Check for updates

TRR
JOURNAL OF THE TRANSPORTATION RESEARCH BOARD

Article

Transportation Research Record
2018, Vol. 2672(8) 1–9
© National Academy of Sciences:
Transportation Research Board 2018
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/0361198118758039
journals.sagepub.com/home/trr
SAGE

Successful Practices and Training Initiatives to Reduce Bus Accidents and Incidents at Transit Agencies: Abridged Version of TCRP Synthesis 126

Jodi Godfrey[1], Lisa Staes[1], Jenifer Flynn[1], and Roberta Yegidis[1]

Abstract

The purpose of this study is to document successful practices and training initiatives that have been effective in reducing transit accidents and incidents. Recognizing that safety does not occur in a vacuum, this study also focuses on other system approaches that have been implemented to address safety hazards. These approaches include various technology applications, infrastructure modifications, and other programs and initiatives, such as driver incentive programs and close call/near miss reporting. The research team conducted a literature review; performed a survey of selected transit agencies; and identified and conducted detailed case studies of 11 public transit agencies, selected from the survey respondents based on their responses to the survey. Effective safety management is comprehensive and multifocused in nature. At the case study agencies, safety management methods are often undertaken concurrently or within a period that does not provide agencies the ability to establish, with certainty, that one method or strategy contributed more to improved safety versus another. Successful programs examined in the case studies have been effective because of multifaceted, coordinated efforts to address transit safety. Strategies such as increased or modified operator training, technology applications, infrastructure modifications, and safety campaigns and promotions were often implemented simultaneously. Thus, judging the relative success of one strategy in reducing transit incidents when multiple strategies were implemented concurrently was difficult. Case study participants agreed that the progress toward a mature safety management system (SMS) framework within their agencies would contribute to an overall reduction in transit safety risks.

For this study, the definition of safety was adopted from the *Transit Safety Management and Performance Measurement* guidebook (p. 17) as, "the state in which the risk of injury to persons or damage to property is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management" (*1, 2*).

Along with the definition of safety used in this study, the institution of safety management systems (SMSs) was central to the safety cultures that were examined. Mature SMS structures and associated activities do not occur in a vacuum. Risk and associated mitigation measures include myriad strategies; risks associated with transit collisions, as an example, are not strictly confined to the training of bus operators. SMSs establish that system approaches must be implemented to address safety hazards, including those that result in, or can result in, transit incidents or other systemic safety failures. In the transit industry, some of the measures undertaken to address system risks include, for example, various technology applications, infrastructure modifications, and other programs and initiatives, such as operator incentive programs and close call/near miss reporting. These strategies are reflected in the case studies and other report elements.

The primary objective of this study was to document public transit agency bus operator training programs and other strategies that have been successful in reducing accidents and incidents, resulting in safer transit systems for the communities they serve. Technology applications and other internal operational and personnel related policies and procedures were also examined. After a comprehensive literature review was conducted to gain an understanding of the impacts of training programs and incentives, technology solutions, and other safety rewards, the initial research objective was completed by means of an online survey that was distributed via email to 42 public transit agencies in the U.S. The transit agencies were chosen based on previous recognition of successful training programs and other collision mitigation methods, in addition to their size and geographical distributions. A total of 37 agencies responded, yielding an 88% response rate. From those 37 respondent agencies, 11 case

[1]Center for Urban Transportation Research, University of South Florida's College of Engineering, Tampa, FL

Corresponding Author:
Address correspondence to Jodi Godfrey Jodis@cutr.usf.edu

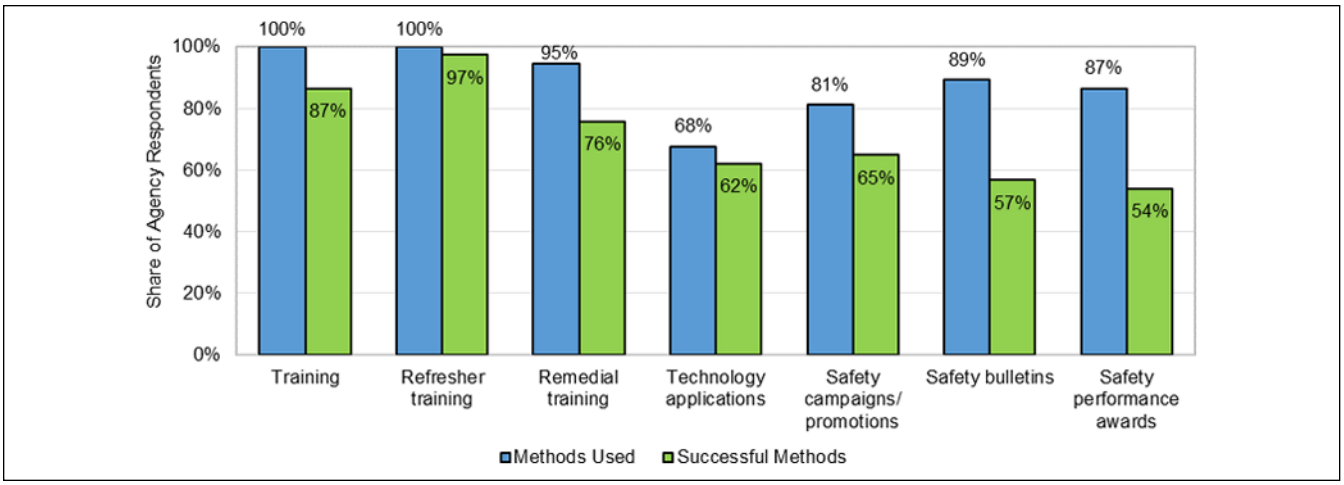

Figure 1. Methods used to mitigate identified safety-related issues and success rates.

study agencies were selected to highlight specific successful safety improvement strategies.

