The National Academy of Sciences was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, nongovernmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

The National Academy of Engineering was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineers to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. John L. Anderson is president.

The National Academy of Medicine (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

The three Academies work together as the National Academies of Sciences, Engineering, and Medicine to provide independent, objective analysis and advice to the nation, and conduct other activities to solve complex problems and inform public policy decisions. The National Academies also encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine.

Learn more about the National Academies of Sciences, Engineering, and Medicine at www.nationalacademies.org.

The Transportation Research Board is one of seven major programs of the National Academies of Sciences, Engineering, and Medicine. The mission of the Transportation Research Board is to increase the benefits that transportation contributes to society by providing leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board’s varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

Learn more about the Transportation Research Board at www.TRB.org.
3 Toward Railroad Trespassing Solutions

Robert L. Sumwalt

The July–August issue of TR News examines the data behind railroad trespassing fatalities, as well as countermeasures and research to reduce the rates of these deaths. The limitations of current interventions, from design solutions to procedures and rules, demonstrate the trespassing challenge: systemwide, the most beneficial interventions are seen as hard to implement on a large scale. But dogged research efforts and technological innovations open new opportunities for trespassing prevention, helping the railroad industry implement the most effective safety solutions.

8 Scope and Trend of U.S. Rail Trespassing and Suicide Fatalities

Kurt Topel

For the past 50 years, freight and passenger rail in the United States has been very safe for employees and passengers, and deaths of motorists at highway–rail crossings have decreased considerably since the mid-1970s. This same reduction in fatalities has not been realized for rail trespassing and suicide, however; these rates have remained constant. The author frames the challenge of trespassing on America’s railroads, examining similarities and differences between accidental trespassing and suicide, research gaps, and why policy makers must devote more attention to this urgent problem.

11 FRA’s Total Fatalities Figures Do Not Count All Deaths

Kurt Topel

16 Development, Implementation, and Evaluation of a Community-Based Trespass Prevention Model

Marco P. daSilva, Michail Grizkewitsch, and Francesco Bedini Jacobini

Most trespassing casualties can be avoided. The Federal Railroad Administration (FRA) and its safety partners conducted studies to better target and implement outreach, public education, and law enforcement efforts. The results, along with national workshops, led to the Community Trespass Prevention Guide, which documents a collaborative, step-by-step problem-solving approach for local communities, as well as the Community, Analysis, Response, and Evaluation—or CARE—model. In this article, the research and process that led to CARE are outlined, along with real-world demonstrations of the model.

18 Railroad Fatalities in the United States: 2012–2017

Steve Laffey

23 Rail Trespassing and Suicide: What Can Be Done to Improve Safety?

Grigore M. Havârneanu and Kurt Topel

The authors identify established, effective countermeasures for preventing and mitigating rail trespassing and suicide, along with examples of the types of countermeasures as well as the research supporting them. Based on the RESTRAIL (REduction of Suicides and Trespasses on RAILway Property) research project in Europe, this article offers information on what can be done to prevent injury and death from rail trespassing and suicide.

30 Artificial Intelligence–Aided Automated Detection of Railroad Trespassing

Asim F. Zaman, Baozhang Ren, and Xiang Liu

Large volumes of surveillance video data deployed in the railroad industry open many possibilities for detecting and preventing unsafe trespassing on railroad tracks. Monitoring these data is highly time- and resource-consuming, however. In this article, authors describe an artificial intelligence (AI) framework that automatically detects trespassing events in real time. The data from studies of the AI system can help researchers understand human factors in railroad safety and can offer a real-time edge in tackling the critical challenges of railroad trespassing.
Safety Education and Community Outreach Initiatives for Trespasser Prevention: Metro-North and Long Island Rail Road

Justin Vonashek, Deidre Mitchell, Lori Ebbighausen, Karl Meyer, and Linda Katz

Through the Together Railroads and Communities Keeping Safe program, Metro-North Railroad and Long Island Rail Road in New York work with MTA Police Department to promote safe behaviors at or around railroad grade crossings and tracks. Since the program was implemented, fatalities on Long Island Rail Road have decreased by 50% and trespasser strikes on Metro-North have decreased by 33%. Community outreach efforts and safety education, at the core of TRACKS, are explored in this article.
The author is Chairman, National Transportation Safety Board, Washington, D.C.

The National Transportation Safety Board (NTSB) board members and staff constantly survey the state of the literature on transportation safety topics, but our unique contribution to that literature comes from accident investigations—case studies. We have investigated every aviation accident that occurred since the Board was founded in 1967. In other modes of transportation, including railroad transportation, we investigate selected accidents.

Safety recommendations are the action items that stem from NTSB investigations. In the 1970s, an NTSB recommendation helped lead to the founding of the national organization Operation Lifesaver, Inc., which raises railroad safety awareness among the public.

In recent years, we have investigated railroad accidents involving trespassers in Jesup, Georgia, and Ellicott City, Maryland.

Jesup, Georgia

On February 20, 2014, at about 4:30 p.m., a crew of at least 12 people was filming a movie scene on a railroad bridge near Jesup, Georgia, when a northbound CSX freight train approached. The train struck a metal-framed bed that was being used as a prop in the scene. Debris from the prop struck crew members on the bridge walkway, killing one and injuring six.

Why would CSX authorize such activity without stopping train movements? It didn’t. On multiple occasions, the film-makers had asked in writing for permission to film on CSX property. CSX had denied the requests, also in writing.

The film crew was trespassing on the railroad tracks.

As the train approached, some film crew members ran to safety off the bridge, while others made for the bridge walkway. One or more of the crew members lifted the metal bed frame from the tracks and stood it upright next to the tracks, but the prop fell back down. The train struck the prop at about 56 mph—in a section of track that had a maximum authorized speed of 70 mph.

NTSB determined that the probable cause of the accident was the film crew’s...
BACKGROUND

On railroads, more people lose their lives accidentally to trespassing than to any other cause. In the wake of the Jesup and Ellicott City tragedies, a conversation about railroad trespassing began at NTSB. Trespassing is so common that engineers and conductors report being told in training that, over the course of a career, they will kill somebody. I am not certain whether any other line of work comes with such a dire prediction. Trespassing casualties occur one or two at a time. Often, the train cannot stop and trains cannot turn to avoid the trespasser.

For NTSB, an effective recommendation to deter trespassers might result in a law—but a law against trespassing already has been enacted. An effective recommendation to reach the public might result in an outreach campaign—but NTSB has played a role in the creation of Operation Lifesaver.

By 2015, our Office of Railroad, Pipeline, and Hazardous Materials Investigations had its hands full with railroad accident investigations, including specification U.S. DOT-111 tank cars erupting in fireballs and mass casualty accidents that would have been prevented by the implementation of positive train control (PTC)—a project which, at this writing, unauthorized entry onto the CSX right-of-way with personnel and equipment, despite CSX Transportation’s repeated denial of permission to access the railroad property.

Following this incident, NTSB recommended that a variety of entertainment industry organizations work together along with Operation Lifesaver to create and distribute educational materials. These materials emphasize that railroads require the owner’s permission to enter and that, if authorization is given, everyone on scene must follow the railroad’s safety procedures to reduce hazards.

Ellicott City, Maryland

On August 20, 2012, a CSX coal train derailed its first 21 cars while crossing the railroad bridge over Main Street in Ellicott City, Maryland. Seven of the derailed cars fell into a public parking area below the tracks to the north; the remainder of the derailed cars overturned and spilled coal along the north side of the tracks.

Before the derailment, two people had climbed over a short wooden fence and had entered CSX property without authorization to access the railroad bridge, on which they were sitting when the derailment occurred. Both were killed by the spilled coal.

NTSB determined the cause of the derailment—a broken rail—but did not specifically mention the role of trespassing in its statement of probable cause.

Laws and outreach programs to prevent trespassing already are in place in many states.
is still incomplete. It was not feasible to prioritize hundreds of such single-fatality accidents; taken together, however, these accidents represent the bulk of all life lost on our railroads.

**FORUM TAKEAWAYS**

In March 2015, we held a public forum, “Trains and Trespassing: Ending Deadly Encounters.” We heard presentations from the railroads, Operation Lifesaver, the government, and the research community.

Then, as now, there was no such thing as a typical trespasser. Then, as now, railroads and train tracks exercised a glamorous pull. At our forum, a film industry representative went into depth on the American love affair with trains and the use of trains and tracks in motion pictures. We also had the opportunity to discuss amateur photography and filming such as selfies and web video.

Then, as now, some trespassers showed no indication of glamorizing trains and tracks; they simply trespassed on their way to and from work or school or walked along the right-of-way because it was the only easily walkable surface.

Then, as now, the same number of casualties occur year after year—approximately 1,000. About one-half of annual trespasser casualties still are fatal. At NTSB, we investigate accidents in transportation; nonetheless, railroad suicides, whose numbers are compiled separately by the Federal Railroad Administration, continue to account for hundreds of additional fatalities every year.

And then, as now, trespasser deaths and injuries struck all age cohorts and all walks of life. The persistent stubbornness of this safety challenge is matched only by the diversity of trespassers themselves and trespassing incidents.

**Perspectives on Trespassing**

**BROAD CHALLENGE**

From a system safety perspective, the most preferred intervention—“designing out” the problem—is attempted only at limited locations. We see new design solutions that keep people separated from trains at and around stations, for example. The more recent the construction of the station and surrounding infrastructure, the more likely that somebody has thought of the design with pedestrian safety in mind.

Like design, the second most preferred intervention—installing guards against the trespassing hazard (for example, fencing)—typically is not envisioned as a systemwide intervention. Also, without public recognition of the hazard, fencing can be defeated—where it exists at all.

The third- and fourth-tier solutions traditionally have been viewed as practical: alerting to the imminent hazard (that is, effective signage) and implementing procedures and rules. For a problem affecting the general population, the latter solution takes the form of laws, enforcement, and public awareness, as much as the rules and procedures followed by the railroad itself.

I raise the system safety order of precedence not because it is the traditional or even the most salient way to view trespassing, but because it illustrates the assumed
status of the trespassing challenge: system-wide, the most effective interventions are treated as impractical on a grand scale and applicable only to select hot spots.

Viewed through the more familiar lens of the engineering–education–enforcement approach—the three E’s—these are engineering solutions. Although railroads should be applauded for every step that they take to engineer out trespassing at specific locations, the very ubiquity of railroad tracks forces an unspoken caveat for every such project: “of course, we can’t do this everywhere.”

**REFOCUSING AWARENESS**

So we arrive at the present status quo: trespassing is thought of largely as a public outreach challenge. This viewpoint is underscored by the fact that the legal onus for a trespassing casualty falls on the trespasser. Advocacy organizations such as Operation Lifesaver have worked tirelessly to hold the line at the present casualty numbers, but as is the case with other transportation safety problems affecting the population at large, the numbers characterizing trespassing appear to have a floor given the interventions attempted to date.

