Deployment and Implementation

Bus 2.0 rolls into service in southern metro

On 296 miles of Twin Cities-area roadways, bus drivers are allowed to operate their vehicles on shoulder lanes to avoid rush-hour congestion. Shoulder operation allows buses to provide faster, more reliable service, but maneuvering 9.5-foot-wide buses on 10-foot-wide shoulders is challenging, and heavy traffic and poor weather add to the difficulty.

But now drivers of 10 buses operated by the Minnesota Valley Transit Authority (MVTA) are getting help navigating the shoulder from a driver-assist system (DAS) developed by researchers with the IV Lab and HumanFIRST Program at the ITS Institute. These buses provide express service on the Cedar Avenue bus rapid transit corridor and on Highway 62 between the southern suburbs and downtown Minneapolis.

This Bus 2.0 project is part of a larger effort to improve traffic flow on I-35W. The ITS Institute collaborated with the MVTA and Schmitty and Sons Transit to equip the buses, with funding provided by the U.S. Department of Transportation’s Urban Partnership Agreement and the state of Minnesota through the Twin Cities Metropolitan Council. Installation of DAS technology was completed in March 2010, and use of the buses was progressively increased through January 2011 as drivers were assigned and trained.

The DAS uses highly accurate differential GPS to monitor a bus’s position on the roadway and provide visual and tactile alerts to quickly deliver critical lane (or shoulder) departure warning information to the driver. A head-up display (HUD) mounted just inside the windshield and located in the driver’s line of sight shows the

*Bus 2.0 is part of a larger effort to improve traffic flow on I-35W.*
location of lane boundaries, helping drivers remain safely on the shoulder even when roads are snow-covered or atmospheric visibility is low. Information about other vehicles or objects on the roadway, detected by laser sensors mounted on the front and sides of the bus, is also displayed on the HUD to help drivers avoid potential collisions.

If the DAS detects the bus beginning to drift from its lane, the white or yellow lane boundary on the HUD will turn red. If the bus touches the lane boundary, the driver’s seat vibrates on either the left or right side, based on whether the bus is departing the lane or shoulder to the left or right, respectively. If both warnings are ignored, the driver feels a “suggestive torque” on the steering wheel; the suggestion indicates to the driver the change in heading needed to maintain proper lane or shoulder position. Drivers remain in control of the buses at all times, but the technology provides these three modes of feedback to help them prevent accidental lane departures.

To familiarize drivers with the new technology, the MVTA built a driving simulator that replicates a DAS-equipped bus cab. Drivers also complete on-the-road training. Feedback from drivers was incorporated throughout the development process; for instance, drivers suggested the “staging” of the feedback levels as the most effective method to display warning information. IV Lab director Craig Shankwitz says the team also made changes after drivers had used the system for a few months.

Michael Abegg, MVTA transit planning manager, says drivers generally like using the system because it’s helpful and they can choose the type of feedback they receive. For example, if a driver prefers the vibrating seat to the head-up display, the visual display can be turned off. “When the weather is bad, without assistance, a driver is hesitant to use the shoulder. He knows that if he gets stuck, 45 people won’t make it to their destination on time,” Shankwitz adds. He predicts that when people see that the bus can adhere to its schedule in those conditions, they’ll be more willing to ride.

Abegg says the system is working well on a technological level. “It’s doing what it’s supposed to do, and that success shouldn’t be underestimated.” He notes, however, that researchers are having difficulty proving that Bus 2.0 reduces travel time. The problem of congestion is so complicated that it’s difficult to isolate and study a single factor. Changing weather conditions and crashes on the roadway have a major impact on traffic. And actual traffic variability is greater than what models can predict.

As researchers evaluate Bus 2.0, they’ll need to ask, among other questions, whether the buses are running on the right sections of shoulder or if there are other sections that would result in faster travel time. Abegg also points out that the current system includes only a small part of all possible driver assistance. Systems could help vehicles pull up to the exact location of the bus stop so that passengers could board more quickly. Other kinds of assistance could be provided for bus drivers in general lanes.

The IV Lab would like to interest other agencies in the DAS. “We can’t build the roads any wider, but we do have the shoulder,” Shankwitz says. “If we can get DOTs and other transit agencies to look at the shoulder not as just a breakdown lane but as a transit lane, we have an opportunity to deploy more technology in different transit applications.” And this same technology, he adds, could potentially be adapted for passenger cars to help prevent single-vehicle lane-departure crashes, which account for nearly 60 percent of traffic fatalities in the United States.

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—Craig Shankwitz
Intersections account for more than two million crashes in the United States every year. In rural areas, crashes often lead to more severe consequences than in urban areas because of higher vehicle speeds and longer emergency response times.