Survey Results

The 28-question survey collected information from 37 transit agencies that represented 23 states. The questions addressed system characteristics, accident review and risk assessment processes, bus operator training, use of technologies, and other agency policies or model practices.

Accident Review and Risk Assessment

Of the 37 survey respondents, 87% have an accident review board or use a similar process. Most of responding agencies (94%) task their accident review board with preventability determinations. Most agencies, 92% of survey respondents, indicated that their agency examines and tracks causal or contributing factors in safety event investigations to determine preventability. Human error is the most prevalent contributing factor reported by survey respondents (78%), followed closely by distractions (73%). Most survey respondents (83%) indicated that they use a database or electronic reporting system to track safety incidents.

Bus Operator Training

Once the safety-related issues are identified, the transit agencies use combinations of several methods to mitigate those issues. Given that these agencies were chosen as participants due, at least partially, to their known successful training initiatives and technology applications, it is no surprise that mitigation methods related to training have such a high indication of use among the respondents, as shown in Figure 1. Refresher training was reported as being the most successful mitigating method used to reduce prevalent safety issues within the transit agencies, with 97% of agencies reporting it as successful.

The subjects included in bus operator refresher safety training vary by agency, with over 90% of reporting agencies indicating they cover safety policies/procedures and defensive driving. Security is the least reported topic that agencies cover in their operator refresher training. In addition, 61% of the agencies indicated that new training opportunities have been offered, specifically targeting the reduction of incidents prevalent in their particular system. The agencies that utilize training simulators indicated that this method is primarily used to target common areas of risk based on agency safety trends. Telemetric video-based event monitoring systems were also identified as valuable tools for addressing not only particular agency incidents, but also risky operator behaviors and near miss incidents. Agencies indicated that this technology provides opportunities to counsel bus operators with the goal of adjusting their driving techniques and behaviors to prevent or reduce the probability of an incident occurring. This proactive approach to addressing safety-related incidents was noted by survey respondents as effective and successful.

The training delivery methods utilized by transit agencies vary depending on the agency. On-site, instructor-led (classroom) safety training is the most common refresher training delivery method reported, with 87% of the agencies indicating a preference for on-site classroom training. Behind-the-wheel training closely followed, with 77% of agencies preferring that delivery method.

Use of Technologies

The number of safety enhancing technologies used by transit agencies varied from 2 to 12 of the 13 technological enhancement options listed in this survey question. Of the listed technologies, all responding agencies indicated the use of a vehicle tracking system, whereas only 5.6% indicated the

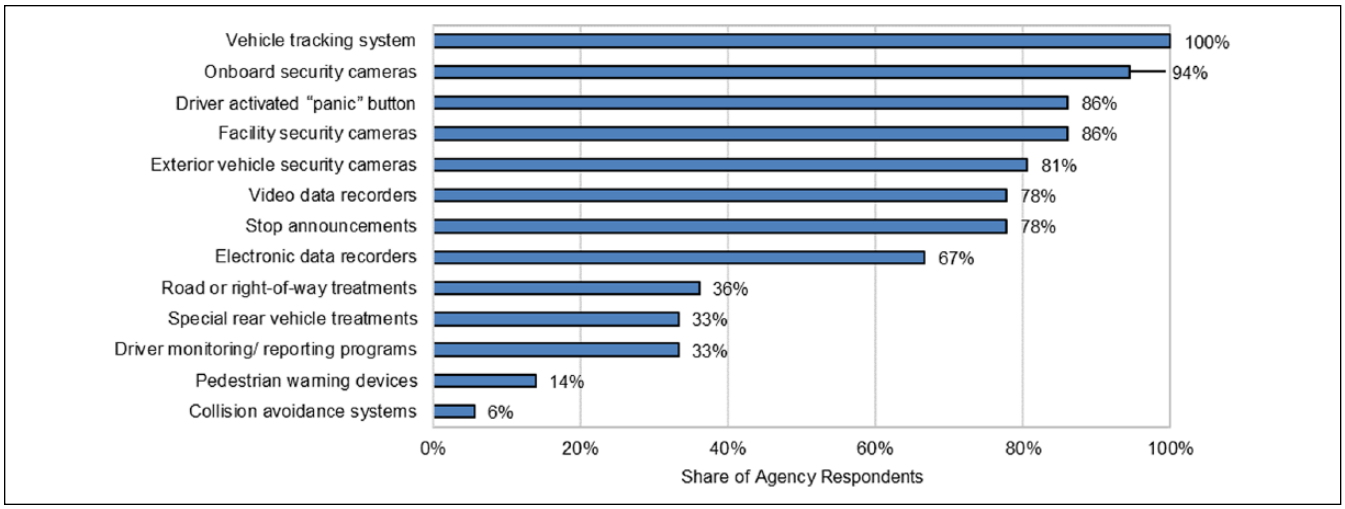

Figure 2. Share of technology use by type.

use of collision avoidance systems. Figure 2 displays the share of agencies that report the use of each safety technology.

