine implemented several intelligent transportation system (ITS) technologies, overall traffic congestion and vehicle emissions declined, and ridership on the Island Explorer buses increased by 17 percent from 2001 to 2002. When Rocky Mountain National Park in Colorado installed its vehicle access control system, park-pass holders and authorized personnel were able to bypass the gates, so that visitors in turn experienced shorter wait times for entry.

Goals and Responsibilities

Many of the new technology deployments and implementations are funded through the Coordinated Federal Lands Highway Technology Implementation Program, a deployment and sharing program of the FHWA Office of Federal Lands Highway (FLH) and NPS, along with other federal land management agencies.

Through its three FLH Divisions, FHWA is responsible for engineering safe and environmentally sensitive roadways and bridges at national parks and on other federal lands. The FHWA Office of Research, Development, and Technology (RD&T), located at the Turner–Fairbank Highway Research Center in McLean, Virginia, studies many of the technologies before implementation by the FLH divisions.

The Eastern FLH Division, in Sterling, Virginia; the Central FLH Division, in Lakewood, Colorado; and the Western FLH Division, in Vancouver, Washington, provide transportation engineering services for planning, design, environment, right-of-way, construction, and rehabilitation of roadways and bridges, as well as material testing and quality assurance. The goal is to work in a context-sensitive manner that protects the environment, reduces congestion, improves aesthetics, enhances communications, and bolsters safety. New technologies help achieve that goal.

The mission of NPS is to preserve and protect America's natural resources for the people. Deploying technology to provide better access to natural resources in the safest and most environmentally sustainable ways is a core mission of FLH.

FHWA has been researching and developing technologies and providing engineering services to the national parks since 1926. But never before have so many new technologies been available, through advances, innovations, and new sources of funding.

The technologies and innovations benefit park visitors and park personnel by reducing crowding, congestion, and pollution, and by providing more pleasing corridors. The aesthetics of the parks are enhanced,

and the quality and durability of roads, bridges, and other infrastructure are improved. The following are highlights of key technologies that the FLH divisions have deployed or plan to deploy in national parks.

Electronic Enhancements

ITS technologies, common in urban areas, are making their way into the national parks. ITS applies computers, electronics, navigational aids, and communications devices to provide real-time information to motorists and transportation decision makers, to decrease congestion and pollution and to increase safety. The Office of RD&T is involved in researching, testing, and fine-tuning these technologies.

To manage roadway capacity, advanced traveler information systems (ATIS) direct travelers to park events, less-congested park entrances, and parking areas. Other ITS approaches use Global Positioning System (GPS) technology to monitor the locations of buses and to predict arrival times at bus stops, keeping visitors informed.

FLH has deployed ITS technologies at several parks, including Acadia National Park, Glacier National Park in Montana, Mount Rainier National Park in Washington, Rocky Mountain National Park, Bryce Canyon National Park in Utah, Cumberland Gap National Historical Park in Kentucky, and Gulf Islands National Seashore in Florida and Mississippi.

Acadia National Park deploys a variety of ITS technologies, including the Island Explorer Operational Enhancement System, which permits two-way voice communications and equips the environmentally clean, propane-powered Island Explorer buses with automatic vehicle location.

In Glacier National Park, FLH completed an ITS architecture report on the Going-to-the-Sun Road in December 2003, and a deployment plan will be in place soon. The plan is expected to focus on ATIS but also will address ways to mitigate and facilitate the road's rehabilitation. The ITS deployment plan for Mount Rainier National Park will offer strategies to reduce traffic and parking congestion and to mitigate the impact of the upcoming construction at the Jackson Visitor Center in Paradise.

To reduce vehicle congestion at the Beaver Meadows Entrance Station in Rocky Mountain National Park, a fourth entrance lane was added for frequent users such as rangers, vendors, maintenance workers,

PHOTO: JOHN BANDURSKI, GULF ISLANDS NATIONAL SEASHORE

Variable message sign on an access road, Gulf Islands National Seashore, informs motorists about road closures and other travel information.