Yet unlike some other safety challenges that also are crimes—drinking and driving, for example—trespassing raises little social outcry. A striking train can be, and often is, operated by a perfectly compliant train crew. The defining behavior that precedes these encounters is the trespassing itself.

Additionally, as diverse as these encounters are, they do have one thing in common: they rarely, if ever, harm train occupants physically. Unlike some drunk drivers, a trespasser does not take out an innocent family; they suffer the harm themselves. (Train crew members fall victim to a range of psychological effects, however, including but not limited to post-traumatic stress disorder.)

The loved ones of a victim of drunk driving can press for harsh penalties. They can decry the irresponsible behavior that led to their loss. They can join a national campaign against drunk drivers. Once organized, the moral authority of their losses can be—and has been—the catalyst for sweeping change.

In contrast, the family of an injured or killed railroad trespasser quickly learns that, by definition, their loved one had only him- or herself to blame. The family can request action by the railroad, but they cannot demand it. Their options are constrained to helping discourage trespassing by others.

Sometimes a community mobilizes for a local design improvement in response to a local tragedy. Proactive, preventive activities against local trespassing often are sponsored by the railroads themselves. National campaigns, however, focus on awareness on the part of the potential trespasser.

Perhaps this has to do with blaming the victim—with trespassing, we’ve done it in the very definition of the precipitating event.

**Constraints**

The harder the constraint, the harder it is to implement systemwide. This state of affairs is not unique to trespassing, but is one that railroad trespassing features in stark relief.

As the reader will recognize in the pages to come, however, research into this

---

**Operation Lifesaver and the Three E’s**

Operation Lifesaver, Inc., is a nonprofit public safety education and awareness organization dedicated to reducing collisions, fatalities, and injuries at highway–rail crossings and lowering rates of trespassing on or near railroad tracks.

Operation Lifesaver was founded in 1972, at a time when the annual average number of collisions at U.S. highway–rail grade crossings numbered more than 12,000. The organization’s nationwide network of authorized volunteer speakers and trained instructors offer free rail safety education programs to school groups, driver education classes, and community audiences, as well as specialized training for professional drivers, law enforcement officers, and emergency responders. These programs are cosponsored by federal, state, and local government agencies; highway safety organizations; and America’s railroads.

The goal of Operation Lifesaver is to promote the three E’s—education, enforcement, and engineering—to keep people safe around railroad tracks and railway crossings:

- **Education**: Operation Lifesaver provides information on how to stay safe around railroad property and rights-of-way, from rail trespassing laws to facts about trains to safe ways to navigate highway–rail grade crossings.
- **Enforcement**: The Grade Crossing Collision Investigation course teaches law enforcement officers and first responders how to ensure their personal safety while responding to rail-collision incidents and during related investigations.
- **Engineering**: Operation Lifesaver supports and encourages research on and innovations in engineering technologies that can help minimize and reduce rail-related collision risks.

*For more information, visit [https://oli.org/about-us](https://oli.org/about-us).*
stubborn safety issue continues. The efforts of the research community, innovative railroads, and public transit rail agencies are the focus of this issue of TR News.

The authors will shine a light on new approaches throughout the railroad safety community writ large. They have collected research results on trespass mitigations in freight, passenger, commuter, and transit rail.

These run the technological gamut from newly poured concrete to intrusion detection technology; from security fencing to drones. Authors have gathered information on demonstration and pilot projects to address security risks associated with trespassers.

Regrettably, progress toward infrastructure designed with public safety in mind seems likely to be incremental. To get the most out of its efforts, the railroad industry needs to know what works—and the research presented here is an important place to start.

When it comes to detection of trespassers and enhanced enforcement of trespassing laws, however, the potential for action is growing. As our railroads deploy security countermeasures against a whole different class of trespassers—those who would harm others—they are laying the same groundwork that can help detain or discourage trespassers who only risk harming themselves.

Power of Research and Data

Pedestrians routinely carry personal devices that could enable personal technology solutions, particularly if the owners of the devices are incentivized. Data can be collected on a large scale and challenges to gathering raw data no longer seem as insurmountable as suggested by the extensiveness of our rail infrastructure. Even analysis of these data is becoming manageable through artificial intelligence.

With all of this technological progress, effective policy about sharing data might be as important as the ability to gather and analyze it. For example, we could learn a great deal about interventions by determining the composition of the pyramid of injury specific to trespassing.

We know how many people are struck and how many die. Railroad police know how many trespassers are apprehended and sent away from the property, as well as how many are charged with trespassing—but these numbers are not compiled across the many transit, freight, and passenger railroads.

Furthermore, we don’t have good data on the total incidence of trespassing—the base of the pyramid. Are police apprehending every tenth trespasser? Every hundredth? Every thousandth? The answer would speak to the relative effectiveness of various railroad policing strategies and the resonance of antitrespassing messages.

The law goes so far as to say that the trespasser is at fault. Given the hazards of trespassing, it is right that the activity is against the law, and the law should be rigorously enforced. The safety view, however, is that the safety issue involves a breach of the law—not that it is thereby explained. This is also true for many other transportation safety issues. The existence of such a law can never be an excuse to justify complacency.

As the old saying goes, the definition of insanity is continuing to do the same thing and expecting different results. The railroad safety community is fortunate to be reexamining this issue at a time when it is possible to do different things and to evaluate what is working and what is not.

It is my hope that this issue of TR News helps to empower engineering, enforcement, and education solutions to the railroads’ statistically deadliest safety issue.

The TR News Editorial Board thanks Lisa Staes, Center for Urban Transportation Research, and Karen S. Febey and Claire E. Randall, TRB, for their work assembling and developing this issue.
According to the Association of American Railroads (AAR), “America’s railroads have lower employee injury rates than most other major industries, including trucking, airlines, agriculture, mining, manufacturing and construction—even lower than food stores. ... Recent years have been the safest on record for the rail sector” (1). These statements are particularly true for passengers and employees. Even for non-passengers, fatalities have decreased, especially at highway–rail crossings.

This improvement in safety has not been realized when it comes to railroad trespassing away from crossings or intentional acts of suicide. As shown in Figure 1 (page 9), fatalities of occupants of motor vehicles at crossings (orange) show a marked and sustained decrease from 1975 until 2010 but are little changed since 2010. Pedestrian fatalities—trespassing away from crossings (blue), suicides (purple), and pedestrians at crossings (green)—have remained flat since 1975, with gradual increase, especially since 2010.

Before 2011, Federal Railroad Administration (FRA) policy deemed suicides to be an exception to reporting requirements. Therefore, the number of rail suicide deaths before 2012—the year FRA began to release total year figures—is unknown.

Background
Railroads are required to report injuries and fatalities to FRA each month, using codes to describe the nature of the injured party’s relationship with the railroad and the location of the incident. For persons receiving rail service (passengers) and providing rail service (employees), reports typically designate the nature of the relationship of the victim to the railroad. For members of the non-passenger public, the key designation is the location or the intention of the victim; for example, highway–rail crossings, trespassing away from crossings, and suicides.1

---

1 For brevity, “highway–rail crossings” will be referred to simply as “crossings” in this article. “Trespasser away from crossings” will be referred to as “trespasser.”
As in railroad systems throughout the world, most people killed on U.S. railroads are members of the public, not passengers or employees. Only the small slice at the top of the pie in Figure 2 (below) represents the deaths of people directly involved in the railroad business (e.g., passengers, employees, and contractors). Almost all the rest of the fatalities are people who put themselves in danger, either accidentally or intentionally. This applies not only to trespassers and suicides (72%), but also to crossing collisions, as less than 2% of crossing collisions result from the failure of automatic warning devices (2).

As stated above, trespassing and suicide comprise almost three-quarters of total U.S. rail fatalities. There has been no improvement in the number of these deaths since 1975. This is in contrast with the dramatic reduction in deaths at highway–rail crossings over this period, especially for occupants of motor vehicles, as seen in Figure 1.

In terms of fatalities, rail safety problems increasingly center on pedestrians. Nearly all trespassers and suicides are pedestrians; even at crossings, pedestrian fatalities are growing. Crossing deaths of pedestrians, as opposed to those of motor vehicle occupants, has increased from approximately 10% of total crossing deaths in the late 1970s to 35% in the middle 2010s. Although crossings have become safer for people in vehicles, they recently have become less safe for pedestrians.

What Works: Attention and Funding
Railroads have been responsible for the safety of individuals who are directly involved in railroad operations—that is, passengers and employees—and U.S. railroads have invested heavily in safety. According to AAR, there is a direct correlation between the increase in rail network investments and enhanced safety performance. With record levels of private spending on capital improvements and maintenance over the last 5 years and more than $25 billion annually on average, America’s privately owned freight railroads are at the forefront of advancing safety. (1)

The U.S. rail industry has done a commendable job of reducing passenger and employee deaths and injuries and keeping them low. Congress and the National Transportation Safety Board (NTSB) expect that the full implementation of positive train control (PTC) will continue the reduction. PTC is designed primarily to reduce train-to-train collisions and derailments and is unlikely to help reduce injury from trespassing or suicide.
Although it is always possible for a train collision or derailment to cause injury to the non-passenger public, the impetus for mandating PTC—precipitated by the 2008 collision in Chatsworth, California, which cost 25 lives—is the loss of life to passengers. By comparison, more than 25 lives are lost every two weeks to rail trespassing and suicide in the United States.

The cost of PTC is substantial:

As of the end of 2018, Class I freight railroads in aggregate had spent $10.6 billion—their own funds, not taxpayer funds—on PTC development and deployment. Maintaining the PTC systems once they are installed will cost hundreds of millions of additional dollars each year. (3)

With help from the rail industry, local, state, and federal government agencies have financed rail safety measures for members of the non-passenger public. The Federal Highway Administration (FHWA) provides funds to states to improve safety at highway–rail crossings. These improvements include grade separations, closings of crossings, upgraded warning devices, and other crossing improvements. FHWA Section 130 funding currently provides more than $230 million annually to states (4). Some states, such as Illinois, have raised their own funding in addition to federal funding to facilitate crossing improvements. In FY 2018, Illinois received $10.9 million in Section 130 funding and raised an additional $39 million (5–6). The U.S. rail industry also provides hundreds of millions of dollars each year for grade-crossing improvements (7).

A newly updated grade crossing in Massachusetts includes new signals. Attention to and funding for grade crossing safety has led to upgraded crossing infrastructure—and fewer fatalities at these crossings.

These government and industry investments appear to have reduced deaths at crossings from approximately 1,000 per year in the late 1970s to approximately 250 per year in the mid-2010s (Figure 1). These funds can be used only at crossings, however, despite the fact that 74% of trespassing deaths and injuries occur within 1,000 feet of a grade crossing (8).