The technological safety improvements have resulted in documented success in 58% of the agency responses. Of all the listed safety-enhancing technology applications, 42% of respondents indicated that the use of video and/or operator monitoring programs have been the most successful, adding that the use of onboard video attributed to documented success in the reduction of transit incidents.

Other Agency Policies and Model Practices

Most (71%) of the reporting transit agencies require their bus operators to report outside employment. Seven out of 10 agencies require their operators to report the use of over-the-counter medications. Nearly all respondents (92%) indicated that their agencies have a distracted driving policy for their bus operators. Most of the responding agencies (92%) follow a standard, rule, policy, or regulation related to operator hours of service.

Key trends that were echoed across agencies that reported model practices were the importance of regular refresher training and agencywide accountability. The safety culture of the agency is dependent on support from everyone from the general manager (GM) to operations, maintenance, administration, and safety. Respondents noted that it is critical that in agencies with labor unions, members of those unions are at the table and that safety is an area of focus in collective bargaining agreements. One of the central pillars to SMS is the ability to not only evaluate and react to existing trends, but also to identify areas of risk for which events have not yet occurred. This is when the telemetry-based driver monitoring and video surveillance systems demonstrate their usefulness and successes, as reported by the survey respondents.

Case Studies

A total of 11 case study sites were selected from the survey respondents based on their successes in instituting programs that demonstrated improved safety results, including the reduction of transit collisions or other incidents, as reported in the responses to the survey questionnaire. Details regarding each of the 11 case study agencies are expanded on in alphabetical order in this section of the paper.

Charlotte Area Transit System (Charlotte, North Carolina)

The mission of Charlotte Area Transit System (CATS) is "to improve the quality of life for everyone in the greater Charlotte region by providing outstanding communitywide public transit services while proactively contributing to focused growth and sustainable regional development" (*3*). CATS' training program was overhauled in 2014 to improve the consistency and structure of bus operator training. The new bus operator training at CATS is a seven-week program consisting of 90 hours of platform time. In addition, 8 hours of refresher training is provided to all operators bi-annually.

CATS buses are equipped with onboard video recording with audio, which was indicated as being the most effective technology in use by the agency because of the ability to substantiate complaints, identify poorly performing operators, and address issues before an incident occurring. The videos are also used for training purposes, as CATS finds it important that the operators observe and recognize practices performed correctly and those performed incorrectly.

CATS launched the "CATS See Say" app to enable riders to alert transit police if they notice something that seems concerning. This app was launched for the system because, as CATS Chief Executive Officer (CEO) Mr Lewis said, "Safety is and always will be a primary concern of CATS.

Through the use of this mobile app, riders can have a bigger hand in helping our public transit system operate as safely as possible" (*4*).

CATS' hours of service regulation are based on Federal Motor Carrier Safety Regulations (FMCSRs), and on-duty time is closely monitored to reduce incidents involving operator fatigue.

The GM is supportive of the training program, reviewed the entire overhaul of the training curriculum, and provided feedback throughout. Having a safety-focused accountable executive shapes the safety culture for the entire agency. Whereas CATS has had varying rates of collisions, probably at least partly attributable to increased population and economic growth, the monthly trend of preventable incidents has been declining over the past 2 years. This trend is especially significant when ridership, population, and construction are also increasing, meaning the chance of collisions is increasing.

City of Madison Metro Transit (Madison, Wisconsin)

The mission of City of Madison Metro Transit (Metro) is to provide safe, reliable, convenient, and efficient public transit to the citizens and visitors of the Metro service area through the efforts of dedicated, well-trained employees. In 2014, Metro officials began a bus stop consolidation project as an approach to address schedule issues caused by increased ridership. Following an analysis of bus stop spacing, a strategic reduction of stops improved on-time performance, while also improving safety and customer satisfaction. Metro has adopted the SMS framework, and includes initiatives such as increased data collection, risk identification and management, and the assurance of a safety manager who reports directly to the accountable executive: Metro's GM.

In 2008, Metro began the process of revamping its training curriculum. The agency reviewed all content used in training programs and modernized the curriculum, focusing more on the local needs specific to Madison. Metro indicated benefits to having as few as two trainees per instructor per bus, and providing more drive time for each trainee. More resources were allocated to training and were used to hire more trainers, reducing the training class sizes. Metro has also allocated an additional bus used in the training program to ensure that each trainee is allotted 4–5 h of behind-the-wheel time per day of training. These training improvements have resulted in noticeable positive feedback from the operators. Metro's annual refresher training follows a roundtable discussion structure. This training structure was designed to gather information and data directly from bus operators to recognize safety concerns and identify problem areas. The purpose of this approach to refresher training is to develop a safety culture within the agency that improves both accident prevention and company morale.