PHOTO: ROGER SURDAHL, FHWA-CFLHD

Vehicle Access Control System *(foreground)* reduced congestion at entrance station to Rocky Mountain National Park, Colorado.

PHOTO: FRANK CORRADO, FHWA-EFLHD

New variable message sign undergoes testing after installation in Great Smoky Mountains National Park, Tennessee.

emergency equipment drivers, and Park Pass holders; FLH installed a vehicle access system at the lane's gate.

"Taking these users out of the normal tourist queue has reduced congestion at the entrance station, enhanced air quality with fewer idling vehicles, and improved the initial visitor experience with less frustration due to wait times," says Renee Sigel, quality coordinator and a former transportation planner at the Central FLH Division. The entrance gate, activated by loop detectors, transponders, or card readers, eliminates the need for a park ranger to collect fees and speeds up access to the park.

Bryce Canyon National Park has installed a dedicated access lane with a fast-pass electronic access-control system for authorized vehicles and shuttle buses. Cumberland Gap National Historical Park has put up variable message signs to allow the tunnel operator to communicate with motorists; the operator can override AM and FM radio signals to broadcast priority messages to drivers. At Gulf Islands National Seashore, portable variable message signs assist in traffic management during special events by alerting motorists on the mainland that the park cannot accommodate additional vehicles.

Other ITS technologies in use include traffic monitoring stations, road weather information systems, highway advisory radio via short-distance transmitters along roadways, and Internet websites that provide real-time information to motorists and park personnel. As the costs of the technology decline, and the value to the public increases, more ITS will be deployed in national parks.

Grassy Pull-Offs

Green Parking Alternatives is a technology deployed in the Great Smoky Mountains National Park in Tennessee and North Carolina to allow for soil stabilization of temporary parking areas or pull-offs while maintaining grass growth. An FLH safety study identified the need for pull-offs along the road for law enforcement and emergency use. The park, however, did not want to pave these areas, and gravel pull-offs were not desirable for either aesthetics or safety.

"In the past, FLH tried cellular concrete pavers, but the surface area and heat retention characteristics did not allow for adequate grass growth," says Laurin Lineman, Technical Services Engineer at the Eastern FLH Division. "A cellular confinement system, a plastic block system, and a PVC [polyvinyl chloride] pipe system are being evaluated to accommodate vehicular loading and support grass growth so that the best methods can be incorporated."

Customizing Software

For every technology that park visitors can see, many more are unseen. An example is QuickZone, a software developed by the Office of RD&T and deployed by FLH planners, designers, and construction engineers in decision making.

The software estimates traveler delay caused by work zones and allows a more complete assessment of total construction costs. The input data—such as the location of the work zones, the detour routes, the anticipated traffic volume, and the construction dates and times—generate figures for expected traffic delays, maximum queue lengths, costs to motorists, and other economic impacts.

The software can compare the delays and associated costs with different types of construction or phasing schedules. QuickZone also can compute and compare the user costs of road closure options with the projected construction costs.

Although several states have used QuickZone for years, FLH in partnership with the Office of RD&T is developing a customized version. Deployment is planned in the Wind Cave National Park in South Dakota, Zion National Park in Utah, Rocky Mountain National Park, Glacier National Park, Denali National Park and Preserve in Alaska, and Yosemite National Park in California.

Scoping the Roads

FLH's Road Inventory Program (RIP) has a long history of identifying road conditions on the NPS network and estimating the corrective costs for the maintenance of features such as culverts, signs, and guardrails. RIP now is using a state-of-the art road analysis program that employs GPS, lasers to detect pavement rutting, pavement roughness sensors to collect International Roughness Index data, an integrated gyroscope to track vehicle movement for determining the roll and pitch of roadway surfaces, front-mounted digital cameras for providing a panoramic view of the roadway, and downward-facing cameras to collect images of the pavement.

Another RIP software package can display processed data with synchronized digital video images. NPS officials can view the road inventory data collected from any of the 254 national parks and generate queries to gather data on specific areas of interest.

The software "is a great new technology for us to maintain our road structure," says Gentry. "We as managers will have data on the conditions and features of the road. There are 500 miles of parkway, and I'll have at my fingertips a visual of every square inch of the parkway, from signs to road curvature to slide areas."