By contrast, almost no federal funding is available for necessary safety improvements away from crossings. Various U.S. Department of Transportation agencies and industry groups contribute to Operation Lifesaver, Inc., and FRA conducts research on trespassing and suicide issues, but this total investment is small compared with the amounts spent to improve safety at crossings and for employees and passengers.

As stated above, the railroad industry is spending $10 billion to deploy PTC and hundreds of millions of dollars annually to maintain those systems, to address 4% of total railroad fatalities—those of employees and passengers (Figure 2). For the 24% of total fatalities that take place at crossings, government agencies spend at least $230 million annually and the rail industry spends hundreds of millions of dollars (7).

Little investment is reported, however, to prevent the death of those who trespass and attempt suicide—the remaining 72% of railroad fatalities.

Findings and Gaps in Research

To find effective ways of preventing injuries and deaths away from crossings, research is essential. Far less research exists on preventing U.S. rail trespassing and suicide, especially from industry and academic sources, than on employee, passenger, or crossing incidents. Some epidemiological information is available from FRA-sponsored research, however, primarily from incident reporting forms required by FRA from railroads.

Current FRA reporting focuses on factors related to the incident and the injured person to understand the fundamentals of trespassing and suicide incidents. A selection of research findings is summarized in the following pages.
Researchers and reporters should be careful when quoting official U.S. rail fatality figures. Total fatalities reported are not “totals” in the common meaning of that word.

Before May 2011, railroads were discouraged from reporting casualties to the Federal Railroad Administration (FRA) if the victim had intended to kill themselves (1). Since June 2011, railroads have been required to report suicides and attempted suicides to FRA; from 2012 and 2017, between 275 and 328 suicide fatalities have been reported annually.

Despite the change in reporting requirements, queries of total fatalities on the FRA website—as well as totals reported to the Bureau of Transportation Statistics; the National Transportation Safety Board; Operation Lifesaver, Inc.; and news outlets, among others—report a “Total Fatalities” number that does not include suicide data.

FRA data also are hampered by the delay of receiving final verdicts from a coroner or medical examiner. The railroads are obliged to report casualties to the FRA on a timely basis, so these reports often are submitted before local responsible parties have made a final determination of the manner of death. According to the FRA Guide for Preparing Accident/Incident Reports, an injury is an accident unless or until a determination of suicide is made (2). Absent an official determination, the railroad reports the casualty in the appropriate accidental category, usually “Trespasser Away from Crossing.”

Because determinations of suicide are made by local officials, when the railroad is alerted to a death by suicide it is directed to amend its reporting to the FRA, and the data totals are corrected (that is, incidents are removed from the categories for accidental deaths and placed into the category for suicide). The lag in official verdicts for recent incidents means that trespasser deaths are overstated and suicides understated, at least for several months after the reporting period. Also, because FRA does not include suicides in its totals, the reported Total Fatalities number decreases over time (for approximately 18 months) as incidents are reclassified as suicides.

Therefore, users of FRA data—whether they obtain the data from the reports on the FRA website from other transportation statistics databases—should be aware that, per those reports, Total Fatalities are not the sum of all people who have died on the rails. To obtain a true picture of total rail deaths, the user must query the FRA database to obtain suicide totals (3) and then add that number to the reported Total Fatalities number.

This counterintuitive reporting system tends to complicate analyses, especially for recent data. The largest issue with the policy of not considering a suicide death to be a fatality, however, is that since 2012, 28% of the fatalities that have occurred on the U.S. rail system have gone unreported in annual fatality totals. One potential consequence of unreported fatalities is that policy makers may not have the best information about the true number of rail fatalities, which could affect funding for addressing right-of-way public safety issues.

—Kurt Topel
Member, Chicagoland Rail Safety Team, Wilmette, Illinois

Author’s Note
The FRA policy in place as of March 2019 does not count rail suicides as a part of the Total Fatalities in summary reports. Future FRA policy may include suicides, but it is unknown at this time whether or when an official policy may change, or how it may affect the issues addressed in this article.

REFERENCES

Statistics are human beings with the tears wiped off.
—PAUL BRODEUR, Outrageous Misconduct, 1985
Similarities Between Trespassing and Suicide

Many fatal pedestrian rail deaths, both accidental and intentional, share similar data characteristics. One potential explanation is the possibility that some people who intended to cause self-harm may be classified as accidental casualties.

The mechanisms of classification can understate suicide deaths and overstate unintentional trespassing deaths. An injury or death is assumed to be an accident in the absence of a definite finding by the local responsible official of suicidal intention on the part of the deceased. Without clear evidence of suicidal intention, each local authority may have differing thresholds of certainty—and sometimes the evidence does not necessarily point to a particular manner of death. For example, is the presence of alcohol or drug use indicative of incapacitation (suggesting an accident), mental distress, or self-administered analgesia (suggesting suicidal intent)? In the absence of certainty, the death often is ruled accidental.

LOCATION

Eighty-eight percent of suicides occur along the right-of-way. By definition, all trespassing casualties occur on railroad property away from crossings (9). The FRA recently found, however, that 74% of trespassing injuries and fatalities occur within 1,000 feet of a crossing (8).

GENDER OF DECEDENT

Both trespassing and suicide fatalities are heavily weighted toward males. Various studies indicate that males represent more than 80% of trespassing fatalities (10).³ Rail suicide studies identify males as 72% of decedents (11). This ratio is similar to the male-to-female ratio of 3.54 to 1, or 78%, in U.S. completed suicides by all means (12).

AGE OF DECEDENT

Trespassing Figure 3 (above) shows the number of trespassing victims by age group. The number of trespassing victims by age peaks at 19 years old, gradually decreasing into the mid-30’s age range. The number of trespassing victims rises again until age 50, after which it drops precipitously (10).

One FRA study reports that the median age of trespassers is 38 (13). This also is the overall median age in the United States, which suggests that the age of persons who die trespassing is similar to the overall age of the population (14).

Suicide The mean age of worldwide railroad suicide victims is somewhat consistent over several studies: 39 to 45 years old (15). Railroad suicide victims tend to be younger than the average suicide victim by all lethal means (11).

Averages can be misleading both for trespassing and for suicide; instead, frequency distributions are more descriptive and more helpful for designing countermeasures. For example, FRA compares the distribution of rail suicide decedent age ranges to the distribution of age ranges in suicides by all means as reported by the Centers for Disease Control and Prevention (see Figure 4, page 13).

In each of the four younger age ranges, rail suicide is overrepresented; in each of the five older ranges, rail suicide is underrepresented. At each end of the distributions, the differences are substantial. This dissimilarity suggests that efforts designed to reduce rail suicide specifically could be more effective if targeted at a younger audience.

DRUG AND ALCOHOL USE

Several studies indicate that intoxicants often are present at the time of the incident both in rail trespassing deaths and suicide deaths. Most studies show that at least 50% of rail trespassing and suicide decedents were intoxicated at the time of the incident, compared to 24% of overall suicide decedents (10, 15–16).

Differences Between Trespassing and Suicide

TEMPORAL CONSIDERATIONS

Fatal trespassing accidents tend to be more frequent on Saturdays and Sundays, whereas rail suicide tends to be more fre-
quent during weekdays, with a peak in the afternoon and early evening (9).

Trespassing fatalities show little seasonality, whereas rail suicide is more likely to occur in the spring and, to a slightly lesser extent, in summer (9). The spring peak of suicide tracks with overall suicide patterns worldwide—running counter to the popular notion of depressed moods in wintertime (17).

LETHALITY

Nationwide statistics are not kept on railroad suicide attempts or on pedestrian trespass incidents that do not involve injury. Therefore, it is not possible to derive a lethality statistic for rail suicide and trespassing actions.

FRA does track trespassing and suicide attempt incidents that involve fatal and nonfatal casualties, however. For the past 5 years, approximately 50% of people injured while trespassing away from crossings were killed and approximately 90% of people injured in confirmed suicide attempts were killed. At grade crossings, around 20% of people injured are killed.

COMPARISONS WITH OTHER COUNTRIES

A comparison of the European Union (EU) and the United States shows that, although trespassing and suicide together comprise the vast majority of rail-related deaths in both regions, the proportions are reversed.

In the EU, 72% of rail-related deaths from 2012 to 2014 were attributable to suicide and 17% were attributable to trespassing (18). In the United States, 28% of rail-related deaths from 2012 to 2017 were attributable to suicide and 44% were attributable to trespassing.4

In the EU, 72% of rail-related deaths from 2012 to 2014 were attributable to suicide and 17% were attributable to trespassing (18). In the United States, 28% of rail-related deaths from 2012 to 2017 were attributable to suicide and 44% were attributable to trespassing.4


Findings Applicable Only to Suicide

RAIL SUICIDE RATES

Worldwide railroad suicide rates—that is, the proportion of all suicides that are railroad-related—range from 1.3% in Canada to more than 12% in the Netherlands (15). In the United States, the rail suicide rate is less than 1%.

The implications for U.S. railroad safety are: 1) it is fortunate that railroad suicide is relatively rare, compared to other industrialized countries, but 2) rail safety efforts must focus on obtaining public health resources to confront rail suicides. Otherwise, public health officials will likely focus means restrictions or other prevention strategies on suicide methods that are more common, such as firearms or poisons.

CHOICE OF RIGHT-OF-WAY AS SUICIDE MEANS

Availability of means is a significant factor in suicide (19). The relative lack of access to a gun and the proximity of railroad tracks to the victim’s residence, as well as mental health issues and substance abuse,
Rail safety efforts to deter suicides must focus on public health resources to address mental health issues.

were found to be major contributing factors to rail suicides (20). Half of all U.S. suicides are conducted using firearms—eight times the average of other industrialized countries (21)—but the overall suicide rate in the United States is similar to that of other countries (22).

Research Gaps

CAUSATIVE AND ENVIRONMENTAL DATA
Information derived from FRA’s incident reporting forms is useful to identify the basics of rail incidents—who, what, and where—but does not give a complete picture of more prevention-oriented data; for example, why or how the person obtained access to the tracks.

Certain causative and environmental data about the incident may be helpful. Little quantitative data exist on the relative proportions of trespassing motivations or the possible reasons for a lack of evasive actions on behalf of the injured. Especially with a fatal accident, it may be difficult to know with certainty why the injured person was on the railroad tracks and why the person was not able to avoid the accident. Having some insight into these issues may help in the design of countermeasures.

LACK OF DIVERSE RESEARCH ON U.S. RAIL TRESPASSING AND SUICIDE
Trespassing

Nearly all of the rail trespassing literature in the United States is published under the auspices of FRA and uses its incident data, but little literature comes from industry or academic sources. Most railroad safety literature from academia and industry is focused on other railroad accident safety issues, such as track, rolling stock, hazardous material handling, operational safety, and grade-crossing safety—all of which involve fewer deaths.