Madison Metro buses are equipped with video and audio surveillance equipment. The system records speed, braking, and turn-signal use. The use of this equipment was reported as beneficial, allowing for event specific one-on-one coaching and counseling of bus operators. In addition, the surveillance equipment is also an effective tool for investigating customer service complaints.

In 2014, Metro installed audible turn signals on all fixed-route buses that make a chirping noise when signaling a turn in traffic or pulling into a bus stop. In response to negative public feedback coupled with questionable effectiveness, Metro turned the audible turn signals off in 2015.

Metro launched the Safe Streets Campaign in November of 2014, which included the release of videos of safety-related close call incidents captured by Metro bus surveillance cameras. The goal of the campaign was to increase safety for everyone and prevent accidents by increasing community education and awareness.

Whereas there are no hours of service restrictions in Wisconsin, Metro operators have the right, through union restrictions, to refuse any work over 10 h behind the wheel, 12 h scheduled, or 13.5 h of spread time.

Metro's GM has been supportive in the development of modernized training manuals, and across-the-agency communication and collaboration on safety-related issues and mitigation strategies. Metro holds biweekly customer service and safety and security meetings in which the GM, deputy GM, marketing manager, customer service manager, and the operations and safety manager discuss issues and trends.

Whereas Metro has taken a multifaceted approach to improve safety, interviewing their general operations supervisor of safety and security revealed that open communication throughout the entire agency is highlighted as the most successful approach to increased safety. Renewed training curriculum along with several other campaigns, promotions, and technology applications, resulted in a 24% reduction in preventable/chargeable collisions from 2008 to 2015.

Greater Bridgeport Transit (Bridgeport, Connecticut)

Greater Bridgeport Transit (GBT) is committed to providing a safe, convenient, reliable bus service to ensure that the travel needs of visitors and residents are met. In late 2012, GBT began restructuring the agency, which included the introduction of two new positions related to safety training, the manager of safety training and the manager of transportation operations. Before the restructuring, safety training focused predominately on remedial areas such as post-accident training, or safety training for repetitive problems or repeat offenses. Since the restructuring, resources dedicated to training have increased, and in addition to new-hire training and remedial training, all GBT operators attend quarterly training sessions.

The new-hire training program is between 6 and 8 weeks in duration depending on the size of the class; 1 week of this is classroom training and the remainder of the time is spent on the road. On the final day of new-hire training, the trainee is in a room with a trainer and is quizzed on every run, every turn, every street, and every stop. On answering all questions correctly, the trainee graduates from the training program.

Two technology solutions have provided major assistance to GBT staff. These include an onboard surveillance system which allows for visual monitoring of activities in and around the bus, and an automated vehicle location (AVL) system, installed in 2009, that provides real-time information for dispatchers, road supervisors, and administrative staff. The combination of these tools allows GBT managers to have a full understanding of safety events and to address them properly.

The FMCSR hours of service regulations restrict operators from driving more than 10 h at a time and no more than 15 h per day.

GBT's CEO and Chief Operating Officer are heavily involved in the agency's safety program from policy development to day-to-day training. GBT credits their entire leadership team with the safety success of the agency. When asked what successful measure attributed to the increased safety culture at GBT, the interviewees indicated teamwork as being most successful, citing that working together to solve common issues has proven to be the most beneficial. The rolling 3-month preventable incident rate at GBT improved by an astounding 57% between October of 2012 and February of 2016.

Greater Cleveland Regional Transit Authority (Cleveland, Ohio)

The mission of the Greater Cleveland Regional Transit Authority (RTA) is "to provide safe, reliable, clean and courteous public transportation," and protecting the safety of employees, riders, and the public is the agency's top priority. RTA's safety program is guided by a culture of teamwork between departments, and accountability throughout the entire chain of command, from the CEO to frontline employees.

RTA installed telemetry-based driver monitoring system (DMS) equipment fleetwide in 2014 to help protect its operators, reduce costs associated with risky driving behaviors, and create a safer experience for riders. RTA makes use of feedback from the DMS, which records events and behaviors such as hard braking or following too closely, to determine when refresher or remedial training is needed for specific operators. Video footage will be shown to the operator and is sometimes shown to other operators for training purposes. Safety rounds are a part of the executive safety committee meeting in which near misses and other incidents are discussed to identify causal factors and ensure that employees are made aware of specific behaviors and actions to avoid. Most topics discussed during the safety rounds originate from video footage.

Exceptionally safe employees at RTA are nominated each month for the "Champions of Safety" award. Awardees are recognized at the executive safety committee's monthly meeting and receive a clock as a reminder that safety should be the top priority "around the clock." The following year, a calendar is distributed throughout RTA, with each calendar month including the Champion(s) of Safety recognized for that month in the year before. RTA also has an annual awards night, which is usually celebrated in April.

RTA follows the 10-hour rest rule, with shifts no longer than 14 hours.