PHOTO: JAMES AMENTA, FHWA-EFLHD

Automated Road Analyzer vehicle is equipped with state-of-the-art technology that enables FHWA staff to collect pavement data on the roadway network within the National Park System.

Profiles by Radar

Interferometric synthetic aperture radar (InSAR) monitors vertical ground movement at centimeter-level accuracy. InSAR detects, maps, and measures movement without survey targets or ground-based instruments.

Synthetic aperture radar (SAR) sensors, attached to either a satellite or an airplane, capture radar images of the earth's surface. The SAR interferometry allows the comparison of two images of the same location taken weeks or months apart, so that analysts can determine profiles of the earth's surface.

Using current and historic data sets, FLH applied InSAR at Badlands National Park in South Dakota, where frequent landslide movement complicates roadway maintenance. InSAR expanded the extent of the observation areas and helped in identifying the size of the landslides near access roads and in assessing the relative stability of alternative routes. The technology pinpointed areas of movement that traditional geotechnical monitoring instruments had not previously identified and that were in the vicinity of park improvements.

InSAR can be used to interpret ground movement and can confirm the nature and location of observations. Interagency observers can review InSAR readings conveniently in conjunction with land deformation maps via the Internet. The software does not replace ground-based surveys or geotechnical studies but adds value to conventional site investigations.

The InSAR ground movement technology also has assisted in observations of slope stability. Other applications include corridor planning and long-term monitoring of highways, railways, dams, groundwater and oil extraction, pipelines, urban development, and mine facilities.

Strength and Durability

Innovative technologies that improve the quality and durability of construction are another benefit to parks, visitors, and taxpayers. The Office of RD&T researched high-performance concrete (HPC) before FLH adopted it for bridges in national parks. The concrete mix meets requirements for higher strength and lower permeability.

PHOTO: DARCEL COLLINS, FHWA-EFLHD

Workers place high-performance concrete on a new bridge in a national park.

HPC uses many of the same materials as conventional concrete, but includes admixtures to engineer and enhance strength and durability. On various bridge components, such as decks and prestressed beams, HPC improves safety, increases the service life, reduces future maintenance and replacement, and ultimately reduces costs.

Bridges on the George Washington Memorial Parkway in Washington, D.C., and the Foothills Parkway in Tennessee have used HPC. Many state DOTs already have made construction with HPC accepted practice.

HPC allows the designer greater flexibility—for example, to reduce the number of beams, increase the span length and beam spacing, and eliminate the need for a special concrete overlay. Construction time may be trimmed significantly with the smaller number of beams and with no concrete overlay. HPC also offers gains in long-term service and reductions in maintenance and replacement.

Guiding Tourists To and Through the Parks

Study Assesses Traveler Information Needs

MATT BURT AND CAROL A. ZIMMERMAN

What information do park visitors and tourists want? How do they want to receive it? When do they want it? How will they use it? A recent study sponsored by the Federal Highway Administration (FHWA) attempts to answer some of these questions.

The crosscutting study examined the impacts of traveler information systems in four locations: Acadia National Park on the coast of Maine; Branson, Missouri; Salt Lake City; and the I-81 Corridor–Shenandoah Valley in Virginia. The study involved an analysis of available data on system use and customer satisfaction, as well as interviews with representatives of the traveler information and tourism communities.

In Acadia, tourism is intense and dominated by the park. The traveler information systems are oriented to helping visitors easily find their way around. The coordination between traveler information and tourism is partly the result of a recent field test of intelligent transportation systems by the U.S. Department of Transportation (DOT) and the National Park Service (NPS). The strategies have enhanced the operations of the free Island Explorer bus service.

The regional traveler information system for the I-81 Corridor–Shenandoah Valley is 511 Virginia, operated by Virginia DOT. The system is atypical in that it integrates an extensive amount of information on tourism destinations with traditional traveler information such as traffic and road conditions. Until recently, however, there was little coordination between 511 Virginia and Shenandoah National Park, so the park had a low profile on the system.

