National Center for Transit Research

# FLOW

*Moving People and Ideas*

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**IN THIS ISSUE**



***This study evaluated the effectiveness of camera-based systems to reduce transit bus side crashes by measuring the reduction of blind zones and analyzing the results of controlled driving tests and driver surveys using sideview video systems.***

# Evaluation of Camera-Based Systems to Reduce Transit Bus Side Collisions

Mirror-based systems have evolved over the years because of the need to provide a better view to the driver and now include more than one mirror with different magnifications. However, current mirror-based systems have several limitations. First, they do not cover the whole side area of the vehicle, thus leaving what are referred to as "blind zones." This brings the bus driver into situations where he/she cannot see vehicles approaching from the side in some situations, especially during lane changing maneuvers. Second, they are less effective during adverse weather, such as rain or fog. And finally, they are required to be large in size and extend out of the vehicle's perimeter in order to provide the necessary view to the driver. Since transit buses come very close to the edge of the pavement to pick up standing pedestrians and passengers, a mirror that extends out of the bus footprint is not desirable. There have been reported cases where a pedestrian was struck by the mirror from a passing bus.

A potential countermeasure to this problem is the use of camera-based systems. The camera-based system for transit buses under evaluation in this study is a system that incorporates video cameras installed on the outside walls of the bus, aimed at the left and right rear sides of the bus, and two monitors connected inside the bus to provide the driver with an image from the cameras. This study evaluated the effectiveness of camera-based systems to reduce transit bus side crashes by measuring the reduction of blind zones and analyzing

*continued on page 3*

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NCTR is located at the University of South Florida's Center for Urban Transportation Research and is a federally-designated University Transportation Center, receiving annual grant funding from the Research and Innovative Technology Administration of U.S. DOT, with matching funds from the Florida Department of Transportation.

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# *Director's Message*

One of the goals of every University Transportation Center is to see the results of its research put into practice and/or modify policy. Clearly, even the best research reports have little value if the results of these reports are not known to those who can benefit. The National Center for Transit Research goes to great lengths to share the information generated by our full-time research faculty and the students who work with them. We apply a search engine optimization strategy that includes offering quality, original content and targeted use of meta tags to make it easy to find NCTR research via web searches on the leading search engines like Google, Bing and Yahoo!. The end result is that NCTR will appear at or near the top of organic search results on "transit research."

We explore every avenue possible to let the transportation community know about the results of the research we do that is funded by the U.S. DOT and the Florida Department of Transportation. Some of the steps we take are keeping our website current, notifying the 5,000+ members of our listservs when new reports are available, making presentations at professional committee meetings and conferences, requesting other transportation websites to post links to our reports, and holding conferences on specific topics. In the past few months, we increased the frequency of our use of webinars for sharing research results. Following NCTR's nearly 10-year record of webinars, the USF Center for Urban Transportation Research (CUTR), in which NCTR is housed, has established a bi-weekly "CUTR Webcast Online Series." The purpose of these **FREE** webinars is threefold:

- Increase knowledge of transportation professionals and policymakers in Florida and the rest of the country by sharing the latest findings of transportation research.
- Increase the reach of technology transfer, especially to those transportation professionals who are unable to travel to state and national conferences, due to time and cost constraints.
- Encourage discussion among participants and receive input on subjects requiring future research.

These CUTR Webcasts are held **every other Thursday** from 12:00 noon to 1 p.m. Eastern time. These webinars have attracted as many as 300 people from all over the country, as well as from around the world. We hope you will join us and share information about our webinars with those in your agencies that have an interest in the topics presented. If you cannot join us for the live webinar, the event will be recorded and available for on-demand streaming. Easy directions for joining and/or viewing can be found at www.cutr.usf.edu/events_news/webcast.shtml. You will also find a listing of upcoming webinars that are already scheduled through June 2011.

We invite you to subscribe to receive announcements by email for webcasts, research reports, and training opportunities at http://lists.cutr.usf.edu/read/all_forums/subscribe?name=cutr

***Joel Volinski***
Director, National Center for Transit Research


*Camera-Based Systems—from page 1*

the results of controlled driving tests and driver surveys using sideview video systems.

This project had five primary objectives:

- Compare available systems, including mirror-, sensor-, and camera-based technologies, to reduce transit bus side and other collisions.
- Measure blind zone reductions on the side of common types of transit buses using camera-based systems.
- Conduct and analyze transit bus driving tests with and without camera-based systems in a controlled environment.
- Conduct and analyze transit bus driver surveys on driver satisfaction for using camera-based systems on lane changes.
- Provide major findings and recommendations.

