Research aims to improve left-turn safety at intersections

In recent years, the transportation community has introduced significant changes to improve left turn safety at signalized intersections—and for good reason. Nationally, intersection crashes represent one-fifth of all fatal crashes, and most of these are crashes involving left turns. During 2012 in Minnesota alone, there were almost 3,300 crashes involving vehicles turning left into oncoming traffic, including more than 1,100 fatal and personal injury crashes.

In response to this serious safety problem, the Federal Highway Administration has adopted a new national standard for permissive left turns: the flashing yellow arrow. This signal warns drivers that they should proceed with a left-turn only after yielding to any oncoming traffic or pedestrians. Studies have demonstrated that the new signals can help prevent crashes, move more traffic through an intersection, and provide additional traffic management flexibility for road agencies.

However, this tool raises new questions for traffic engineers. For example, engineers must decide when to use a protected “green arrow” left-turn signal and when to use a permitted “flashing yellow arrow” left-turn signal. “Using protected left-turn treatments when opposing traffic volumes are low can lead drivers to believe they are being needlessly delayed and reduce the intersection’s capacity for accommodating other movements,” says Gary Davis, a University of Minnesota civil engineering professor and researcher with the Roadway Safety Institute (RSI). “The key is finding the right balance between the safety provided by protected left turns and the delay that they can cause.”

Many transportation agencies, including the Minnesota Department of Transportation, are interested in using the new flashing yellow arrow signals to accommodate within-day changes: protected left turns could be used when needed to reduce delay and lower crash risk, while permitted left turns (signaled by a flashing yellow arrow) could be used to reduce delay when the crash risk is acceptably low. “Of course, this requires being able to predict how the risk of left-turn crashes changes as intersection and traffic characteristics change within the course of a day,” Davis says.
To answer this question, Davis is spearheading an RSI research project that will create an advanced simulation model of left-turn crashes. The project will first reduce crash rates by incorporating traffic signals, and then it will incorporate the findings into a previously developed prototype crash simulation model. To further improve the model’s accuracy, the study will compare the crashes described by the simulation model with reconstructed real-world left-turn crashes and use those results to enhance the model.

Davis projects that the findings will be immediately useful to researchers and modelers seeking realistic descriptions of driver behavior in left-turn situations. “By simulating how crash risk changes as traffic conditions change, this model could help identify conditions when permitted left-turn treatments would be a good choice and what times of day a protected left turn might be a better option,” he says.

Advancing pedestrian safety through countermeasures that work

In conflicts between pedestrians and vehicles, pedestrians are clearly at a disadvantage. “The driver has the weapon,” said Ron Van Houten, a professor of psychology and a member of the behavior analysis faculty at Western Michigan University. “Pedestrians include children, people with disabilities, seniors who no longer can drive... When you drive the car, you have a higher responsibility than when you’re walking.”

Van Houten, who is also a researcher with the Roadway Safety Institute, has worked extensively in the field of traffic and pedestrian safety and has developed many innovative traffic safety countermeasures. At a recent seminar sponsored by the Institute, Van Houten discussed treatment options that target the behavior of both pedestrians and motorists to improve safety.

On the pedestrian side, one approach is to increase compliance with crossing signals. “One of the most important things we discovered... is that people will only wait so long [to cross a street] and then they’ll take a risk,” Van Houten said. Some ways to increase compliance with the signal is to give pedestrians something to do (or read or look at) as they wait—flowers in the median or artwork, for example.

Uncertainty—about whether the push button works, how long they’ll need to wait to cross, and how much time is left to cross—also reduces pedestrian waiting compliance. User countdown times and push buttons that confirm they’ve been pressed increase the percentage of pedestrians waiting, Van Houten said.

An approach that targets driver behavior is the use of offset or advanced stop bars. Moving them further back from the intersection improves safety for both pedestrians and drivers. This gives pedestrians and drivers a clearer view of each other, especially at multilane crossings, which have a greater potential for screening crashes.

Another countermeasure for multiline roads is to create a “gateway” configuration of in-street signs—one installed between the two travel lanes in each direction, and one on both edges of the roadway in each direction—to produce an apparent narrowing of the travel lane. Van Houten also described a recent high-visibility enforcement initiative in Gainesville, Florida, aimed at improving driver-yielding behavior to pedestrians on a citywide basis. The team was interested in learning whether efforts could change the culture—not just at enforcement sites, but at all sites—and whether changes could be sustained.