The Acadia and Shenandoah experiences suggest that traveler information systems can support the overall visitor information strategies and the traffic management strategies of national parks and their gateway communities. In interviews, nearly all of the tourism stakeholders agreed that traveler information is valuable. Satisfaction levels are generally high among tourist users, and many tourists report that traveler information has an impact on their travel decision making and on the quality of their travel experience.

511 Virginia provides callers with real-time traffic information, travel conditions, and tourism services for Virginia's I-81 Corridor.

Nevertheless, the Acadia and Shenandoah site studies indicate that several challenges must be overcome to realize the full potential of traveler information systems.

◆ **Low awareness and use.** Lack of awareness is a problem for most traveler information systems and is a special challenge for systems serving national park visitors and other tourists. Many stakeholders speculate that tourists—who are in a relaxed vacation mode, in an area for a short time, and perhaps resigned to traffic congestion—are less motivated than daily commuters and other frequent local travelers to obtain traveler information. Attracting the attention of tourists is difficult, and tourists who are less motivated to use traveler information will be turned off more easily by any hassle in accessing the information.

◆ **Limited coordination, despite improvements.** The Shenandoah Valley experience shows that even tourist-oriented traveler information systems may not effectively support the visitor and traveler infor-

Recycling Materials

Technologies such as HPC can reduce the long-term costs of construction and maintenance, but other technologies can reduce costs immediately. Foamed asphalt stabilized base, for example, reuses or reclaims pavement materials such as old asphalt, base materials, and subgrade soil.

Cold water is introduced into a stream of hot asphalt, causing the asphalt to foam and expand. The expanded, foamed asphalt is immediately injected and mixed with pulverized in situ materials in the mixing drum of a road reclaimer. The reworked material is then relaid, graded, and compacted, resulting in a high-strength stabilized base.

Although foamed asphalt is not a new technique, advances in equipment have introduced improvements in metering and in the design of the expansion chamber. The technology provides cost savings, does not sacrifice pavement performance, and is environment-friendly, with less hauling of materials,

mation objectives of nearby national parks; moreover, the parks may not be taking advantage of available traveler information systems. Increased coordination between traveler information system operators, national parks, and the extensive state, regional, and local tourism promotion community—with its expertise and infrastructure for marketing and information dissemination—is one of the most promising ways to increase the visibility and use of traveler information systems. Coordination among these parties is increasing.

Inspired partly by the vision of 511 as a comprehensive source of nationwide traveler information, many traveler information system operators are including multimodal and other information—for example, about national parks and other tourist attractions. At the same time, national parks are focusing on managing visitation through their own visitor information strategies, as well as through coordination with other traveler information systems.

NPS also is paying greater attention to how parks influence and are influenced by gateway communities. Finally, tourism stakeholders are focusing on outdoor recreation and scenic and historical resources, and are becoming more aware of the parks' transportation-related challenges.

◆ **Differing agendas and sensitivities.** National park personnel, the transportation agency operators of traveler information systems, and local tourism stakeholders have some common interests that traveler information systems can advance. However, these groups also have differing sensitivities, as well as differing—sometimes conflicting—objectives.

The Virginia Tech Transportation Institute operates the control room of 511 Virginia.

For example, tourism stakeholders may maintain that information showing full parking lots and jammed streets will deter potential tourists or will route tourists away from businesses that depend on drive-by traffic. Transportation agencies, on the other hand, aim for system efficiency and safety and usually are not sensitive to microscale routing or to the economic development objectives of an area.

These differing perspectives are not show-stopping impediments but must be acknowledged and addressed. Whenever perspectives have clashed, the primary cause has been a lack of coordination and participation by all parties from the earliest stages of problem definition and project design.

The crosscutting study's final report, prepared by Battelle, is scheduled for completion in August 2004 and will be available through the U.S. DOT Electronic Document Library, www.its.dot.gov/itsweb/welcome.htm. For more informationabout the study, contact FHWA Task Manager James Pol, telephone 202-366-4374, e-mail james.pol@fhwa.dot.gov.