Suicide

The bulk of published rail suicide literature worldwide has used EU data. Aside from the EU’s RESTRAIL (REduction of Suicides and Trespasses on RAILway property) project, most European literature has not addressed unintended deaths from trespassing, presumably because of the low proportion of accidental rail deaths relative to suicides in Europe.

U.S. rail suicide data were not available until 2011, so there is minimal research using data from sources other than FRA.

EFFECTIVENESS EVALUATION OF MOST COUNTERMEASURES

There is a great need for additional, scientifically rigorous research into railroad trespassing and suicide prevention activities or countermeasures, especially in the United States. Researchers in both the United States and the EU have pointed out that countermeasures are often installed without empirical evidence of effectiveness (23–25). Although many of the identified countermeasures have seemed to help reduce trespassing and suicide, it would be helpful to have long-term, large-scale, well-controlled (that is, test-and-control or before-and-after) tests. Countermeasures often are installed due to their low cost and relative ease rather than as a result of well-planned, cost-effective efforts that increase the chances of saving lives.5

1 Although countermeasures primarily are designed to reduce incidents and casualties, they can only be evaluated by measuring changes in trespassing behavior; this evaluation may not result in a proportional change in casualties. Also, countermeasures must be evaluated over a long period of time. This is because changes in small populations may be due to randomness, not to countermeasure effectiveness, and because it is possible that countermeasure effectiveness may decline over time.

Conclusion

Much is known about the epidemiology of rail trespassing and suicide, but little is known about the causative and environmental factors of rail trespassing and suicide or the efficacy of countermeasures to prevent incidents. A disproportionately high number of fatalities and injuries on railroads are caused by trespassing and suicide—nearly three-quarters of rail-related deaths in the United States. Additional research into these rail safety issues would benefit all stakeholders, including the federal government, industry, academia, law enforcement, and the public.

Research investigating the following areas would prove particularly helpful: 1) descriptions and measures of causal factors; 2) improving the railroad industry and law enforcement’s ability to prevent and respond to railroad trespassing and suicide attempts; and 3) determining effective countermeasures and mitigations.

Some progress already has been made; FRA recently announced its National Strategy to Prevent Trespassing on Railroad...
Property, which describes its plans to address railroad issues:

The report examines the causal factors that contribute to trespassing incidents on railroad property, and responds to a U.S. House of Representatives Committee on Appropriations request. … Over the long term, FRA will measure the success of this National Strategy by how much trespassing incidents and casualties are reduced nationwide. (26)

Soon, the nationwide installation of PTC will be complete. After its completion, if some of the current rail safety focus on PTC were to shift to address the different categories of pedestrian-related rail trespasser incidents, perhaps this would reduce the overall number of deaths. In its National Strategy, FRA has recognized that it needs and plans to do more to address trespassing.

With more policy maker attention and funding, U.S. rail safety stakeholders may be able to confront the trespassing problem more effectively.

REFERENCES


In the United States, more people are struck and killed by trains each year while railroad trespassing—illegally entering or remaining on a railroad right-of-way (ROW)—than in motor vehicle collisions with trains at highway–rail grade crossings.

Between 2012 and 2017, the annual number of trespassing-related pedestrian fatalities increased 18%, from 725 in 2012 to 858 in 2017 (1). In 2018, 783 pedestrian trespassing fatalities had occurred by September 30. Data indicate that the number of trespassing occurrences on railroad property each year far exceeds the number of fatalities and injuries. This raises the serious concern of a high potential for even more trespasser accidents.

By definition, trespassers are illegally on railroad property without permission. In the majority of states, trespassing is codified as a property crime and a general offense, and trespassing on railroad property is specifically forbidden.¹

Most often, trespassers walk across or along railroad tracks as a shortcut to another destination; rail ROWs often provide an easy, though illegal, shortcut to many walking destinations. Trespassers also may be engaged in other activities like loitering, hunting, bicycling, snowmobiling, or riding all-terrain vehicles. In other cases, a trespasser may have accessed the ROW in an attempt to end their life.

A study conducted in 2014 determined that the most commonly observed risk factors for pedestrian and bicyclist trespassing include intoxication, disregard for highway–rail grade crossing warning systems, and the use of electronic handheld devices (2).

**Trespass Prevention**

The railroad operating environment is inherently hazardous, and one in which railroad employees receive extensive safety training. Trespassers do not have the benefit of this safety training nor are they aware of current and pending train movements. Many trespassers risk life-threatening injury and loss of life by failing to use designated

---

¹ A list of state-by-state trespassing laws is available at www.fra.dot.gov/StateLaws.
crossing locations properly. To other trespassers, the dangers of the rail environment may present a perceived opportunity to harm themselves via an act of suicide.

Most trespassing casualties can be avoided. The Federal Railroad Administration (FRA), along with its safety partners, has been tackling this issue on several fronts, including developing guidance and conducting and sponsoring research. FRA has conducted several major activities in rail trespassing mitigation and has funded two studies to conduct a demographic and market analysis of rail trespass fatalities (3–4). The objective of these studies was to establish a foundation for either an outreach or a public education program and to create law enforcement efforts focused on those most at risk of rail trespassing.

The results of the studies indicated that “trespassers who are involved in fatal incidents on railroad rights-of-way are most typically identified as white males who are possibly intoxicated, with a mean age of 38, and with low socioeconomic status” (3). In his article “Scope and Trend of U.S. Rail Trespassing and Suicide Fatalities” on page 8 of this issue, Kurt Topel provides more detailed data about the characteristics of those who trespass.

Additionally, FRA held national rail trespassing workshops to identify and share industry best practices and to explore new abatement and mitigation strategies that may reduce the number of ROW and trespasser incidents and fatalities. Three workshops have been held to date, in 2008, 2012, and 2015, and one is scheduled for 2019 (5–7). Along the way, FRA also developed rail ROW trespass prevention guidance for local communities.

**Community Trespass Prevention Guide**

As part of its Community Trespass Prevention Program, FRA developed and published a guidance document, *Community Trespass Prevention Guide*. This document details a collaborative, step-by-step problem-solving approach for local communities to address rail ROW trespassing (8) and presents a problem-solving model called Community, Analysis, Response, and Evaluation (CARE). As shown in Table 1 (page 19), CARE consists of four general steps:

1. **Community**: Identification of the trespassing problem and the associated stakeholders within the community.
2. **Analysis**: Data analysis of the trespassing problem and identification of the underpinning causes.
3. **Response**: Identification and implementation of the most effective response(s).
4. **Evaluation**: Evaluation of the effectiveness of the implemented treatment(s).

The objective of CARE is to “create safer communities by fostering the development of long-term trespass prevention strategies through collaborative community problem-solving partnerships to reduce trespass fatalities” (8). It is aimed...
According to Federal Railroad Administration (FRA) data, 6,204 people were fatally injured on railroad property between 2012 and 2017. Trespassing on railroad rights-of-way (ROWs) rather than at a highway–rail crossing is the leading cause of railroad-related death—accounting for 44% of all railroad-related fatalities (Table 1, below). Suicide on railroad property is the second-leading cause of death, followed by fatalities that are due to non-suicide-related highway–rail crossing collisions. Of particular note is that, between 2012 and 2017, the rate of total fatalities per million train miles of operation increased by 19.6%.

When the fatality data are grouped by type, the magnitude of each group is highlighted, as well as the trend in quantity between 2012 and 2017 (Figure 1, at right). It appears that trespassing incidents are increasing and suicide incidents are declining; however, after further analysis and follow-up with local medical examiners and coroners, a small number of the trespassing incidents reported in 2017 likely will be reclassified as suicides—smoothing out the trend.

Pedestrians, trespassers, and other nonmotorized users constitute the majority of railroad-related fatalities. A common perception is that most people fatally injured by trains are motorists at highway–rail crossings; in reality, non-suicide vehicle operators at highway–rail crossings account for only 15.6% of all railroad-related fatalities.

### What Can Be Done?

The traditional three E’s approach of engineering, education, and enforcement has been successful in reducing the number

---

**TABLE 1 Summary of FRA Fatality Data by Type of Fatality**

<table>
<thead>
<tr>
<th>Type of Fatality</th>
<th>Number of Fatalities</th>
<th>Percent of Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employee or Contractor</td>
<td>18 19 16 20 19 15 19 15 17</td>
<td>1.7%</td>
</tr>
<tr>
<td>Other, e.g. Passenger</td>
<td>15 24 20 42 19 25 145</td>
<td>2.3%</td>
</tr>
<tr>
<td>Trespasser: Not at Crossing</td>
<td>405 427 470 450 467 513 2,732</td>
<td>44.0%</td>
</tr>
<tr>
<td>Suicide: Not at Crossing</td>
<td>234 256 242 278 228 229 1,467</td>
<td>23.8%</td>
</tr>
<tr>
<td>Suicide at Crossing: Pedestrian</td>
<td>30 50 28 33 39 30 210</td>
<td>3.4% 27.9%</td>
</tr>
<tr>
<td>Suicide at Crossing: Vehicle</td>
<td>12 8 6 17 5 6 54</td>
<td>0.9%</td>
</tr>
<tr>
<td>Crossing Collision: Pedestrian</td>
<td>67 70 54 83 104 103 521</td>
<td>5.4% 24.0%</td>
</tr>
<tr>
<td>Crossing Collision: Vehicle</td>
<td>164 182 187 154 152 168 968</td>
<td>15.6%</td>
</tr>
<tr>
<td>Total</td>
<td>945 1,016 1,043 1,077 1,033 1,090 6,204</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

**Rate Per Million Train Miles**

<table>
<thead>
<tr>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.292</td>
<td>1.357</td>
<td>1.362</td>
<td>1.458</td>
<td>1.498</td>
<td>1.544</td>
<td>1.417</td>
</tr>
</tbody>
</table>

SOURCE: Federal Railroad Administration.
The purpose of the demonstration was to show potential benefits of the CARE community-based approach, document lessons learned, and provide recommendations for implementation and evaluation of trespass prevention strategies.

An example of trespassing on the ROW captured by the research team in West Palm Beach is shown in the photo below.

Stakeholder representatives from federal, state, and local (that is, city and town) governments, local operating railroads, and other interested groups. The ultimate goal is to reduce the number of rail ROW trespassing incidents nationwide by promoting partnerships at the local level.

Implementing the Guide
The Community Trespass Prevention Guide was tested from 2009 to 2013, when FRA funded a major research initiative (9). Specifically, FRA directed the Volpe National Transportation System Center to conduct a trespassing prevention research study demonstrating the CARE model on a roughly 7-mile stretch of South Florida Regional Transportation Authority (SFRTA) ROW in the city of West Palm Beach, Florida.

This area was selected based on fatal incidents in 2008 on the SFRTA line as well as because by 2009 a stakeholder group already had been created to address the issue—reflecting the first step in the CARE process, or Community. FRA determined that West Palm Beach was most appropriate for a research study on precursors, mitigation strategies, and support for the development of national guidance related to trespass prevention.