When asked to comment on the keys to the success of RTA's safety program, staff cited the DMS, open and honest dialog with employees, a relentless pursuit of improvement, recognizing and rewarding employees for exceptional safety performance, and using teamwork between the safety and operations departments to create a true atmosphere of safety. Staff also strongly emphasized the importance of having a consistent, agencywide definition of safety, and commented that an agency can adjust service, but not an injury, because when safety is compromised the consequences can be permanent. The efforts at RTA have led to reduced collision rates in the agency's busiest districts.

Jacksonville Transportation Authority (Jacksonville, Florida)

The mission statement of Jacksonville Transportation Authority (JTA) is "to improve Northeast Florida's economy, environment, and quality of life by providing safe, reliable, and efficient multimodal transportation services and facilities" (*5*). With the arrival of JTA's new CEO in 2014, the agency undertook an aggressive restructuring and re-design initiative "Blueprint 2020," the primary catalyst for the evolution of JTA. One initiative of many that were implemented to support Blueprint 2020 was JTA's Route Optimization Initiative (ROI). The ROI was described by JTA as a "massive overhaul" of the agency's system, the first time in 30 years a comprehensive analysis and restructuring had been performed. Central to the ROI was a concerted effort to not only evaluate and modify JTA's legacy fixed-route system from operational and planning perspectives, but also from a position of mitigating safety risks inherent in the system.

In 2013, JTA instituted mandatory quarterly safety training meetings in which refresher training is conducted. During these meetings, representatives from JTA's safety, operations, and training departments combine to provide focused training on various topics, including those related to current areas of concern for the agency. Many of these topics are drawn from registering events from the telemetry-based video monitoring system and video footage. JTA installed DMS technology on 50 fixed-route buses in 2015, and at the time of data collection for this study, they were in the process of fitting all buses with this technology. JTA indicated that the system has been a valuable tool for individual coaching

with bus operators, and has led to a decrease in liability claims and insurance premiums.

JTA also utilizes a training simulator, which reportedly allows drivers the opportunity to associate muscle memory, reaction time, problem solving, decision making, and judgment all at the same time in a repetitive manner with none of the repercussions that would be associated with the same scenarios in the real world.

In November 2015, JTA kicked off the communitywide "Keep it in Your Pocket" distracted driving campaign, specifically emphasizing social media marketing. The success of the campaign was attributed to cooperation between JTA, the Jacksonville Sheriff's Office, Jacksonville Fire Department, and the Northeast Florida Safety Council.

The CEO at JTA, Nathaniel Ford, was identified as the driving force behind the agency's improved safety culture, particularly his agencywide challenge to do things differently. The combination of many efforts has evolved as JTA's SMS approach to improving bus safety, which has also led to improvements in preventable and non-preventable incidents and collisions.

Kansas City Area Transportation Authority (Kansas City, Missouri)

The mission statement of Kansas City Area Transit Authority (KCATA) is "We connect people to opportunities" (*6*). In response to some alarming safety trends, KCATA developed a comprehensive corrective action plan to reduce bus accidents. This five-point plan began in 2013 and focused on the five "E"s: engineering, education, enforcement, encouragement, and evaluation. In the area of engineering, KCATA spent $350,000 retrofitting its bus fleet with accelerometers to monitor operator driving behaviors. In the area of education, refresher and remedial training focused on pedestrian awareness, along with understanding and recognizing blind spots and how to mitigate them while driving. The agency's accident discipline policies and associated enforcement were strengthened, as well as the penalties associated with noncompliance with those policies. Recognizing the importance of encouragement, the agency created a safety suggestion program with recognition and rewards for employees who promote safe driving behavior. Finally, they established an evaluation program with metrics that are monitored and tracked.

KCATA utilizes bus simulators in all segments of its training program, including new operator, refresher, and remedial training. While the agency does not have data to establish the success of the simulator in training bus operators, KCATA indicated that the simulators were "absolutely effective." Onboard audio and video recordings of bus collisions and other events are saved in a video library and utilized in both refresher and remedial bus operator training.

The KCATA Passenger Code of Conduct was developed to inform passengers of rules and guidelines to promote safe behavior. KCATA celebrates Pedestrian Safety Week annually in May and pedestrian safety tips are communicated through KCATA's Transit Talk articles. They also adopted FTA's "Transit Watch," "Be Alert," and "Is This Yours?" public awareness outreach campaigns. KCATA representatives suggested that the combination of these passenger and pedestrian campaigns and programs be considered as a model for agencies across the country.

KCATA utilizes an incident occurrence tracking system to record transit incidents, both those meeting the National Transit Database (NTD) major incident reporting thresholds and minor incidents. KCATA tracks and trends incidents for routine discussion at KCATA's Safety Committee meetings in which mitigation measures are discussed and put forward for implementation.

The GM was very supportive of the safety programs instituted and he was central to the decision to purchase (and obtain funding) for the agency's simulators. The combination of many efforts along with GM support have led to reductions in pedestrian collisions, a 10% reduction in total bus collisions, and a 92% reduction in total claims paid by KCATA between 2012 and 2015.

King County Metro (Seattle, Washington)

Protecting the safety and security of customers, employees, and facilities is King County Metro's (Metro) top priority. In response to a spike in pedestrian-related events, Metro added several key components to its safety program that resulted in significant safety improvements throughout the agency. Metro requires annual refresher training (previously required every 3 years) for all bus operators, with an emphasis on pedestrian awareness. Metro also uses agency onboard video recordings in its training curriculum.