Burt is Principal Research Scientist and Zimmerman is Vice President, Battelle, Washington, D.C. Zimmerman chairs TRB's Transportation Needs for National Parks and Public Lands Task Force.

Photo: Khamis Haramy, FHWA-CFLHD

Entrance to the Zion–Mt. Carmel Tunnel, Zion National Park, Utah. Inside the tunnel, FHWA staff use True Reflection Tomography™ to assess the technical and economic feasibility of enlarging the tunnel.

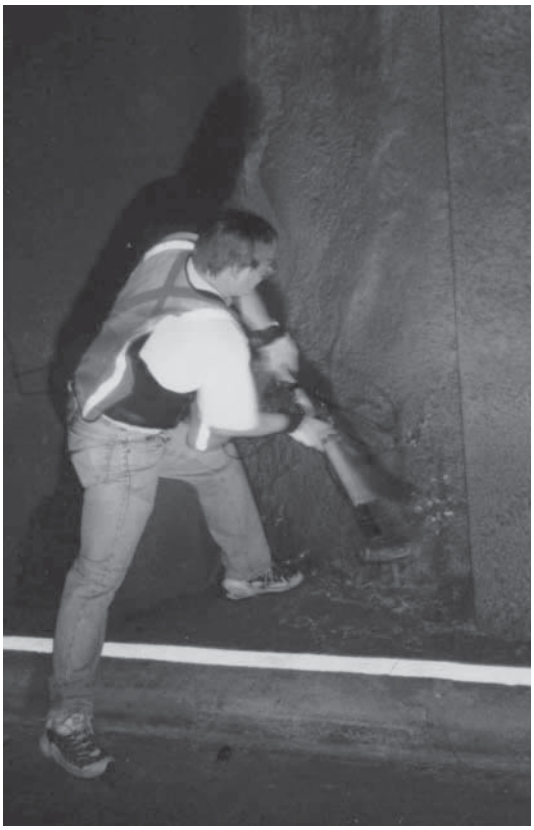

Photo: Khamis Haramy, FHWA-CFLHD

Investigator uses a title hammer to survey seismic characteristics of Zion–Mt. Carmel Tunnel.

quicker construction time, and less impact on park visitors and wildlife.

With a tight project budget, Canyon de Chelly National Monument in Arizona chose a foamed asphalt stabilized base for pavement with thermal cracks more than 2 inches (5 centimeters) wide. The monument is in a remote location without local material sources; the pavement materials were reclaimed and reused at a relatively modest cost. The Delaware Water Gap National Recreation Area in New Jersey and Pennsylvania also has used foamed asphalt, and plans are to apply the process in Colorado National Monument and in Rocky Mountain National Park.

Michael Voth, pavement engineer at the Central FLH Division, notes that one of the keys for completing a successful project with foamed asphalt stabilization is conducting a thorough field investigation beforehand.

"It is important that the existing materials are compatible with the foamed asphalt process," he says. "Developing a good specification and having adequate oversight by personnel knowledgeable about the process and requirements during construction are also important."

Seismic Signals

Constructed in the 1920s, the 1-mile- (1.6 kilometer-) long Zion–Mt. Carmel Tunnel in Zion National Park is not large enough to accommodate two-way, over-

sized vehicle traffic. NPS and FLH are evaluating remedies such as enlarging the tunnel or constructing a parallel tunnel.

"Accurate appraisal of the technical and economic feasibility of these options depends in large part on assessing ground conditions around the existing tunnel and the proposed parallel facility," notes Khamis Haramy, geotechnical engineer at the Central FLH Division.

FLH conducted the assessment by applying a proprietary seismic reflection–holography technique. The technology analyzes the seismic signals from several source and receiver locations, identifying reflector zones within the rock mass that may correspond to voids, fracture zones, or significant changes in the geologic structure. The survey area included zones with known ground support problems and voids, for verification of the tomography results.

Historic Walls

Glacier National Park's spectacular Going-to-the-Sun Road is supported and protected by a series of 127 retaining walls and guard walls. Constructed in the early 1920s, the stone masonry walls not only improve safety but also are part of the park's cultural heritage.

Aging has created an urgent need to ensure the integrity of the walls, however. Continued deterioration could lead to major and possibly catastrophic failures.