Finally, one missing component seems to be the lack of an overall goal to reduce the number of railroad-related fatalities by a significant number in a set time frame. An example of such an effort can be seen in 2016 attempt to set a measurable goal by the DuPage Railroad Safety Council, which suggested a 50% reduction in the total number of fatalities nationwide within 10 years. Using the 1,033 railroad-related deaths of 2016 as a benchmark, this would mean a reduction of 516 railroad-related fatalities by 2026.

**WEST PALM BEACH: COMMUNITY**

The purpose of the demonstration was to show potential benefits of the CARE community-based approach, document lessons learned, and provide recommendations for implementation and evaluation of trespass prevention strategies.

An example of trespassing on the ROW captured by the research team in West Palm Beach is shown in the photo below.

Stakeholder representatives from federal, state, and local (that is, city and town) governments, local operating railroads, and other interested groups. The ultimate goal is to reduce the number of rail ROW trespassing incidents nationwide by promoting partnerships at the local level.

Implementing the Guide
The Community Trespass Prevention Guide was tested from 2009 to 2013, when FRA funded a major research initiative (9). Specifically, FRA directed the Volpe National Transportation System Center to conduct a trespassing prevention research study demonstrating the CARE model on a roughly 7-mile stretch of South Florida Regional Transportation Authority (SFRTA) ROW in the city of West Palm Beach, Florida.

This area was selected based on fatal incidents in 2008 on the SFRTA line as well as because by 2009 a stakeholder group already had been created to address theissue—reflecting the first step in the CARE process, or Community. FRA determined that West Palm Beach was most appropriate for a research study on precursors, mitigation strategies, and support for the development of national guidance related to trespass prevention.

**TABLE 1 CARE Model Steps**

<table>
<thead>
<tr>
<th>COMMUNITY</th>
<th>ANALYSIS</th>
<th>RESPONSE</th>
<th>EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify and describe the trespassing problem.</td>
<td>Develop data collection and analysis plan.</td>
<td>Identify and implement feasible countermeasures.</td>
<td>Assess impact of the response and determine whether the trespass problem was displaced, reduced, unchanged, or eliminated.</td>
</tr>
<tr>
<td>Identify community resources and begin involvement.</td>
<td>Collect trespassing data.</td>
<td>Develop countermeasures implementation plan.</td>
<td>Evaluate the process used and assess whether the key stakeholders were identified and included, the underlying causes were correctly identified, and the response was implemented as planned, as well as why any part of the plan may not have been implemented.</td>
</tr>
<tr>
<td>Organize a problem-solving committee with community stakeholders and develop an action plan.</td>
<td>Analyze the data collected to determine the underlying causes of the trespassing problem.</td>
<td>Implement such countermeasures as engineering, education, enforcement, and other strategies developed by the committee.</td>
<td>Develop and implement a long-term program monitoring plan if needed.</td>
</tr>
<tr>
<td></td>
<td>Establish baseline and identify measures to be used to determine program’s effectiveness.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Trespassing event in West Palm Beach.
county) governments—as well as railroads, neighborhood groups, and Operation Lifesaver, Inc.—participated in the demonstration (see Figure 1, above).

The photo at right shows one of several stakeholder group meetings held during the demonstration project. A picture of the stakeholder group during one of its site visits in the city is shown on page 21.

WEST PALM BEACH: ANALYSIS
For the second step in the process, Analysis, the research team adapted and applied a hazard analysis methodology described in FRA’s “Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service” (10). This resulted in the development of a risk-based hazard analysis process and prioritization algorithm to analyze trespassing data, which consisted of casualty incidents, trespassing observations by train crews, contacts by law enforcement, analysis of locomotive video data, and field observations by research staff.

The development and implementation of the risk-based analysis used to identify several trespassing high-risk areas in West Palm Beach was detailed in a technical paper published and presented at the American Society of Mechanical Engineers 2013 Joint Rail Conference (11).

WEST PALM BEACH: RESPONSE
Figure 2 (page 21) shows the results of the trespassing risk analysis on the SFRTA route through the city of West Palm Beach. These results were used by the study’s stakeholder group to develop a set of mitigation strategies for identified higher-risk locations, shown in yellow and red; this comprises the third step of the process, Response.

Recommended strategies included engineering treatments like fencing and signage; education programming, such as rail safety mailers, station posters, and outreach to local schools; and enforcement initiatives like enforcement blitzes. Some of these strategies were immediately deployed; others proved to be resource intensive and required additional work to secure the needed funding for such improvements.

WEST PALM BEACH: EVALUATION
Evaluation, the last step in the CARE model, assesses the effectiveness of the responses based on the measures identified in the data-analysis step. The research team evaluated the strategies implemented during the study and determined their effectiveness in mitigating the trespassing problem.

Evaluating the Guide
FRA conducted an evaluation identifying lessons to use in the design and implementation of future trespassing prevention studies (12). A key finding was that community-based intervention strategies such as CARE can help railroad agencies and other stakeholders better leverage community resources and apply diverse safety strategies.
MAXIMIZING EFFECTIVENESS
A key weakness of the model, however, is its resource and time intensiveness. The CARE model requires committed stakeholders with the power and incentives to implement proposed responses. For this approach to be effective, the underlying causes of trespassing must be determined, as well as the specific target audience for problem-solving efforts. Unless both of these variables are identified and addressed, it is unlikely that significant reductions in trespassing will be realized. Ultimately, the study successfully identified how to refine the CARE model and how to improve its effectiveness in the communities in which rail trespassing is a problem.

The general guidance worked well to establish a framework for the stakeholders to organize, collect, and evaluate the data, develop solutions, and implement trespass mitigation strategies. It increased stakeholder collaboration, leveraged collective resources, and maximized overall effectiveness of the community-based effort to decrease trespassing on railroad ROWs within the city. The implementation of the CARE model also educated non-rail stakeholders about the nature and severity of the trespassing problem with respect to their community, an issue that is often not well understood outside of the operating railroads.

WORCESTER PILOT
After the study, FRA has demonstrated the use of the CARE model on the rail ROWs in Worcester, Massachusetts. That effort, initiated in 2016, resulted in the identification of three high-risk locations along one of the city’s rail ROWs in the city. The stakeholder group developed a set of recommended strategies, many of which already have been implemented, including the removal of an unauthorized skate park under railroad property and the removal of an abandoned loading dock on the ROW that could have been used for unauthorized encampments. Signage and surveillance cameras also were installed.

The city of Worcester currently is implementing the remaining strategies that were recommended for law enforcement.

Lessons from implementing the CARE model in West Palm Beach and Worcester helped identify appropriate circumstances in which community-based interventions are warranted and likely to be effective. FRA and the Volpe Center are engaged actively in the process to show the benefits of the CARE model in the approach to solving the rail ROW trespassing problem.

Prevention Strategy Status
In its report on the Fiscal Year 2018 budget, the U.S. House of Representatives Committee on Appropriations asked FRA to study and identify the factors that lead to trespassing incidents on railroad property and to develop and submit a national strategy to prevent these accidents to the House and Senate Committees on Appropriations by August 1, 2018 (13). The House Committee directed FRA to include milestones, timelines, and metrics to define success in its strategy, with the expectation that FRA implement a tres-
passer accident prevention strategy within the recommended timelines.

In October 2017, FRA formed a team of experts to study the problem of people being killed or injured while trespassing on railroad property. To help define the scope of the problem, the team conducted an analysis of the costs of railroad trespassing accidents to railroads and to society. They found that the total cost to society of all trespassing accidents—the value of fatalities, injuries, and travel-time delay caused by trespassing incidents over 5 years, from 2012 to 2016—was approximately $43.2 billion (14).

The team also reviewed research and data related to railroad trespasser fatalities nationwide for the 4-year period between November 2013 and October 2017. They concluded that, out of the 3,100 counties and county equivalents in the United States, approximately 14% of all fatalities had occurred in the same 10 counties located in four states. Additionally, 74% of all trespasser casualties during the same period occurred within 1,000 feet of a grade crossing—less than one-quarter of a mile away.

To this end, FRA has developed the National Strategy for Trespass Prevention on Railroad Property, which focuses on four areas: 1) data gathering and analysis, 2) community site visits, 3) funding, and 4) partnerships with the affected stakeholders (14). The report to Congress has been finalized and was detailed at the FRA Grade Crossing and Trespasser Summit, held on October 30, 2018 (15).

The CARE Guide, which details a collaborative step-by-step rail ROW trespassing problem-solving approach for local communities, is one of the tools in the overall National Strategy.

REFERENCES
What can be done to reduce the frequency and severity of injury from railroad trespassing and suicide? According to the Federal Railroad Administration (FRA), trespassing away from crossings has been the leading cause of deaths on U.S. railroads every year since 1997; today, trespassing fatalities comprise 44% (450) of annual rail-related fatalities (1). Suicide fatalities comprise the next-largest category of rail deaths (28%, or about 300 annually) (7).

Although other categories of rail deaths—for example, at railroad crossings or of employees or passengers—have been successfully addressed and reduced, railroad trespassing and suicide rates have stubbornly resisted improvement. Although highway–rail crossing fatalities still comprise a significant share (24%) of all rail deaths, this figure has decreased consistently over time (2). This decrease is correlated to grade-separation projects, crossing closures, upgraded warning devices, and other engineering improvements installed at crossings, which have been made possible through substantial investments by the federal government.
and some state governments (2). Driver education also was found to contribute significantly to this decrease (3).

To date, efforts to reduce deaths related to rail trespassing and suicide have not received a similar level of investment.

**Classification and Countermeasures**

A suicide is differentiated from other rail casualties by a finding of intent to self-harm, as determined by a coroner, public police officer, or other public authority (4). Unless such a determination is made, FRA classifies the casualty in the appropriate accidental injury or death category—usually “trespasser away from crossing” or simply “trespasser.” Some rail safety researchers believe that this standard of determination is stringent and probably leads to some suicides being classified inaccurately as trespassers (5).

Because the intent of each person entering the track area is different, it sometimes makes sense to look separately at the countermeasures for rail suicides and for trespassers. But if not properly implemented, some countermeasures intended to deter one behavior could actually encourage the other behavior. For example, educating the public about the likely fatality of a train–person strike may decrease trespassing behavior but could encourage suicidal behavior by reminding a distressed person of the high lethality of the train as a possible means of suicide.

Although the reasons for suicide and trespassing are different, the physical means of accessing the track are remarkably similar. As shown in Figure 1 (below), countermeasures for before the subject enters the right-of-way (ROW) are different but countermeasures for after the subject reaches the tracks are the same. This suggests that at some point in the prevention process, suicide and trespassing can be approached as a single problem, with exceptions for announced public-policy countermeasures.