The project coordinated engineering, education, and enforcement efforts into what Van Houten called a “treatment package.” The strategy consisted of four two-week enforcement waves over the course of a year, staggered to attract attention from the media.

Enforcement efforts began with a warning period during which officers distributed flyers to help “sell” the program and allow a transition from “no enforcement” to “enforcement.” Sandwich boards placed downstream of the enforcement site informed drivers that a pedestrian operation was being conducted. Other important components were standardized procedures that held up in court and a standard protocol for staged crossings to mitigate reactions against potential accusations of entrapment.

Engineering components included “no passing” zones before the crosswalk, advanced yield markings, and in-street signs to remind motorists that yielding to pedestrians is a state law.

Results showed a steady increase in the percentage of drivers yielding right-of-way to pedestrians over the course of the year, and higher levels of yielding to natural pedestrian crossings than to staged crossings (yielding for natural crossings rose from 45 to 82 percent), and changes in both were highly correlated, Van Houten said. The program also seems to have produced a marked increase in yielding behavior best described as a sustained change in driving culture, he added. The team will follow up after three years’ time to test this.

App for blind pedestrians featured in media

Work by Roadway Safety Institute researcher Chen-Fu Liao to improve safety for blind pedestrians was featured this summer in the Minneapolis Star Tribune.

To help pedestrians who are blind or visually impaired find their way safely, University of Minnesota researchers have developed a smartphone app that can detect upcoming work zones and provide routing instructions. The project, funded by the Minnesota Department of Transportation (MnDOT), was led by Liao.

The app builds on a previously developed smartphone-based system that was designed to provide visually impaired pedestrians with geometric and signal timing information at signalized intersections. Funding for the original project, also led by Liao, was provided by the Intelligent Transportation Systems Institute.
As part of their work developing the new work-zone component, the researchers surveyed a group of teen drivers and parents. The goal was to better understand their challenges and the information that would be most helpful to them when approaching a work zone. Results provided the researchers with guidelines as to what information the app would communicate to users.

The app uses Bluetooth beacons—which can be attached to signs, posts, or construction barriers in a work zone—that communicate with the GPS receiver on a user’s smartphone. When a beacon is detected, the phone vibrates and provides an audio message. The message includes the pedestrian’s current location, the location of the work zone, and suggested routing instructions. The user can tap the smartphone to have the message repeated.

The federal government strongly encourages states to provide either audible warnings or tactile marks at work zones where visually impaired pedestrians will likely be affected.

“The smartphone application is a step in that direction,” says Ken Johnson, a work zone, pavement marking, and traffic devices engineer at MnDOT and the project’s technical liaison. “It’s a way to see if this type of wayfinding device would work.”

The researchers also integrated the work-zone component with the intersection crossing information provided by the previously developed system. If a Bluetooth beacon mounts both work-zone and intersection information, the app provides the work-zone message followed by the intersection and traffic signal information, based on the direction the smartphone is pointing.

Moving forward, the researchers plan to work with MnDOT and local cities to access real-time traffic signal information and work-zone construction information on a larger scale. Prior to the release of the app, additional testing will also be conducted.

In addition, the research team has received funding from the Roadway Safety Institute to expand the project by creating a “condition aware” infrastructure that can be integrated with the smartphone app. The goal is a system that can self-monitor and keep the information it broadcasts to app users as up-to-date as possible.

The project will include the development of Bluetooth devices that can be installed anywhere, such as on a light post at an intersection or on a construction barricade or traffic cone. These devices, which will be able to sense other devices within their range, will help create a local map of the environment. A database that contains the location and message of each device will be integrated with the smartphone app to provide navigation information to visually impaired pedestrians.

“This mapping methodology will ensure that correct audio information is provided to app users at the right location,” Liao says. “It could be used anywhere—at traffic intersections, skyways, or underground tunnels—to provide directions for travelers.”

Researcher Spotlight: Gary Davis
Gary Davis is a professor in the Department of Civil, Environmental, and Geo-Engineering at the University of Minnesota and a researcher for the Roadway Safety Institute. He has worked at the University since 1989.

Davis’s research interests revolve primarily around traffic safety. He recently partnered with the Minnesota Traffic Observatory and Minnesota Department of Transportation (MnDOT) on a study to investigate the safety benefits of flashing LED stop signs and their crash-reducing effects at intersections. Davis also just completed a project with MnDOT that examined left-turn crash risk changes as a function of traffic volumes. MnDOT plans to use the findings to draft new guidelines on protected versus permissive phasing.