In response, the park partnered with FLH in 1999 to develop a wall management program. A systematic approach to managing the historic walls, the program includes an ongoing condition assessment that requires a detailed inspection of one-third of the walls each year. An electronic management database tracks the inspection records, characterizes the severity and extent of deterioration, and defines costs to support the program.

The program has enabled park personnel to manage and repair the aging wall systems more effectively, to predict deterioration, identify actions to improve conditions, estimate the cost of alternatives, determine least-cost maintenance and rehabilitation strategies, and generate reports and summaries for planning and programming.

"Response has been very positive from Glacier National Park," says Alan Kilian, geotechnical engineer at Western FLH Division. "The park staff feels that [the program] has helped them proactively manage this cultural heritage while also striving to provide a safe and enjoyable environment for the traveling public and park personnel."

Stone masonry walls, originally constructed in the 1920s, undergo repair and maintenance at Going-to-the-Sun Road, Glacier National Park, Montana.

According to Kilian, integrating the program into the park's project planning efforts has gone smoothly. Costs have been minor—approximately $8,000 every other year.

Tapping into Sensors

The primary access road at Denali National Park and Preserve undergoes severe damage during the spring thaws. Predicting when the road could open safely to tourist buses and other vehicles is difficult. The challenge has prompted implementation of a communications system for transmitting road information from remote sites in the park.

The time domain reflectometry (TDR) system places sensors in the roadway that measure the moisture content of the soil. The TDR sensors do not measure temperature but can indicate if the soil is frozen. Ground temperature sensors also have been placed and connected into the communications network.

The TDR and temperature sensors are hardwired to a solar-powered, low-frequency radio transmission array, which uploads real-time data for analysis by the park's roads and trails staff. NPS personnel had required a full day to collect information on road conditions, but now staff can compile the data within minutes.

In the past, Denali staff responsible for long-term ecological monitoring had managed the road with winter condition data from the headquarters office, the only physically accessible area. Now, the TDR radio system and satellite sensors transmit data from several sites throughout the park, and sites are being added to extend the network's capabilities.

The results have enhanced decision making about when to open the park road to buses, concessionaires, and maintenance vehicles without damaging the roadway. The technology helps the Denali roads and trails staff develop efficient plowing schedules and to prepare for the park opening dates. TDR information also aids in setting weight restrictions for park and concessionaire vehicles during the spring thaw, preventing damage that can take as much as 70 percent of the season to heal or repair.

"The technology has strengthened communications among the various user groups, giving them more accurate and timely information to help manage park resources," says Robert Beck, drill coordinator at the Western FLH Division. "This supports not only the general park traveler but also the scientific community working in the park."

In Glacier National Park, the U.S. Geological Survey (USGS) is responsible for avalanche predictions

Time domain reflectometry system in Denali National Park, Alaska, provides improved information about winter road conditions.

to improve safety, especially for the crew that plows and opens the road in the spring. Previously, USGS had guessed about snow conditions in making safety forecasts. Now the TDR weather station at Logan Pass sends data to headquarters several times a day through a low-frequency radio system.

The technology has worked so well that the park plans to expand the number of weather data collection sites and to connect the east side weather station to the radio system. Other scientific groups are considering how to use the established TDR radio systems in these parks for air quality monitoring, animal tracking, and vehicle tracking to mitigate congestion.

Big Picture Overview

Technologies like these are implemented only after research, development, and testing. The process may start with park officials confronting a transportation-related problem and requesting the assistance of FLH. Or FLH itself may identify a problem and develop a solution.

The national park system is decentralized, and each park has unique needs. FLH takes a context-sensitive approach to implementing solutions but also identifies trends, problems, and general themes that may apply to many parks.

FLH makes technological innovations in the many areas related to transportation available to the national parks and other federal entities. An array of specialists—known as "champions" under FLH's technology program—works with the parks to solve problems, enhance amenities, and implement the technologies. The successful results are evident in the variety of technologies deployed and the benefits gained—especially by visitors, who enjoy a safer and more pleasant stay in the national parks.