Metro upgraded its ride-check program to ensure that practical drift was not present in the pre-trip inspection process. The agency uses data analyses to determine and educate drivers of the places and times that are statistically of greatest risk. There has also been examination and piloting of several technologies at Metro such as audible bus turning warnings, strobe lights, automatic braking, and warning decals on the mirror frames to remind drivers to look for passengers.

Metro hosts an annual Safety Awareness Day with a barbeque, dunk tank, and other activities to emphasize the agency's safety message. In addition, Metro has adopted national safety campaigns such as "Be Seen, Be Safe, Be Smart," and even added "Look Up" to the campaign to remind pedestrians to be cognizant of their surroundings.

Metro has contracted with King County Police for an Operator Assaults Reduction Initiative. As part of this program, police trainers visit all Metro venues to explain the initiative and to educate operators on techniques they can use, such as "verbal judo" and other common-sense tools, to de-escalate tense situations. This initiative was reported as successful by the agency with a 6.1% decrease in operator assaults from 2014 to 2015.

Metro started a nonpunitive near miss pilot program to make sure operators have an opportunity to communicate hazards and other things that affect their ability to be safe in

the workplace. Feedback is also received through green cards, a hazardous reporting program, safety committee meetings, and safety awareness days.

Metro observes FMCSRs, allowing operators to drive for 14 hours, with 10 hours of rest.

Metro saw a 35% reduction in pedestrian events compared with 2013, and the reduction has continued into 2015. Overall, liability claims of all types against Metro were down 8% in 2014 versus 2013, and down 6.8% from the agency's 2009–2013 average. In 2014, claim payouts were down 39% from those in the 2009–2013 period. Moreover, reducing the cost of these claims has allowed Metro to put the savings back into its core operations.

Lane Transit District (Springfield, Oregon)

The mission of the Lane Transit District (LTD) is "to provide and improve services to all our diverse communities in ways that are sensitive and responsive to cultural differences, including accessibility for persons with disabilities" (*7*). LTD's overall approach to safety has been guided by an agencywide focus on customer service. The emphasis on customer service is so strong, in fact, that LTD places its advertisements for new operators in the customer service category rather than the driving category.

LTD has two types of refresher training. There is an annual "back to basics" refresher training that is mandatory for all operators. Mandatory refresher training also includes video footage of actual LTD accidents, a practice that has been found to be highly effective for keeping trainees fully engaged. The second type of refresher training is provided by a proprietary driver training system and is tailored specifically to operators who have had an accident.

LTD staff also distribute a monthly written "Review of Accidents" to operators discussing all accidents, preventable and non-preventable, that occurred during the previous month. According to LTD, the Review of Accidents is a benefit to all operators because it allows them to see what went wrong from a wider perspective, one that includes the entire bus, not just the view from behind the windshield. One thing that is heavily stressed in the discussion is the impact major collisions and hard braking incidents have on LTD passengers. This has made a strong impression on operators by allowing them to witness shocking real-life examples that they would be far less likely to notice while focusing on driving.

All LTD buses are equipped with video surveillance equipment, with up to 16 cameras per bus and at least 10 cameras on smaller vehicles. LTD reported using a telemetry-based DMS on a trial basis on a select number of its buses. Ultimately, it was determined that the system was not a good match for LTD's needs, due in part to the cost burden given the small size of the agency.

At LTD, hours of service regulations require that operators have a break of at least 9.5 h before beginning a new shift and drive no more than 14 h consecutively.

Route timing is reviewed on a regular basis by LTD's planning department, and the safety department is included in the process of planning for a new route or when a different style of vehicle is placed on a route. LTD has an open-door policy as well as a "blue card" reporting system. Operators document unsafe conditions or other concerns on specially designated blue cards, which are then submitted to an assigned employee and routed internally to the appropriate department. LTD maintains a database on all accidents, and the database includes information on causal and contributing factors for preventable accidents. LTD's management has been supportive of safety programs, which has helped lead to improvements in both total and preventable accidents.

Solano County Transit: Operated by National Express (Vallejo, California)

The mission of Solano County Transit (SolTrans) is to "deliver safe, reliable and efficient transportation services that link people, jobs, and our communities" (*8*). SolTrans representatives suggested that a minimum duration of 20 h of behind-the-wheel driving be a nationwide standard for new bus operators. Currently SolTrans requires new bus operators to receive 25 h of actual behind-the-wheel training before they are allowed to transition into revenue service. Annual recertification training is eight hours in length and is required for all employees. The recertification training includes both behind-the-wheel and classroom training.

SolTrans has continuous video feeds on its bus fleet, which includes audio capabilities. Videos are used for remedial training and addressing customer complaints. Whereas the videos can be used for coaching opportunities or punitive measures, the focus of the video usage is to recognize exceptional operators. SolTrans uses an asset management and tracking company with a technology-based software platform that has GPS-enabled advanced fleet monitoring, real-time vehicle location, and an asset management system, which they describe as beneficial to the agency. At the time of the case study, SolTrans had been utilizing the technology for 1.5 years for ride checks, road observations, accident reporting, and evaluations. This technology collects, stores, and transforms raw data into usable data that facilitates data-driven analysis and decision making (*9*).