Other reasons why suicide and trespassing incidents can be addressed as one problem include the following:

- Suicidal intent is not always clear nor is it easy to prove, especially to railroad safety stakeholders.
- Once the individual has entered the track area, most of the measures aimed at reducing trespassing incidents also could work for suicide prevention.
- Trespassing can be driven by various reasons—such as shortcuts, vandalism, thrill seeking, and photography—but also by the intention to put oneself in harm’s way.

This model focuses attention on the trespassing person, or subject, and suggests countermeasures for authorities to consider based on the decision-making process of the subject. This approach contrasts with the traditional three E’s approach (engineering, education, and enforcement), which focuses primarily on the stakeholder that is providing the countermeasure and on the mode of implementation. For further details and discussion about this model, including the input and output of the model, see research by Burkhardt et al. (6).

**Trespassers use railroads for many reasons and the intention of the decedent in a fatal trespassing incident is not always clear.**

**Project RESTRAIL**

This article’s approach to rail trespassing and suicide countermeasures is based in part on one developed by RESTRAIL.

---

**FIGURE 1** A model of the chain of events leading to railway suicides and trespassing incidents and corresponding classes of preventive measures (6).
In Figure 2, the third process, selection of measures, suggests that it may be appropriate to implement more than one countermeasure either simultaneously or consecutively depending on the circumstances. What follows are examples of the types of countermeasures available to address rail trespassing and suicide.

Organizational and Procedural Measures
Patrols may be conducted by local police, railroad police, or community volunteers. To deter trespassing, the patrols should be conspicuous—that is, not in plain clothes—and on foot if possible. If the trespassing behavior has a temporal component—for example, vandalism that often takes place in the evening and nighttime or shortcuts that often are taken during rush hour—the patrols should be deployed accordingly.

Patrols work well with other countermeasures, especially if combined with awareness campaigns. Depending on the local situation, patrols can issue either citations or warnings to trespassers. In some situations, trespassers are aware of the illegality of their behavior; in other situations, they are not. For example, according to

---

1 More information on the project and toolbox, as well as further examples of countermeasures, can be found at www.restrail.eu/toolbox.

---

FIGURE 2 The RESTRAIL countermeasure selection process model (7).
Countermeasures for trespassers who are taking a shortcut differ from countermeasures for those who may be loitering, or those who may be vandalizing.

Freeman and Rakotonirainy, more than 80% of respondents to an Australian survey understood the rules about when it was legal to cross the tracks (8). On the other hand, a Croatian study found that 85% of respondents did not know they could be fined for illegally crossing the tracks at a grade crossing when a train is approaching (9).

By consecutively testing awareness, targeted education, and enforcement, Lobb, Harré, and Terry found that punishment may be more effective than targeted education in reducing unsafe behavior and much more effective than communications to heighten awareness (10).

Patrols do have some drawbacks, however. Municipal and railroad police often have competing priorities. At a recent conference, an FRA official indicated that, in one county with high trespassing casualty rate, more than 95% of the trespassing violation cases were filed by railroad police rather than by local police (11). Railroad police also may focus more on vandalism and theft than more benign forms of trespassing.

Anecdotal evidence also indicated that railroad trespassing violations are not taken seriously in the judicial process.

As reported at the same FRA conference, 228 trespassing violations were issued in a different high-casualty county—but only one was prosecuted.

A 2016 FRA report concluded that “empirical data on the effectiveness of law enforcement initiatives for preventing rail trespassing is not readily available;” the report nonetheless asserts that “enforcement plays a key role in preventing rail trespassing incidents and casualties” (12). Early in 2018, FRA initiated a program to evaluate the effectiveness of funding local law-enforcement activities intended to reduce trespassing incidents and casualties.²


Photograph: StockSnap, Pixabay

Physical and Technological Measures
Detection and surveillance systems are an example of the physical and technological family of trespassing countermeasures. These systems detect an incursion and provide a warning in real time either to

In the United Kingdom, members of the West Midlands Police Safer Travel Team patrol a station to deter trespassers.
the trespasser or to a monitor who may take action to avert a collision.

**FINNISH STUDY**
The RESTRAIL pilot tested an automatic detection and alarm system at two illegal footpaths in Finland (13). Trespassers were detected by an infrared sensor, which triggered a prerecorded voice message instructing them to leave the area immediately. At one test site, a 44% decrease in trespassing behavior was recorded over a 60-day period after installation; the other location showed an 18% decrease.

**PITTSFORD STUDY**
A similar study was performed by FRA at a railroad bridge at Pittsford, New York, in 2006:

At least two events in which a total of four trespassers were removed from the bridge just minutes from a train arrival occurred during the 3-year evaluation period. These comprised over 1% of the 173 logged trespassing events. A third event involving one trespasser occurred just after the conclusion of the evaluation period. (14)

Some technical and operational difficulties were encountered during the Pittsford study. A major problem encountered was “false positives;” that is, detections triggered by irrelevant stimuli. With the advances in video analytics since 2006, as well as more elaborate detection algorithms, false positives may perhaps be minimized in future applications. Although automatic sound warnings seemed somewhat effective, at least in the short term, issues such as the following must be considered:

- Sound warnings may be more effective for children than for adults.
- Neighbors may object to the noise, especially during nighttime hours.
- Unless the trespasser fears punishment, the effect of a sound warning alone likely will wane over time.
- It is not known whether a sound warning would dissuade a trespasser’s intent to die by suicide, although it may interrupt their behavioral intention. In any case, it is assumed that a prerecorded sound warning against suicide should be different than one against trespassing.

**BRUNSWICK STUDY**
In 2013, FRA and the Maine Department of Transportation (DOT) announced a field research system that would “utilize remote presence detection sensors and secure, wireless cameras at locations frequented by trespassers. Upon detecting a person on the tracks, the Brunswick Police Department will be immediately notified for appropriate response” (15).

As of March 1, 2019, results were not yet published by the FRA.

**Awareness and Educational Measures**
Several studies indicate the positive effects of restrained reporting of suicide events, especially public suicide events. Conversely, news stories on rail suicide that include images and specific descriptions of locations can lead to copycat behavior (16–17). One study implied that any reporting—not just sensational or specific reporting—could increase incidences of suicide (18).

A recent FRA study compared media treatment of FRA-reported suicide and
Countermeasure Implementation and Evaluation

Implementation of the selected countermeasures should be conducted carefully and should consider both practicality and plans for ongoing evaluation. The first step is to plan the implementation, addressing operational issues such as how the project is to be financed, who the committed partners are, and how the implementation schedule will proceed. Also, methods for evaluation of countermeasure success must be planned from the beginning, including anticipated outcomes and how these can be quantified and evaluated (20).

If the implementation plan is experimental, a baseline measure should be taken so that the effectiveness of the countermeasures can be determined. Also, it is helpful at this stage to consider whether a long-term evaluation period should be scheduled after the initial evaluation period. This is important because some countermeasures may become less effective over time.

Next, if possible, the countermeasures must be implemented according to the plan. If changes to the plan must be made, they should be documented alongside any lessons learned. Data on outcomes both expected and unexpected should be collected carefully and consistently to enable the integrity of the evaluation process (21). Documentation and communication of the effectiveness of the countermeasures can improve future preventive practice and help develop better safety policies (22).

Conclusion

Although countermeasures at highway–rail crossings—grade separations, crossing closures, upgraded warning devices, and other education and engineering improvements—have greatly reduced the rate of fatalities at these locations, it has proved more difficult to reduce fatalities and injuries from rail trespassing and suicide, despite the range of potential countermeasures.

Some of the possible reasons progress has not been made in reducing trespassing and suicide incidents include a...
Although there is hope that the recently published FRA national strategy might bring guidelines and funding, each local trespassing and suicide problem must be addressed based on local needs.

No single “magic bullet” countermeasure can be implemented by all communities nationwide. Some communities have a graffiti or vandalism problem in the vicinity of the railroad tracks; some have issues with frequent, heavy usage of drugs and alcohol near the tracks; and some have a problem with pedestrians who ignore safety rules because of distraction, ignorance, or impatience. Although there is hope that the recently published FRA national strategy might bring guidelines and funding, each local trespassing and suicide problem must be addressed based on local needs.

Acknowledgement

Project RESTRAIL was supported by the European Union’s 7th Framework Programme for Research, Technological Development and Demonstration.

REFERENCES


At the 2018 American Public Transportation Association Rail Conference, Federal Railroad Administrator Ronald L. Batory encapsulated one of the biggest problems in the rail industry today, noting that “trespassing on railroad property is the leading cause of all rail-related deaths” (1). Ninety-five percent of railroad deaths on freight and passenger railroads between 2009 and 2016 were due to trespassing and grade-crossing collisions. The number of trespassing casualties from 2013 to 2016 was 16% higher than the number of casualties from 2009 to 2012 (2–4). In this research, trespassing is defined as incursions 1) at grade crossings, when roadway users enter after the signal lights have been activated, and 2) at right-of-way (ROW) locations that are neither intersections nor crossings, except by authorized railroad personnel (5).

Most rail trespassing behavior does not result in injuries or fatalities, however. Many instances of trespassing go undetected or are not recorded in Federal Railroad Administration (FRA) safety databases because no immediate harm occurred. This lack of data prohibits comprehensive analyses of trespassing risk; although not all trespassing events cause damage, they indicate certain behaviors that may lead to severe consequences if repeated. Learning from trespassing is a critical element of effectively developing the three E’s of safety—education, enforcement, and engineering strategies—to prevent trespassing on railroad tracks (6).

Trespassing and Big Video Data

Greater availability of video data in the rail industry has made it easier to acquire trespassing data. Closed-circuit television (CCTV) cameras can be found throughout railroad yards, bridges, grade crossings, and stations. In 2015, the Fixing America’s Surface Transportation Act mandated the installation of cameras throughout passenger railroads to promote safety objectives;
ever since then, the deployment of CCTV systems in the United States has increased (7). For example, in Palo Alto, California, Caltrain has installed CCTV cameras at safety-critical grade crossings to monitor and prevent illegal incursions via an integrated alert system (8).

The CCTV trend is global. For example, in 2018 India began an initiative to install cameras on more than 11,000 trains and in 8,500 stations throughout the country (9).

These cameras provide valuable video-based sources of big data for railroads—but analyzing the data accurately in real time is a challenge. At present, many camera systems are reviewed manually by railroad staff, but limited resources and operator fatigue can lead to missed trespassing events (10–11).

Artificial Intelligence for Trespassing Detection

This article presents research on an artificial intelligence (AI) algorithm that uses an existing video infrastructure to watch for, recognize, and understand trespassing events in real time. The algorithm is coupled to a live alert system that sends trespassing alerts to designated destinations.

Evidence from parallel industries that use similar algorithms, such as highway and aviation, indicate that AI can help current railroad staff detect more trespassing. The AI detection system outlined here combines two computer-vision AI techniques: region of interest (ROI) and Mask R-CNN.