Researchers from the ITS Institute’s Intelligent Vehicles Laboratory (IV Lab) and HumanFIRST Program, in cooperation with the Minnesota Department of Transportation (MnDOT), have developed an infrastructure-based driver-assist system designed to help drivers make better decisions and prevent collisions at rural highway intersections.

This Cooperative Intersection Collision Avoidance System–Stop Sign Assist (CICAS–SSA) system uses multiple sensors and advanced computer algorithms to track vehicles moving along a rural divided highway. This information is used to warn drivers stopped on a secondary rural road when gaps in highway traffic are too small to merge or cross safely; an active LED icon-based sign switches to an alert or warning as needed depending on the gaps to the left or right.

System field-testing began in 2010 at the intersection of U.S. Highway 52 and County State Aid Highway (CSAH) 9 near Cannon Falls, Minnesota, and at the intersection of U.S. 53 and Wisconsin Highway 77 south of Spooner, Wisconsin. These intersections were chosen because of their history of serious crashes and fatalities for which unsafe gap acceptance was a key contributing factor.

After the first year of testing, the Minnesota intersection went from six crashes per year to three; the Wisconsin intersection went from three crashes per year—and an average of five fatalities every six years—to zero crashes last year.

Two more test systems were activated in Minnesota in June 2011: the first on Minnesota Highway 23 at CSAH 7 near Marshall and the second on U.S. Highway 169 at CSAH 11 near Milaca. Between 2006 and 2008, an average of four right-angle crashes per year occurred at each of these intersections.

According to MnDOT District 3 traffic engineer Tom Dumont, during this time period, 21 total crashes occurred at the Milaca intersection, approximately 15 of which were right-angle crashes. This intersection is located at the crest of a vertical curve and beginning of a horizontal curve on a rural stretch of trunk highway where the speeds are 65 miles per hour and sight distance is limited. Previous low-cost safety improvements—adding lighting, advance warning signs, and flashing stop signs, and lowering the grade on 169 northbound—have had limited success in reducing crashes here. And the intersection does not meet the minimal traffic volume levels necessary to justify installing a traffic signal system, Dumont says.

Testing at this and the other selected intersections is planned to run for three years. Researchers are using data collected at these locations to analyze driver responses in relation to the system’s sign modes and to determine whether the CICAS-SSA system improves the gap acceptance of drivers. If drivers learn better behavior, crash rates should drop for all intersections, not just those at which the CICAS-SSA system is deployed.

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In 1971, the completion of the George Parks Highway opened up the interior of Alaska, and Denali National Park became a popular tourist destination. Today visitors tour the park in buses that travel along a single road. And as the number of visitors has increased, managing traffic has become increasingly important.

Several years ago, the National Park Service asked researchers at the Institute’s Minnesota Traffic Observatory (MTO) to investigate how changing the annual trip limit would affect both the visitors’ experience and the wildlife they come to see.

The research team, led by Institute director Max Donath, MTO lab manager Ted Morris, and MTO director John Hourdos, created a complex simulation tool that accounted for the unique traffic patterns in the park. Building on this work, the research team next tested several scheduling scenarios that would increase the number of tours during the peak season.

The results revealed that allowing more bus trips might lead to visitor dissatisfaction. For example, the view from a scenic overlook might also include too many buses on the road below. In addition, increased traffic would have a negative impact on the Dall sheep that regularly cross the road during migration and foraging seasons.

As a next step, the research team adapted the simulation tool to test several proposed alternative systems. One system, for example, removed a route and replaced it with another that carried visitors further into the interior of the park.

Park planners eventually focused on two of the alternatives. These were tested against standards, such as: “The availability of vehicle gap headway times at wildlife crossings must be at least 10 minutes on the hour.” MTO researchers also developed additional tools that allow park planners to analyze and visualize violation of standards.

“The simulation tool developed by MTO has been instrumental in helping us understand how different schedules and traffic volumes impact visitor crowding at key locations along the road,” says Melissa Snover, ecologist at Denali Park and Preserve. “The results are being used by management to propose transportation alternatives in the upcoming Vehicle Management Plan/Environmental Impact Statement.”

According to Morris, the next phase will be the development of monitoring tools that use actual GPS and wildlife siting data. Park managers will then be able to evaluate if their transportation system is exceeding set standards while the season progresses. Schedules and other route adjustments can then be made to mitigate overcrowding and other problematic situations.

These tools have broad application for the management of any public space affected by road use. “We want to help protect and preserve not only Denali, but other parks as well—while keeping them accessible to visitors,” Morris says.

*A simulation tool developed by ITS Institute researchers is helping managers at Denali National Park plan transportation alternatives. Some stretches of the Denali Park Road are treacherous.*
The SMART-Signal system, developed by civil engineering associate professor Henry Liu to improve traffic management on urban arterials, was recently implemented in Pasadena, California—the first installation of the system outside of Minnesota. The Minnesota Department of Transportation (MnDOT) also expects to equip nearly 100 additional Minnesota intersections with the system later this year as part of a large-scale implementation project.