SolTrans representatives indicated that "positivity and safety culture are interrelated. At SolTrans employees are treated as internal customers, with the understanding that an agency's employees are the most important people in an organization. It is necessary to thank them for a job well done and provide them with the opportunity to provide good customer service" (*8*).

SolTrans follows the company policy for hours of service regulations, which restricts operators from being on duty for more than 10 h a day.

SolTrans' GM has championed the safety culture at the agency. Quarterly town hall meetings are held as an opportunity to reveal any issues to corporate regional managers.

SolTrans is working toward SMS implementation with its close call reporting pocket-sized safety culture guidebook, which is a small book with carbon copies that the operators carry with them at all times. The book is used to document any near misses or unsafe conditions, which are then turned in. The operator keeps a copy as a way to track them, and management is required to respond within 48 hours.

Initial results indicated a 71% decrease in total incidents in the last 6 months of 2013 compared with the first 6 months of 2013. During that same time, passenger falls decreased 75% and employee injuries decreased 66%, indicating great initial success of the restructuring of SolTrans' safety practices. These successes have been followed by continued success through 2015. Preventable collision rates decreased 52% from 2013 through 2015, during which time the total injury rate decreased 65%.

TriMet (Portland, Oregon)

TriMet's mission is "to provide valued transit service that is safe, dependable and easy to use" (*10*). TriMet's GM created the Safety & Service Excellence Task Force in July 2010. According to TriMet representatives, the Task Force was charged with addressing "how to migrate TriMet to the highest levels of safety performance, and thereby improve performance in all areas of its business" (*10*). The Task Force made several recommendations which resulted in the following actions: required annual recertification training for all bus operators, realigned organizational structure with the safety and security division as direct reports to the GM, appointment of an executive director of safety with a seat at the leadership table, and review of reports and operational data to track close calls to eliminate potential hazards in the system.

TriMet buses include GPS-based AVL systems, a seat alarm which sounds if the operator leaves the operator's seat without setting the parking break, front and rear wheel turn lights that provide illumination of crosswalks during turns, turn signals on exterior mirrors, rear-facing cameras on both the operator's side and the curb side, and a message display unit called the vehicle control head (VCH). The VCH has an emergency alarm button that alerts dispatch when police, fire, or rescue services are needed; messages may also be sent to all buses or an individual bus.

TriMet recently acquired a training simulator that had only been used for new operator training for approximately 1 month before the interview. The agency plans to use the simulator for all training, including recertification and remedial training.

There is also a major emphasis on public education and outreach. Every fall TriMet rolls out its "Be Seen, Be Safe" campaign, which stresses the importance of wearing bright clothing, reflective materials, and personal lights to be visible, especially during the fall season when daylight savings time comes to an end. TriMet runs a safety awareness campaign every spring as well, and the 2016 theme was "Stay Alert, Stay Alive."

In 2013, the hours of rest for operators was increased from 7 h to 10 h. Per TriMet policy, safety sensitive employees cannot work more than 70 h in any 7-day period and cannot work more than 13 days consecutively.

Operators can report close calls of various types with the push of a control head button. These events can be instantly recorded, mapped with GPS, and aggregated with other data to reveal potential "hot spots" in need of attention. This type of proactive hazard identification is paramount for an SMS-style safety culture. TriMet has made safety its core value and the lens through which the organization makes all of its operational, planning, and strategic decisions. This includes everything from hiring and training employees to operating and maintaining vehicles. In addition, every TriMet employee is charged with embracing safety as a value.

Utah Transit Authority (Salt Lake City, Utah)

The mission of Utah Transit Authority (UTA) is to "strengthen and connect communities enabling individuals to pursue a fuller life with greater ease and convenience by leading through partnering, planning, and wise investment of physical, economic, and human resources" (*11*). The agency stated that the hiring of UTA's chief safety officer (CSO) 5 years ago has improved the overall safety culture of the entire organization.

Refresher training at UTA is conducted at the business unit level and is focused on the current prevalent incidents and training needs determined at that business unit. As of 2016, each business unit received approval to conduct up to 16 h of refresher training for all bus operators. This training is based on predetermined training needs of the business unit, but the agency works to ensure a consistent training message between units.

In May of 2014, UTA installed a telemetry-based DMS on its entire fleet of buses. The DMS is not only used for incident investigation, but the system also provides bus operators with an extra level of protection via capabilities to manually activate recording in the case of circumstances such as robbery, unruly passengers, and road rage. In addition, the DMS gives UTA the opportunity to track incidents by type, allowing for focused coaching on current prevalent incidents. The system can also produce reports over a specified time period, which is used to identify the top three driving concerns that are addressed via safety bulletins and coaching.

In 2015, an illuminated yield sign was added to the rear lighting configuration of UTA's buses to increase visibility in an attempt to reduce rear-ended collisions. Although there are no data available to prove the effectiveness yet, bus operators feel favorably about it.