ROI is a user-defined area in the camera’s field of view that denotes a trespassing event if the area is entered by a person or vehicle. Mask R-CNN is an artificial neural network (that is, AI that mimics the network of neurons in the human brain) used for image recognition (12). For neural networks to function, they must be trained to recognize certain objects. In this research, Mask R-CNN was integrated with the Common Objects in Context (COCO) data set, which consists of more than 328,000 labeled images of everyday scenes built for object-recognition research. This provides valuable training data for computer-vision algorithms to recognize commonly seen objects like people, cars, and trains (13).

As developed, the AI system parses a video live stream, prompts the user to identify the ROIs within the frame, detects whether people or vehicles are in the ROI, and sends alerts if trespassing has occurred.

STEP 1: PARSING THE LIVESTREAM

The first step of the AI system is to establish a connection to the livestream of the selected location. After raw video data is provided—for example, via Internet livestream—the program will proceed to Step 2.

STEP 2: DRAW ROI

The second step of the program is to identify the ROI. A user will be prompted with a static image of the video feed and then can select the outer limits of the trespassing area in sequential order. The borders of the ROI will be represented by a green line and can be closed by selecting the first point.

Multiple ROIs can be identified in the same frame and differentiation can be made between ROWs and grade crossings (see Figure 1, page 32). The difference is that any object—for example, person, motorcycle, bicycle, car, or truck—detected within the ROW ROI will be deemed illegal and will trigger an alert, except for authorized railroad personnel. Conversely, the grade-crossing area only will trigger an alert if the algorithm detects that the signal lights are active.

STEP 3: TRESPASSING DETECTION

The third step in the algorithm utilizes Mask R-CNN (12). Each frame is checked for objects within the selected ROI. If a grade-crossing ROI is identified, a subroutine will actively check for the initiation of a crossing signal light. As soon as that light activates, anyone who enters the ROI is considered to be trespassing. Both freight and passenger trains also are identified by the algorithm, but are deemed legal occupiers of the ROI and therefore do not trigger alerts.

One limitation of the algorithm is its inability to differentiate between authorized railroad personnel and trespassers. In future research, this will be resolved by providing the Mask R-CNN with training data to automatically filter out authorized railroad personnel and workers based on the unique characteristics of their attire. In the current system, these possible trespassing events are filtered out manually.
To maximize accuracy, the AI system was tested on two new locations. Two ROWs were selected for this portion of the analysis and a cumulative 100 hours of live video were reviewed. The AI was not modified during this phase and a copy of the footage was reviewed to see if the system missed an instance of trespassing or if it raised false alarms. Longer, more diverse training data would increase the accuracy and adaptability of the AI in future research.

To select an appropriate stream, researchers searched for several variables, including a clear view of signal lights for grade crossings and an urban population, to increase the chance of trespassing events. With these factors considered, three streams were identified for analysis. Figure 2 (above) shows a typical view of the locations.

A grade crossing in Ashland, Virginia, and two ROWs in Thomasville, North Carolina, were chosen for two reasons:

The study did not address passive grade crossings, which lack active signalization such as lights and gates, because of a lack of available video coverage of these locations.

A training and testing plan was put into place to ensure that the AI system achieved the highest accuracy and smallest number of missed detections and false alarms. First was initial development of the AI, using 130 hours of recorded grade-crossing footage. A known quantity of trespassing was established by manual inspection of the training data and then by debugging the AI until 100% accuracy was achieved.

The final step is twofold: 1) an alert text message or e-mail is sent to a designated user and 2) the trespassing event video and metadata are recorded to a database. The alert text messages or e-mails can be directed to railroad safety officials for immediate action. The database contains information on time, object detection, and identified zone (that is, grade crossing versus ROW), as well as the name of the associated video file.

**Results**

This system was tested on two different safety-critical scenarios: grade crossings and ROWs. Grade crossings are highway–rail intersections with active signalization that alerts pedestrians and vehicles to an approaching train. During a trespassing event at a grade crossing, pedestrians and vehicles enter the crossing after the signal lights are activated. ROW locations are defined as railroad property with no intersection or crossing; in these locations, all incursions are deemed illegal except for those by authorized railroad personnel.

**FIGURE 1** ROI for (a) grade-crossing stream, (b) first ROW stream, and (c) second ROW stream. (ROW = right-of-way; ROI = region of interest.)

**FIGURE 2** Selected (a) grade-crossing stream, (b) first ROW stream, and (c) second ROW stream.
availability of video streams with a clear view of signal lights and 2) demonstration of the flexibility to different trespassing environments.

**Ashland, Virginia**

Between July 19 and 25, 2018, 120 hours of live footage of the Ashland grade crossing were analyzed. The alert system reported 140 positively identified trespassing events. The analysis period included a range of environmental conditions, including heavy rainfall, fog, and many day–night cycles.

The AI system was able to automatically differentiate among types of trespassers. Figure 3 (at right) shows a breakdown of the results acquired during the analysis period. This graph represents the results during the limited duration testing and does not indicate a general trend. With a longer analysis period, this system could ascertain general trespasser demographics and trends. The AI algorithm searched for six categories of trespassers—car, truck, bus, person, bicycle, and motorcycle—selected from more than 80 object categories allowed by Mask R-CNN and the training data from the COCO data set (12, 13).

The most common type of violation observed in the study was the passage of vehicles through the grade crossing while the signalized intersection lights were activated. A total of 116 events of this kind were detected—comprising 83% of all detected trespassing events at the study location. Figure 4 (below) shows several typical examples of this type of detected event. The color overlay of the vehicle, automatically generated by the AI, indicates a recognized object. The masking also preserves the privacy of detected trespassers.

The second most common trespassing event, shown in Figure 5 (page 34), was the illegal incursion of pedestrians while the active signalized gates were down. These events, 24 in all, made up 17% of all detected trespassing events at this location.

Both types of trespassing events represent typical nonconforming behaviors at grade crossings. Drivers and pedestrians who traverse the crossing while the gates are lowering appear to be confident that they have enough time to pass through the intersection before the train arrives. Individuals who cross the intersection while the gates are raising assume that the crossing is safe, disregarding the possibility that a second train might approach and reactivate the gates.

These events were recorded to a local trespassing database. If such a database is expanded, commonalities between trespassing behaviors can be better understood. If the data gathered by the AI system indicate trends—for example, increased trespasser activity at similar time periods during the day—the presence of law enforcement may deter a large portion of illegal behavior (15). In another example, if it is discovered that most trespassing at the selected grade crossing occurs from a particular roadway direction, installing additional active signalization

![Figure 3](image)

**FIGURE 3** Distribution of Ashland, Virginia, grade-crossing trespassers by type, based on 120 hours of sample video data.

![Figure 4](image)

**FIGURE 4** Vehicle (a) driving around deployed gates from far roadway, (b) driving around deployed gates from near roadway, and (c) school bus bus crossing as gates are closing.
and barriers for traffic coming from that direction may mitigate excessive crossing (15). In the future, expanding this research to more locations and aggregating a large trespassing database could highlight trends and inform solutions to the trespassing problem.

An additional feature of the Mask R-CNN is its ability to anonymize trespassers automatically (12). The overlay of colored masks on the images of detected trespassers prevents the identification of the individual. Similarly, the masks overlaid on the images of vehicles obscure the license plate sufficiently to prevent identification, therefore maintaining the privacy of the driver.

**Thomasville, North Carolina**

In the final portion of the study, two completely new locations were tested with the AI system to demonstrate the flexibility of this algorithm to different trespassing scenarios. In the first ROW location, the AI analyzed 69 hours of live footage from July 21 to 27, 2018. During this period, the AI recognized 10 trespassing events in several distinct environmental conditions, including rain, fog, and nighttime (see Figure 6, at right). The AI was able to identify trespassers correctly, despite suboptimal detection conditions.

To date, the AI system is 100% accurate at this location; that is, producing no false positives and no false negatives. Most of the trespasses detected at this location show individuals walking along the railroad tracks instead of the sidewalk on the roadway to the north of the camera’s view. It is unclear why these individuals made the choice to trespass on railroad tracks, but the aggregation of these events can inform proactive strategies for preventing accidents. A feature of the AI is the live-alert system that sends text messages or e-mails to a user-defined destination. In a trespassing scenario, it is conceivable for the AI to inform railroad staff that a trespasser is present on their property. At this point, law enforcement could be contacted and a trespasser could be removed before potentially catastrophic consequences occur (15).

**FIGURE 5** Single pedestrian (a) walking behind gates and (b) crossing behind train, (c) multiple pedestrians crossing behind train, and (d) single pedestrian waiting on railroad tracks.

**FIGURE 6** Single trespasser (a) detected crossing in foggy weather, (b) group of trespassers detected at night, (c) single trespasser detected before crossing, and (d) single trespasser traveling within railroad property.
At the second ROW location, the AI system analyzed 48 hours of live footage between July 29–30, 2018, successfully detecting 109 trespassing events. The livestream view (Figure 7, above) overlooks a stretch of track leading to a grade crossing that can be seen at the far upper right of the screen. The detection of grade crossing–specific trespassing was impossible at this location because the view of the active signalization was obstructed and because of the extreme distance of crossing in the frame. Despite these limitations, a ROI was identified on the ROW and trespassing events were detected.

Some cases captured by the AI appear to show trespassers using the railroad property as a shortcut to travel between a parking lot and a downtown area. If aggregation of the data into a larger trespassing database shows this behavior to be a trend, it is possible to compile large data sets of trespassing events and provide useful insights into trespassing behavior to ultimately support risk mitigation decisions.

**Conclusion**

This research tested a customized AI algorithm for automated trespassing detection based on big video data in the railroad industry. Previously, collecting and analyzing camera video data for railroad trespassing was very laborious. With this AI technology, it is possible to compile large data sets of trespassing events and provide useful insights into trespassing behavior to ultimately support risk mitigation decisions.

**REFERENCES**

Metro-North Railroad and Long Island Rail Road (LIRR) continuously seek ways to mitigate trespassing within the system, using a comprehensive strategy that includes education, outreach, and community partnerships; inspections and system hardening; and, most recently, technology.

Safety education and community outreach efforts have been established as important methods to prevent trespasser activity and consequent incidents. In 1989, LIRR initiated the Together Railroads and Communities Keeping Safe (TRACKS) program, along with the Metropolitan Transportation Authority (MTA) Police Department. In May 2016, Metro-North’s Office of System Safety launched its own TRACKS program. TRACKS is a fully customizable rail safety education and community outreach program that promotes safe behaviors at or around railroad grade crossings and tracks. Both the LIRR and Metro-North TRACKS programs educate more than 100,000 people every year on issues including trespasser prevention.