SMART-Signal (Systematic Monitoring of Arterial Road Traffic Signals) simultaneously collects event-based high-resolution traffic data from multiple intersections and generates real-time arterial performance measures, including queue length and travel time. System equipment is installed directly in signal controller cabinets.

Liu began work on the SMART-Signal system in 2006, and it has been installed at 20 intersections on three major arterial corridors in Minnesota. Funding and in-kind support for the SMART-Signal system have been provided by MnDOT, the ITS Institute, the Minnesota Local Road Research Board, Hennepin County, and the National Cooperative Highway Research Program.

The system was installed at six intersections on Orange Grove Boulevard in Pasadena, California, between March and April 2011. It began collecting traffic data in May. Pasadena DOT director Fred Dock became interested in implementing the SMART-Signal system after reading the initial project report, Liu said.

Liu and his team provided system calibration and initial data monitoring, then contracted with California-based technology company Iteris to complete the installation. Beginning in September 2011, Iteris and the City of Pasadena will be responsible for all operations, and the University team will no longer maintain the system at the California sites.

According to Liu, the system is already performing well. Depending on the results at the initial six intersections, the city may be interested in implementing the system in more areas, he said.

Expanded implementation of the SMART-Signal system in Minnesota is also expected later this year. Plans for late 2011 include installing the system at 92 additional intersections on Minnesota arterials, including State Highways 55, 7, and 65. “This will be the first time such a large-scale real-time performance monitoring system has been implemented on urban arterials in the U.S., maybe even the first in the world,” Liu said.

This large-scale implementation will provide the research team with more detailed traffic data on urban arterials than have ever been available, which could lead to even more in-depth research, Liu explained. “The fundamental issues of traffic flow can be reinvestigated,” he said. “These data may allow us to confirm the old traffic model or construct a new one.”
**Solar-powered signs aim to improve rural intersection safety**

In Minnesota, most intersection-related crashes occur at rural, two-way-stop intersections because drivers stopped on a minor road often cannot see traffic on the major road. Nearby vertical and horizontal curves increase the risk when entering the intersection. At these intersections, right-angle crashes account for the largest percentage of crashes, and most are related to drivers’ inability to recognize a safe gap in the traffic stream.

To improve safety at these rural, two-way-stop intersections, researchers from the University of Minnesota Duluth and St. Louis County, Minnesota, developed the ALERT System (Advanced LED Warning Signs for Rural Intersections Powered by Renewable Energy). This low-cost, dynamic warning system provides traffic information to drivers approaching the intersection. The project was funded by the Minnesota Local Road Research Board.

Vehicle detectors placed at each approach send messages to LED blinker signs. The system is wireless and powered by solar panels, which eliminates problems associated with buried wires as well as the need to connect.

**Institute lab hosts online accessibility tool**

People who make transportation and land-use decisions in the Twin Cities region have a new tool: an online “accessibility matrix” that illustrates variations in accessibility—the ability of people to reach the destinations they need or want to visit—to different types of destinations for travelers who drive, bike, walk, or use transit.

The tool is hosted by the ITS Institute’s Minnesota Traffic Observatory (MTO), which is staffed by experts in managing large data sets and creating visual models of complex data.

The matrix displays four types of maps: accessibility (the ability to reach destinations), mobility (the ability of people to move on the network), travel time (how long it will take to get between census blocks with each of the travel modes), and land use (the distribution of activities by census block). Users can select up to four filters, including year, mode, time of day, and destination type (such as retail, restaurants, or recreation). The result, for example, could be maps showing the accessibility of jobs between two distant suburbs by transit or by car.

The tool is an outcome of the Access to Destinations (ATD) Study, an interdisciplinary research effort coordinated by the Center for Transportation Studies, with support from sponsors including the Minnesota Department of Transportation, Hennepin County, the Metropolitan Council, and the McKnight Foundation. ITS researchers on the ATD study team were Gary Davis, John Hourdos, Eil Kwon, Taek Kwon, David Levinson, Panos Michalopoulos, Chen-Fu Liao, and Ted Morris.

This tool is just one of several at the MTO that support effective transportation and land-use planning. Researchers plan to further develop the tool and add new data as they become available. Tutorials are also available to assist users with the new tool. The matrix is available on the MTO website at www.mto.umn.edu/Capabilities/PlanningSupport.
When the alert signs were flashing, westbound traffic on the major road slowed by four miles per hour, drivers on the minor road waited longer before crossing, and roll-throughs were eliminated.

The system was installed at the intersection of West Tischer Road and Eagle Lake Road in Duluth. This intersection has a severe vertical curve on the east approach of the major road that significantly reduces sightlines for drivers stopped on the north and south approaches of the minor road. In addition, westbound drivers on the major road cannot see cross traffic until they are nearly in the intersection.