## Findings

The comparison of mirrors and camera systems from this study showed that the side blind zones that exist due to the mirrors' inability to cover the area were greatly reduced or eliminated when using the sideview video system with wide-angle cameras. The result from volumetric measurements of blind zone reduction from this study showed that the camera-based system with a regular-angle lens (no distorted image) can reduce about 64% of the blind zones of a flat mirror system. It can reduce about 43% of blind zones of a common combined flat and convex mirror system. Using a wide-angle lens, the blind zones on the both sides of transit buses can be completely eliminated.

The camera-based technology for transit buses to reduce blind zones is fairly new, so there are no crash data associated with the implementation of the technology. The approach selected in this study was to closely evaluate the aftermarket sideview video system using a controlled driving test that simulated reality scenarios. Twenty-eight participating bus drivers performed the controlled driving tests with and without using the sideview video system. It was found that most bus drivers were able to adapt to the sideview video system and quickly learn how to use the system to drive without mirrors. While using the video system, the bus drivers could perceive distances similar to the mirrors while the bus was in motion. By using the sideview system, bus drivers could still see the vehicle in the blind zone of the mirrors; thus, the controlled driving test confirmed the great potential of camera-based systems to reduce transit bus side collisions caused by the blind zones of mirrors.

Driver surveys were taken by 28 bus drivers before and after the controlled driving test to provide valuable feedback on the sideview video system. It was found that bus drivers valued the benefits of having the sideview video system. The majority of drivers agreed that the sideview video system can be useful in helping

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them see passengers better and observe vehicles in the next lanes during lane changing maneuvers. They agreed that the system can minimize or eliminate the side blind zones of the bus.

The majority of bus drivers agreed that the mirrors become less effective during rainy weather and that it is difficult to identify a person with them at night. It was observed in this study that the sideview video system with infrared sensors could perform better than the mirrors in dark conditions and in rain. Also, the wide field of view provided the drivers with a much better sideview, thus creating great potential to avoid vehicles during lane changing maneuvers. Overall, the majority of the participating bus drivers valued and liked the sideview video system, but they were not completely confident about replacing the mirrors with the system used in the controlled driving test without further enhancement. The survey result suggested that the reliability of the sideview video system needs to be further explored and the system setup can be further improved.

The reduction of transit bus side collisions can significantly improve the safety of transit bus operations and save lives. It is also important to note that the sideview video systems tested in this study were available as aftermarket systems designed and manufactured to provide additional side views of the vehicle, but were

**Comparison of Systems for Side Collision Avoidance**

| *System* | *Advantages* | *Disadvantages* |
|---|---|---|
| **Mirror-Based** | Used since beginning of vehicle manufacturing. Default device on all vehicles. Trusted by drivers. Does not malfunction except if removed. Relatively inexpensive. | Does not cover the necessary area on the side to help drivers avoid all potential collisions. Passive devices (require driver attention to work). Weather deteriorates their effectiveness. |
| **Sensor-Based** (ultrasonic, lidar, radar, infrared, computer vision) | Relatively accurate, active devices that provide the driver with audio/visual warning on imminent hazard. Long range, cover all blind zones. Used for a decade on vehicles. Beginning to gain driver's trust. | Expensive. Prone to damage easily. Can malfunction. Maintenance required. Some environmental conditions required to work. Shown to not work 100% of the time. Does not provide visual image. |
| **Camera-Based** | Used to add views in blind zones. Relatively inexpensive. Provide a visual image, similar to the mirrors. Can cover a very large area covering all blind zones. | Passive devices like mirrors. Fog deteriorates their effectiveness. More expensive than mirrors. Not widespread use yet. Can malfunction. Require maintenance. |

not perfect and were not designed to be used in place of mirrors. Therefore, the existing sideview video system has great potential to be further enhanced and evaluated for use in the field to replace mirrors.

If sideview video systems can be enhanced and implemented in a widespread manner in the future, they can save lives, significantly reduce the number of side crashes due to blind zones of mirrors, decrease crash-related costs, and eliminate the possibility of hitting waiting passengers with mirrors. The successful implementation of sideview video systems on transit buses in Florida will provide considerable safety and economic efficiency benefits for Florida.

This research project was conducted by Drs. Pei-Sung Lin, Chanyoung Lee, and Achilleas Kourtellis and Ms. Meeta Saxena at the USF Center for Urban Transportation Research under the guidance of Ms. Erin K. Schepers, FDOT Project Manager. Contact Dr. Lin at 813-974-4910 or lin@cutr.usf.edu for more information.