As an Institute researcher, Davis will lead work on a simulation model for left-turn crashes, which will help provide insight on issues surrounding signal timing, left turn onsets, and other design questions. (See related article.)

“I’m really interested in trying to drill down (traffic safety issues) — going from aggregated crash statistics to trying to understand what happens in individual crashes,” Davis says. Historically, that’s been a difficult thing to pursue because one had to rely primarily on after-the-fact crash investigations, he explains. But with today’s newer measurement technologies, “There are interesting opportunities to take more advanced measurements and push the understanding beyond what was possible in the past.”

Davis says he believes the most pressing traffic-related issue in the United States is how to balance a rapidly growing population with increasing demands for transportation. “In other words, having to accommodate more and more people on a transportation system that’s basically more or less limited in terms of its capacity,” he says.

Davis received his B.S. and M.S. degrees in experimental psychology from Eastern Washington University and M.S. and Ph. D. degrees in civil engineering from the University of Washington. Before coming to the University, Davis worked as a visiting researcher at the Royal Institution of Technology in Stockholm, Sweden.

Researcher Spotlight: Huagao Zhou and Albert Luo
Huagao (Hugo) Zhou’s research focuses on improving roadway safety through advanced geometric design, access control, and ITS technologies. An associate professor of civil engineering at Auburn University, Zhou is also a leading expert on wrong-way driving crashes and has authored reports for the American Traffic Safety Services Association and the Illinois Center for Transportation on the subject.

Zhou holds doctorate degrees in transportation engineering from the University of South Florida and in highway and railway engineering from Beijing Jiao-Tong University, Beijing, and a bachelor of science degree in civil engineering from Beijing Jiao-Tong University.

“On average, 360 people are killed each year by wrong-way crashes,” says Zhou. “This trend has been consistent even though the total number of fatal crashes has decreased over the last several decades.”

As part of his wrong-way driving research, Zhou has investigated possible countermeasures to reduce wrong-way crashes and fatalities, and discovered that directional rumble strips are one possible countermeasure for the wrong-way driving problem.

The need for additional research in this area led Zhou, who was a faculty member at Southern Illinois University Edwardsville (SIUE) from 2008 to 2013, to recruit colleague Albert Luo, a distinguished research professor of mechanical engineering at SIUE, to the RSI research team. Luo holds a B.S. in mechanical engineering from the Sichuan Institute of Chemical Technology, Zigong, Sichuan, China, an M.S. in engineering mechanics from the Dalian University of Technology, Dalian, Liaoning, China, and a Ph.D. in mechanical engineering from the University of Manitoba, Winnipeg, Manitoba.

“Many safety countermeasures require a multidisciplinary research team, and this is no exception,” says Zhou. “Dr. Luo’s background in field testing and vibration modeling will be extremely important for developing an innovative countermeasure—directional rumble strips for reducing wrong-way driving.”

One of the main advantages of being part of the Roadway Safety Institute (RSI) research team is the ability to work closely with other researchers across a variety of disciplines, Zhou says. “RSI provides a great opportunity for researchers to develop cutting-edge research projects and to exchange ideas with the world-class roadway safety researchers at other institutions.”

Through this unique partnership and the RSI, Luo and Zhou will work together to help reverse the continuing trend of deadly wrong-way crashes.

Speakers and dates announced for seminar series
The schedule has been released for the new Roadway Safety Institute (RSI) seminar series. From September 11 through December 4, seminars will be held Thursdays, 3-4 p.m. CST, on the University of Minnesota’s east bank campus in Minneapolis and will also be streamed live on the web.

In the first seminar, “Supporting New Teen Drivers During Independent Driving,” RSI researcher Jason Crouse will provide an overview and preliminary results of a field operational test of the Teen Driver Support System. This smartphone-based system provides real-time, in-vehicle feedback to teen drivers about risky driving behavior and immediately communicates (via text messages) with parents if the behavior continues.
On September 18, RSI researcher Huaguo Zhou will present findings of a project that investigated the causes of wrong-way crashes and identified potential cost-effective countermeasures.

Visit the Roadway Safety Institute website at roadwaysafety.umn.edu/events/seminars/2014/ for more details about these and other seminars.

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