UTA has a distracted driving policy, with discipline dependent on the type of distraction. The cell phone and audio policy at UTA is zero tolerance, meaning cell phone use while driving is terms for immediate termination. There is a civil ordinance that allows UTA transit police to ticket members of the general public for distracted behavior exhibited near its rail lines.

UTA hours of service restrictions include no more than 10 h driving in a 15 h maximum spread following 8 h consecutively off duty.

Improvements in the safety culture at UTA are largely due to the safety championing of authoritative personnel, with the CSO reporting directly to the GM/CEO. The appointment of the CSO has led to UTA's improved safety culture, as proven by a reduction in avoidable bus collisions. Between 2012 and 2015, UTA's avoidable bus collisions were decreased by 36% whereas the number of claims payments were decreased by 9% during the same period.

Conclusions

The purpose of this study was to document successful practices and training initiatives, including bus operator training and retraining programs, that have been effective in reducing transit bus accidents and incidents. The study also focused on other system approaches that have been implemented to address safety hazards, including various technology applications, infrastructure modifications, and other programs and initiatives, such as close call/near miss reporting.

Training is an effective and necessary method that must be used to ensure and improve transit bus system safety. Agencies with well-designed and consistent bus operator refresher training and post-event or event avoidance technology-directed refresher training and counseling were very effective in reducing the riskiest behaviors among bus operators.

The use of telemetry-based DMSs was found to be more prevalent across the industry. These systems automatically collect data for analysis of many safety-related events such as incidents, near misses, speeding, and distracted driving. The systems used by four case study agencies, GBT, Greater Cleveland RTA, JTA, and UTA, capture, identify, prioritize, and analyze causes of poor or risky driving before an incident occurring, allowing for corrective actions to be undertaken by the transit agency (*12*).

Successful programs utilize multipronged or multifaceted coordinated efforts to address transit safety. In all case study agencies, there was no single method identified that led to improved safety. Judging the relative success of one strategy in reducing transit incidents when multiple strategies were implemented concurrently is difficult. However, other agencies that are considering the institution of various corrective actions to improve safety issue areas should embrace what is reflected in this study: strategies that include multiple approaches to improve bus safety do find success.

Several topics that would benefit from further research based on the survey results include longitudinal research on the effectiveness of simulator training over time, and an independent assessment of telemetry-based DMSs to evaluate the effectiveness of the technology. In addition, the actions of other drivers that result in collisions with transit buses are a critical point that could be addressed through research to evaluate public outreach programs and other strategies designed to increase the public's awareness of the dangers of distraction and other collision-related contributing factors.

Acknowledgments

This research was sponsored by the Transportation Research Board's Transit Cooperative Research Program. We also thank Mariela Garcia-Colberg, the National Academies' staff contact for the study.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: Jodi Godfrey, Lisa Staes, Jennifer Flynn, Roberta Yegidis; data collection: Jodi Godfrey, Lisa Staes, Jennifer Flynn, Roberta Yegidis; analysis and interpretation of results: Jodi Godfrey, Lisa Staes, Jennifer Flynn, Roberta Yegidis; draft manuscript preparation: Jodi Godfrey, Lisa Staes, Jennifer Flynn, Roberta Yegidis. All authors reviewed the results and approved the final version of the manuscript.

References

1. Staes, L., J. Godfrey, J. Flynn and R. Yegidis *TCRP Synthesis 93: Successful Practices and Training Initiatives to Reduce Bus Accidents and Incidents at Transit Agencies*. Transportation Research Board of the National Academies, Washington, D.C., 2017.
2. Ahmed, S.A. *Transit Safety Management and Performance Measurement*. Report FTA-OK-26-7007.2011.1. Federal Transit Administration, 2011.
3. City of Charlotte, North Carolina. *Charlotte Area Transit System, Mission, Visions & Goals*. 2018. http://charlottenc.gov/cats/about/Pages/mission.aspx.
4. Greater Cleveland Regional Transit Authority. *Mission, Vision, Values*. 2018. http://www.riderta.com/mission-save.
5. Jacksonville Transportation Authority. *About JTA*. 2018. https://www.jtafla.com/about-jta/.
6. Kansas City Area Transportation Authority. *Mission*. 2018. http://www.kcata.org/about_kcata/entries/mission.
7. Lane Transit District. *2016–2025 Capital Improvements Plan*. 2015. https://www.ltd.org/file_viewer.php?id=1356
8. *Solano County Transit (SolTrans) Performance Goals and Measures*. 2015. http://www.soltransride.com/wp-content/uploads/2012/05/FINAL-FY-15-16-SolTrans-Performance-Measure.pdf.
9. TrackIt, 2016. http://www.trackit.co.nz/.
10. TriMet. *Our Vision, Mission, and Values*. 2018. https://trimet.org/about/mission.htm.
11. Utah Transit Authority. *Mission and Vision*. 2005. https://www.rideuta.com/About-UTA/Mission-and-Vision.
12. Lytx. Fleet Safety Management Solutions 2016. http://www.lytx.com/our-solutions/drivecam-programs.

The Task Force on Transit Safety and Security (AP018T) peer-reviewed this paper (18-01040).