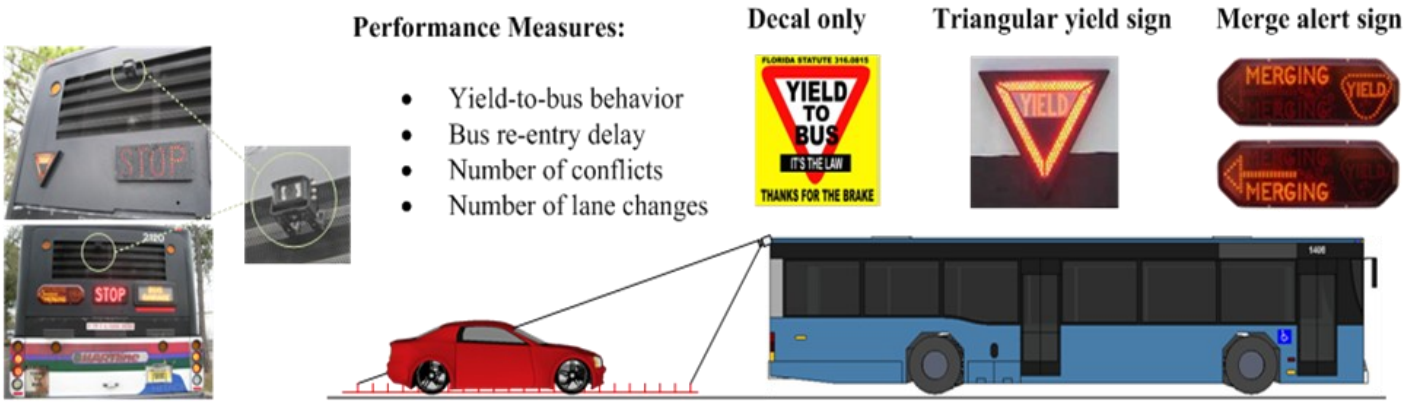
# *Moving the Bus Safely Back Into Traffic*

**Background and Objectives**

The difficulty experienced by transit buses in moving back into traffic safely from bus pullout bays has become a serious problem due to potential hazards between buses merging from the pullout bays and the surrounding traffic. Previous studies have determined the need to closely examine the engineering side of the Yield-to-Bus (YTB) program and to develop effective countermeasures to address the issue.


In 2004, a crash study was conducted to examine all reported bus crashes during the period of 1998 to 2002 on the State Highway System in Florida. It was found that most of the serious crashes occurred near bus stops and were characterized by vehicles striking the back of the bus. Most transit agencies expressed their preferences for the implementation of more pullout bays, while those with reservations about this measure were concerned regarding the ability of the buses to merge back into traffic safely. Bus operators have called pullout bays “bus traps” because traffic often does not allow buses to easily re-enter flowing traffic. The Florida Department of Transportation (FDOT), through the National Center for Transit Research (NCTR) at USF, has actively focused on determining the best set of treatments to promote YTB compliance. As part of these efforts, Phase I of this research was completed in November 2007. It presented a comprehensive overview of

the existing signage, lighting configurations, and existing YTB laws to help buses merge back into traffic from bus pull-out bays. The recommendations from Phase I included (1) develop potential traffic control devices, i.e., signs, pavement markings, and flashing beacons to help buses merge safely back into traffic, (2) evaluate the latest YTB Light Emitting Diode (YTB-LED) flashing signs on the back of buses, (3) assess safety and operational benefits, and (4) develop recommendations for implementing an effective program to increase public awareness of YTB laws.




This study focuses on the assessment of the safety and operational benefits of the use of YTB-LED signs on the back of buses. The main objectives of this study are as follows:

- Determine if the use of YTB-LED signs on the back of buses has an effect on the yield-to-bus behavior of motorists behind the bus.
- Assess the potential effects on traffic safety with the use of YTB-LED signs.
- Establish the operational benefits of the YTB-LED signs.
- Provide recommendations for implementation of YTB-LED signs and a public awareness campaign for YTB programs.

## Findings and Conclusions

### *Safety*

Yield-to-bus issues are present not only in bus bays but also at several locations that require transit buses to pull out of the traffic mainline (such as parking lanes and right turn lanes). All these locations can benefit from the implementation of YTB-LED signs.

There is statistical evidence that the use of YTB-LED signs will have a positive effect on the yield-to-bus behavior of motorists behind the bus. In all three test corridors in this study, the proportion of maneuvers involving yielding to the bus increased with the implementation of YTB-LED signs.

