RITA Office of Research, Development, and Technology

UTC Spotlight

University Transportation Centers Program

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Technology Aids Bus Drivers on Narrow Shoulder Lanes

A driver-assistive system (DAS) developed by the Intelligent Vehicles Laboratory (IV Lab) at the University of Minnesota's Intelligent Transportation Systems (ITS) Institute integrates sensing, positioning, and user-interface technologies to help bus drivers operate safely and comfortably on bus-only shoulder lanes—even in adverse weather conditions and heavy traffic.

ITS Institute

Side view of a bus equipped with the driver-assistive system.

With funding from the U.S. Department of Transportation's Urban Partnership Agreement program, buses equipped with the DAS will soon provide express service between downtown Minneapolis and the city's southern suburbs. The project is a partnership between the IV Lab, the HumanFIRST Program in human factors research, the Minnesota Valley Transit Authority (MVTA), and Schmitty and Sons Transportation.

Project Motivation

There are a number of advantages to using shoulders as busways. Modifying shoulders is less expensive and time-consuming than developing additional right-of-way, and buses can continue to follow their established routes. Transit users perceive a significant time savings—which can be greater than the actual time savings—when buses are kept moving rather than stopping because of traffic congestion. Research has also shown that ridership along routes with bus-only shoulder service increased even while total ridership in the metropolitan area was trending downward.

Because shoulder lanes are narrower than regular traffic lanes, bus-only shoulder operation imposes additional stress on bus drivers. Staying within the shoulder lane boundaries at speed is difficult even under optimal conditions; heavy traffic and inclement weather can make it nearly impossible for an unassisted driver.

It is during difficult weather and traffic conditions, however, that bus-only shoulders offer the greatest transit benefits in terms of avoiding traffic congestion and slow-moving vehicles. For transit riders, reliable bus-only shoulder service means speedier travel, better schedule adherence, and greater customer satisfaction.

DAS Technologies

The main positioning sensor on the bus is a Differential Global Positioning System (DGPS) receiver. This enhanced GPS receives a real-time correction signal derived from a network of six GPS receivers located around the perimeter of the Twin Cities metropolitan area. These six base-station receivers send, via landlines, raw satellite information to a central server operated by the IV Lab. These satellite signals provide each bus with a location-optimized DGPS correction signal via the 3G cellular network, which results in centimeter-level accuracy.

ITS Institute

To train drivers in the proper use of the DAS, the research team constructed an immersive driving simulator that creates an accurate reproduction of a DAS-equipped bus cab.

The DAS correlates position information from the DGPS system with an onboard map database of the locations of lane boundaries and other relevant features. Suitable digital map databases can be created in several ways; the IV Lab developed a truck-mounted mapping system combining three dual-frequency carrier-phase DGPS receivers, a pair of LIDAR scanners directed at the road surface, and cameras recording the road surface to help analyze any data irregularities.

ITS Institute

Sensing for collision awareness is provided by a forward-looking multi-plane LIDAR unit mounted on the front bumper. Similar sensors scan both sides of the bus.

A major challenge in developing the transit DAS was ensuring that the lane-guidance function could operate effectively even when the GPS satellite signal was lost. Underpasses, tunnels, and tall buildings can all interfere with GPS-based positioning systems. When DGPS signals are lost, the vehicle-based augmentation system (VBAS), developed by the IV Lab, estimates vehicle position based on measured ground speed, vehicle yaw rate, and the last known accurate position and heading. The performance goals of the VBAS are less than 20 centimeters of error for a vehicle traveling at 25 miles per hour over a 15-second period of signal loss. If DGPS is unavailable for more than 15 seconds, the DAS alerts the driver and deactivates its positioning functions until the signal is reacquired.

For the collision-awareness function of the DAS, a forward-looking multiplane LIDAR unit is mounted on the front bumper, and similar sensors scan both sides of the bus. The location of obstacles detected by the LIDAR units are cross-correlated with the on-board map database; any elements of the landscape detected by the LIDAR sensor are filtered and not regarded as a collision threat.

The DAS uses multiple display and feedback modes to communicate with the bus driver. Lane-keeping and obstacle-avoidance information is communicated visually through a head-up display (HUD) positioned between the driver's eyes and the windshield. Looking through the HUD, the driver sees virtual lane boundaries and graphical indicators of vehicles and other obstacles ahead of the bus overlaid on his or her view of the actual roadway. Vehicles detected alongside the bus are displayed on an LCD screen. Finally, haptic feedback in the form of seat vibration and steering wheel resistance is triggered if the bus begins to veer out of its lane.

Driver Training

To train drivers in the proper use of the new DAS, the research team constructed an immersive driving simulator in an MVTA facility. Seated in an accurate reproduction of a DAS-equipped bus cab, drivers can operate under both normal and extreme low-visibility conditions. Drivers must also complete additional on-the-road training before getting behind the wheel of a bus filled with passengers.

About This Project

The technologies used in the transit DAS represent 15 years of research and development effort by ITS Institute researchers. Leading the project is Craig Shankwitz (shank004@umn.edu), director of the Intelligent Vehicles Laboratory. Michael Manser (mikem@me.umn.edu), director of the HumanFIRST Program, Mike Abegg, planning manager with the MVTA, and numerous IV Lab and HumanFIRST research staff have made significant contributions to the project as well. Max Donath (donath@me.umn.edu) is the director of the ITS Institute at the University of Minnesota and a co-investigator of this research.