Westbound drivers see the message “CROSS TRAFFIC WHEN FLASHING.” North and southbound drivers on the minor road see the message “VEHICLE APPROACHING WHEN FLASHING.”

The research team included Taek Kwon, a professor in the Department of Electrical and Computer Engineering; research associate Ryan Weidermann; and St. Louis County traffic engineer Victor Lund.

According to Lund, ALERT was “tremendously successful” at changing driver behavior. When the alert signs were flashing, westbound traffic on the major road was slowed by four miles per hour, drivers on the minor road waited longer before crossing, and roll-throughs were eliminated.

However, when the alert sign was not flashing, drivers on the minor road apparently assumed that there was no cross traffic. As a result, they did not always obey the stop sign, and roll-throughs increased, Lund says. This increases the risk of crashes when the device stops working—as ALERT did on several sunless days last winter.

Gap selection-assistance devices like ALERT are effective, Lund says. But he adds that standardization is needed before these devices can be widely used. This means that state and federal standards must be established for messaging, illumination, and placement of signs. Fail-safe issues—such as malfunctioning solar panels—must also be dealt with.

Ease of maintenance is also an issue. Lund notes that county employees currently need to climb a ladder to service ALERT, but he’s hopeful that one day all components will be enclosed in a ground-level service cabinet, which would eliminate the need for a ladder and allow for easier access.

IV Lab patents research on vehicle positioning system

Craig Shankwitz, director of the Intelligent Vehicles Laboratory, was granted a patent titled “Vehicle Positioning System (VPS) Using Location Codes in Passive Tags.” The patent employs passive electronic tags installed in or on roadways to locate vehicles for a number of ITS applications.

VPS uses codes in the electronic tags to represent locations along the roadway. Electronic tag readers installed in vehicles use the code information to determine a vehicle’s position in relation to the roadway. These on-board readers can then communicate the information with other vehicles or with nearby roadside infrastructure units.

Messages may be used for traffic management and control or for issuing alerts about other vehicles, environmental factors, or infrastructure conditions.

The system’s design was motivated by the fact that in certain areas, GPS is unavailable or unreliable, such as environments where tall buildings or expressway overpasses distort or block GPS signals. VPS may also be an alternative to radar-based roadside vehicle sensors, which can experience signal interruptions caused by nearby vehicles or other objects blocking a sensor’s line of sight. According to Shankwitz, because VPS relies on tags installed directly in the roadway, it can provide highly accurate position measurements regardless of what’s around a given vehicle.

VPS also provides more specific information than GPS, such as which lane a vehicle is traveling in and the amount of space a vehicle occupies on the roadway. This means that safety messages broadcast using VPS could provide other drivers in the area with more detailed information—for example, which lane a braking vehicle is in, so following drivers could take appropriate action—and decrease the occurrence of false alerts. Because of the ability of VPS to communicate such accurate information to drivers, a large-scale deployment of the technology could substantially reduce vehicle crashes and fatalities.
Alaska DOT uses IV Lab technology to tackle extreme conditions

Five vehicles with driver-assist technology have been deployed in Alaska, where high snowfall rates and blowing snow routinely cause whiteout conditions and zero visibility. Because of its success with the IV Lab, the state of Alaska ordered three new driver-assist systems and two upgrade kits for its systems that operate near Valdez. The kits provide new on-board computation capability not provided by the current computers. In the summer of 2011, IV Lab staff traveled to Alaska to upgrade two vehicles that have been in continuous service since 2003 and to install the driver-assist system in three new snow-removal machines (two plows and one blower).
Technology Transfer

The Institute could not accomplish its goals without sharing its expertise and research results with local, national, and international audiences for use in real-world applications. Technology transfer also communicates to the world who we are—raising the profile of the Institute and its research—and educates students, policymakers, and the general public about ITS issues and solutions.

Our efforts in this area are far-ranging in order to reach a broad and diverse audience of researchers, students, practitioners, policymakers, and others among the public. Over the past year, we have provided tours and demonstrations of our research and facilities, sponsored seminars, sent electronic newsletters and announcements, published printed pieces, and enhanced our website. But perhaps the most direct method of transferring technology has been to educate students who join the workforce.

This section of the annual report highlights some of our technology transfer activities over the past year.

Research showcased through demos, tours, and exhibits

Two ITS Institute projects were featured at University Research Technology Transfer Day, an exhibition of the U.S. Department of Transportation’s Research and Innovative Technology Administration (RITA), on April 6 at the USDOT headquarters in Washington, D.C.

“Traffic Signal Performance Measurement Using High-Resolution Data: The SMART-Signal System,” led by Associate Professor Henry Liu of the Department of Civil Engineering, simultaneously collects event-based...