On the test corridor in Tampa, where buses were observed merging from bus bays, it was found that with YTB-LED signs, the proportion of merging maneuvers involving a yield increased 34% compared to the use of the decal-

only treatment. On the test corridor in Fort Myers, where buses were observed merging from right turn lanes, the implementation of the YTB-LED sign improved yielding behavior by 20%. On the test corridor in Daytona Beach, where buses were observed merging from parallel parking spaces, the use of YTB-LED signs improved yielding behavior by 50%.

Bus bays are more likely to experience direct conflicts than bus stops at right turn lanes. This is mainly because in a bus bay the bus cannot gain enough speed to facilitate the merging maneuver. Longer bus bays potentially could alleviate this issue.

On the test corridor in Tampa, the total number of maneuvers involving conflicts was reduced by 80% through using YTB-LED signs. On the Daytona Beach corridor, the number of conflicts was reduced by 66%. On the Fort Myers corridor, the number of conflicts across the different YTB treatments (YTB-LED signs and decal) was similar.

The use of YTB-LED signs has great potential for reducing the number of conflicts for buses merging back into traffic from pullout bays on urban minor arterials. For major roads, the use of YTB-LED signs may improve yield-to-bus behavior without compromising safety. The YTB-LED sign potentially can help to improve the yield-to-bus behavior of motorists without introducing new traffic conflicts.

### *Operations*

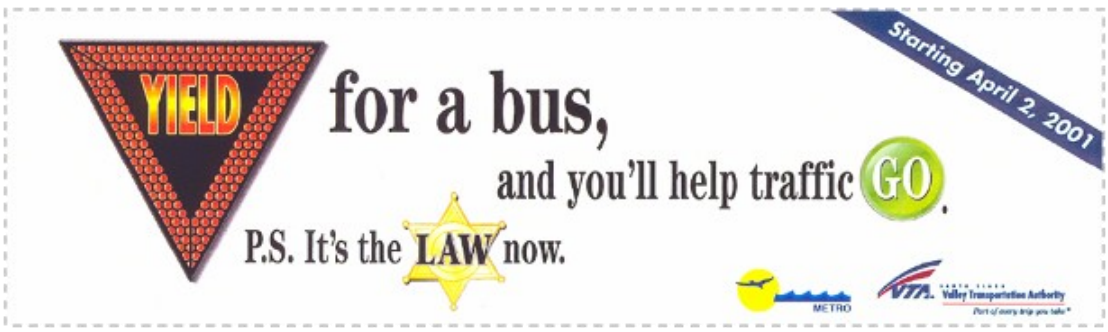
The use of YTB-LED signs on the back of the buses helps to reduce the re-entry time of buses in bus bays on 2-lane urban corridors. Based on field observations, this reduction ranged from 10% to 23%, helping buses to maintain schedules.

YTB-LED signs can help the bus merge back into traffic in long traffic lines during peak hours.

YTB-LED signs have a considerable impact on reducing re-entry time for cases of 2-lane and 4-lane corridors. This is mainly due to the reduced space in which to maneuver on such corridors for both transit buses and motorists. On 6-lane corridors, the re-entry time was not significantly affected.

### *Public Education*

Periodic reminders to the public and bus operators are needed to carry out a successful yield-to-bus program.




Placing educational ads on the back of buses is one of the most effective ways to keep the general public informed about traffic safety practices related to transit buses.

Traffic safety and engineering studies are important to justify the benefits of a YTB program. This also will help ensure the continuity of the program.

Promotion of effective communications between YTB program leaders and enforcement officials is necessary. Police can help YTB efforts and improve road safety for buses.

**Benefits**

This study provided recommendations for YTB-LED sign compliance and installation in accordance with NHTSA standards and national regulations. It also provided recommendations on the operations and proved that the use of a YTB-LED sign will not impair any of the regulatory lamps. This will be beneficial in case any transit agency decides to implement these types of signs.

***The study results indicated that YTB-LED treatment has the potential to improve safety for transit buses and surrounding vehicles.***

This study assessed the impact of the use of YTB-LED signs on yield-to-bus behavior. The data indicated that the use of a YTB-LED sign has a positive impact on the yield-to-bus behavior of motorists on both minor and major arterial roads. The increased YTB behavior did not increase the number of traffic conflicts; therefore, YTB-LED signs are a viable treatment to improve road safety for transit buses.

This study assessed the operational impact of the use of YTB-LED signs. It was observed that the use of the signs helped the bus merge back into traffic in long traffic lines. This feature can be beneficial for transit agencies with bus routes on congested roads during peak hours. The use of the signs may also have a beneficial effect on improving the bus travel time reliability during peak hours.

This study compiled yield-to-bus experiences and lessons learned from agencies outside Florida. This information will be beneficial to all transit agencies that are initiating YTB campaigns. The information provided through the interviews can help agencies to better allocate their resources among the different YTB initiatives.

This study provided an evaluation of the safety and operational benefits of one of the many available yield-to-bus treatments. The study established different performance measures for behavior, safety, and bus operations. Also, a data collection methodology was devised and proved to be feasible to implement in the majority of transit buses. The results indicated that YTB-LED treatment has the potential to improve safety for transit buses and surrounding vehicles. The YTB-LED signs need to be properly introduced to the public through an education campaign. This study also provides recommendations on this subject. Overall, this study is beneficial for agencies looking to implement yield-to-bus treatments by providing an estimation of their possible short- to medium-term effects.

This research project was conducted by Dr. Pei-Sung Lin at CUTR. For more information, contact Dr. Lin at (813) 974-4910 or lin@cutr.usf.edu.

## *FY 2011 Newly-Designated NCTR Projects*

- Best Practices in Bus Dispatch (DeAnnuntis, CUTR, 77930)
- Assessing the Impact of Proposed Transit Investments and Public Policy Choices on Land Use Patterns (A Simulation Approach with UrbanSim) (Lee, CUTR, 77931)
- Estimating Cost and Benefits of Emission Reductions Strategies for Transit by Extending the TRIMMS Model (Concas, CUTR, 77932)
- Dynamic Delivery of the National Transit Database Sampling Manual (Chu, CUTR, 77933)
- Analysis of the Status and Impact of Transit Research (Audino, CUTR, 77934)
- Development of a Regional Public Transportation GIS Architecture and Data Model (Barbeau, CUTR, 77935)
- Quantifying the Benefits of the Transit Research Inspection Procurement Services (TRIPS) Program (Davis, CUTR, 77936)
- A Guide to Design, Policies, and Operational Characteristics for Shared Bicycle/Bus Lanes (Hillsman, CUTR, 77937)
- Field Evaluation of YTB Roadside Treatments and Bus Pullout Bays Design Characteristics (Lin, CUTR, 77938)

## *FY 2011 Ongoing NCTR Projects*

- An Assessment of Public Transportation Markets Using NHTS Data (Chu, CUTR, 77920)
- Improving Value of Travel Time Savings Estimation for More Effective Transportation Project Evaluation (Perk, CUTR, 77921)
- Project UCARE: Uniform Cost Accounting and Reporting Elements for TDM (Winters, CUTR, 77922)
- Exploring Opportunities to Expand Public Transportation Services in Florida through Potential Private Sector Participation: Phase I – Analysis of Contracting for Fixed Route Bus Service (Reich, CUTR, 77923)
- Florida Bus Maintenance Staffing Practices (Goodwill, CUTR, 77924)
- Exploration of Transit's Sustainability Competitiveness (Polzin, CUTR, 77925)
- Enabling Cost-Effective Multimodal Trip Planners through Open Transit Data (Hillsman, CUTR, 77926)
- Tracking Costs of Alternative Fueled Buses in Florida (Reich, CUTR, 77927)
- HSR Station Area Access (Gregg, CUTR, 77928)
- Expanding the Google Transit Data Feed Specification to Support Operations and Planning (Catala, CUTR, 77902)
- Development of a Program Assessment Instrument for the Certified Transit Technician Program – Phase One (Reich, CUTR, 77911)
- TBEST Model Enhancements – Parcel Level Demographic Data Capabilities and Concepts for Park-and-Ride Modeling (Polzin, CUTR, 77801)
- Dynamic Travel Information – Personalized and Delivered to Your Cell Phone (Barbeau, CUTR, 77804)

## *NCTR Projects Completed in FY 2011*

- Travel Assistant Device – Deployment to Transit Agencies (Barbeau, CUTR, 77904)
- Assessing Air Quality Impacts of Managed Lanes (Stuart, Environmental Engineering, 6402-1041-00)
- Developing a Framework for a Toolkit for Carbon Footprint that Integrates Transit (C-FIT) (Hendricks, CUTR, 77909)
- Moving the Bus Back into Traffic Phase 2 (Lin, CUTR, 77910)

Information on NCTR research projects and contact information for principal investigators can be accessed at www.nctr.usf.edu/list_of_projects.html.