TRACKS delivers rail safety presentations to people of all ages within the Metro-North and LIRR territories. The program’s content not only teaches individuals to act safely around trains and tracks, but also focuses on the dangers and unlawfulness of trespassing on railroad property. The presentations include short educational videos and testimonials to reinforce the seriousness of trespassing incidents and to prevent individuals from trespassing. These presentations are tailored for different ages and are revitalized frequently to keep content engaging, current, and effective.

**Community Outreach**

Community outreach is a primary component of the TRACKS effort to reduce trespassers. In conjunction with MTA police, safety professionals at Metro-North and LIRR conduct frequent outreach sessions at stations and grade crossings, handing...
out rail safety information to pedestrians, passengers, and drivers during peak hours. The information outlines safe behaviors on or near train tracks and grade crossings so as to prevent individuals from trespassing on Metro-North and LIRR properties (see photos above).

Education

The TRACKS program also focuses on educating drivers so that they do not trespass on railroad property with their vehicles. Metro-North and LIRR work with Operation Lifesaver, Inc., to remind drivers of the importance of making safe choices at grade crossings, abiding by vehicle traffic laws, and considering penalties for violations. Metro-North and LIRR also support and participate in International Level Crossing Awareness Day. At this annual event, Metro-North and LIRR employees conduct TRACKS outreach at grade crossings located throughout the Metro-North and LIRR territories, relaying grade-crossing safety information and the dangers of trespassing with vehicles and answering customer questions.

Metro-North's TRACKS program recently partnered with its social media team to address trespasser issues. This partnership facilitates the creation of effective messaging targeted at trespassers to be posted to Metro-North's Twitter, Facebook, and Instagram accounts. The content is created and revised as new trespasser-related issues arise.

For example, the teams recently created a hiker safety campaign that involved social media blasts during the hiking season to prevent trespassing on tracks near trails. Many of these social media messages have also been transformed into creative posters, which are displayed at Metro-North stations.

Community Partnerships

Another key component of Metro-North's strategy is community partnerships. Metro-North's TRACKS program has developed outreach on the topic of suicide prevention and awareness. Since 2015, Metro-North has had 52 trespasser strikes, 47 of which (90%) were confirmed suicides or suicide attempts. In 2016, Metro-North TRACKS and the National Suicide Prevention Lifeline partnered on a poster campaign to encourage individuals experiencing a mental health crisis to seek help. These posters are displayed in Metro-North train cars and stations and are revised and reposted annually.

In addition to the poster campaigns, the TRACKS program participates in community Out of the Darkness Walks, hosted by local chapters of the American Foundation for Suicide Prevention. Employees staff informational tables and hand out rail safety and trespass prevention information to event attendees. The TRACKS program will continue to expand the suicide prevention program to reduce this subset of trespasser incidents.

Similarly, LIRR is helping to promote awareness of the issue of suicide, working with the New York State Office of Mental Health and the Suicide Prevention Coalition of Long Island. The Coalition is dedicated to saving lives through suicide prevention training, education, and resource distribution. Two Coalition

Example of Metro-North (left) and LIRR (right) rail safety information distributed at outreach events.

Metro-North's TRACKS program works with social media to discourage hikers from trespassing on rail property.
members, the Response Crisis Center and the Long Island Crisis Center, staff the LIRR suicide and crisis intervention hotline, which operates 24/7, 365 days per year. Professionally trained and supervised counselors provide callers with emotional support and assess level of risk. The counselors can immediately contact MTA police to intervene if the individual is on LIRR property. When indicated, crisis counselors follow up and provide ongoing outreach via telephone.

LIRR has installed suicide prevention awareness posters at all 124 of its stations and metal signs at 30 of its stations to continue to publicize the availability of resources and support.

**Inspections and System Hardening**

Inspections and system hardening also are critical to managing risk. For this reason, the LIRR Right-of-Way Task Force (ROWTF) was formed in 2003 to conduct proactive safety and security improvements of the property immediately adjacent to active rail corridors. ROWTF is a partnership between the LIRR Corporate Safety Department and MTA police. Two dedicated employees analyze trends, investigate immediate reports, and perform real-time patrols to identify potential security breaches, unauthorized encampments, illegal dumping, encroachments, and trespass conditions. Combined police and railroad resources help abate these conditions through coordinated oversight of clean-up, enforcement, community education, and right-of-way hardening such as high-security fencing.

In April 2018, LIRR initiated a grade-crossing delineator program to install delineators and reflective road markers at all crossings. The delineators guide motorists over the crossings and offer a warning not to turn onto the tracks. All LIRR crossings were furnished with delineators by August 2018. LIRR monitors, investigates, and tracks all incidents at crossings and shares the findings with senior management. By analyzing the incident data, LIRR will be able to determine the effectiveness of the delineator program.

**Technology**

Most recently, Metro-North and LIRR have leveraged technology to enhance their approach to minimizing trespassing. In May 2018, Metro-North and LIRR joined Waze’s Connected Citizens Program (CCP). Waze is a community-based traffic and navigation app created as a social navigation tool for private cars. The program issues real-time traffic alerts, leveraging a wide subscriber base to receive safety notifications for at-grade railroad crossings. As a member of Waze’s CCP, Metro-North and LIRR can keep their grade-crossing hazard alerts active regardless of consumer interaction.

Fatalities on LIRR have steadily decreased over the years, from an average of 30 fatalities per year between 1992 and 1994 to an average of 20 fatalities per year in the past 3 years—a 33% reduction—according to internal figures. At Metro-North, after TRACKS was implemented in 2016 along with other trespasser prevention initiatives, the number of trespasser strikes by train also decreased by 33%. According to Metro-North’s internal safety claims database, the number of broken gates at grade crossings decreased by 25% since the TRACKS program began.

Metro-North and LIRR continue to invest in initiatives to mitigate trespassing-related issues. As two of the largest commuter railroads in the United States—serving more than 177 million customers annually—Metro-North and LIRR are committed to the safety of employees, customers, and communities.

TR NEWS July–August 2019
Rear-Seat Passenger Safety Lags

Although front-seat occupants have benefited significantly from advancements in safety restraints, rear-seat safety has not kept pace. A recent study by the Insurance Institute for Highway Safety (IIHS) examined the factors contributing to serious and fatal injuries for belted rear-seat passengers in frontal crashes, especially those in which front-seat occupants survived.

Researchers conducted a series of case reviews, examining crashes in which occupants were 6 years of age or older and in which the vehicle was within 10 model years of the crash. Case reviews of 117 rear-seat injuries and fatalities showed that more than half of those occupants were more severely injured than the front-seat occupants of the same crash, most often due to seat belt load limiters. IIHS reported that backseat occupants are more likely to have head injuries from a lack of airbags and are more likely to have chest injuries because of seat belt limiters.

For more information, visit www.iihs.org/news/detail/rear-seat-occupant-protection-hasn't-kept-pace-with-the-front.

Guide Pups Train at Oakland Airport

In May, Oakland International Airport and Alaska Airlines hosted 70 puppies in training, along with handlers, volunteers, and staff, from the Bay Area Guide Dogs for the Blind (GDB) to navigate ticketing and security, gate check-in, boarding and deplaning, and claiming baggage.

Only 42% of dogs who begin the service training program go on to graduate. According to a 2017 study published in the Proceedings of the National Academy of Sciences, a successful guide dog needs not only to be obedient but also to have problem-solving abilities, perseverance, and calmness, and lack distractibility. The study also pointed out that real-world experience before training can lead to higher success rates.

The partnership between the airport, airline, and GDB gave the young dogs early exposure to what often can be a stressful experience. When dogs are introduced to the complexities and distractions of an airport at a young age, they are more likely to handle such situations calmly as working adults. The dogs also act as ambassadors, teaching airport, security, and airline personnel best practices when working with service animals.

To read more about the training, visit www.mercurynews.com/2019/05/11/65-guide-dogs-in-training-descend-on-oakland-airport.

Thriving Ports Buoy U.S. Economy

The nation’s ports added $5.4 trillion to the economy in 2018, according to a recent economic impact study. This figure, which is up 17% since 2014, accounts for more than one-quarter of the total U.S. economy and represents 165 million tons of additional international cargo over the past 4 years.

The study by Martin Associates examines the impact on four business sectors associated with marine terminals: surface transportation, cargo marine transportation, vessel operations, and cargo handling. Data and interviews were collected from more than 14,000 firms in the industry to develop a baseline; tax impacts were estimated based on published Tax Foundation data.

The gains included a jobs increase of 7.7 million; an 18% increase in federal, state, and local tax revenues; and personal wage and average salary increases.

To read more, visit www.ttnews.com/articles/ports-shipping-industry-responsible-26-us-gdp-study-says.

Flying Cars an Answer to Congestion?

According to a new study by the University of Michigan Center for Sustainable Systems, electric vertical takeoff and landing (eVTOL) aircraft may alleviate traffic congestion, compete in a ridesharing environment, and fill a niche role for longer trips.

Using publicly available information, researchers created a physics-based model to compute energy use and greenhouse gas emissions for eVTOLs. They then compared the model outputs with ground-based drones and found that eVTOLs carrying a pilot and three passengers outperformed ground-based cars in all areas—even when accounting for the electricity generated in producing the vehicles’ batteries.

Five phases of flight—takeoff, climb, cruise, descent, and landing—were evaluated. Takeoff and climb used the most energy; longer trips were the most energy efficient because of a longer cruise time. According to the study, point-to-point eVTOL trips could result in an 80% time savings compared with ground-based vehicles. Researchers note, however, that eVTOLs are most sustainable in trips of more than 22 miles.

To learn more about the study, visit https://aashtojournal.org/2019/04/12/university-study-says-flying-cars-ideal-for-congested-cities-as-ride-share-taxis/.

Guide Pups Train at Oakland Airport

Photo courtesy of Rebecca Lacefield

Tampa and her handler practice boarding an airplane as part of an Oakland Airport training designed to expose the puppies to real-world travel experiences.

Thriving Ports Buoy U.S. Economy

Photo: Spielvogel, Wikimedia

Jaxport’s container volumes were up 25% in February.

firms in the industry to develop a baseline; tax impacts were estimated based on published Tax Foundation data.

The gains included a jobs increase of 7.7 million; an 18% increase in federal, state, and local tax revenues; and personal wage and average salary increases.

To read more, visit www.ttnews.com/articles/ports-shipping-industry-responsible-26-us-gdp-study-says.

Flying Cars an Answer to Congestion?

Photo: JAXPORT, Flickr

Use of fully electric, automated urban air taxis, like the Volocopter 2X shown here, could reduce traffic congestion and be more environmentally friendly.

According to a new study by the University of Michigan Center for Sustainable Systems, electric vertical takeoff and landing (eVTOL) aircraft may alleviate traffic congestion, compete in a ridesharing environment, and fill a niche role for longer trips.

Using publicly available information, researchers created a physics-based model to compute energy use and greenhouse gas emissions for eVTOLs. They then compared the model outputs with ground-based drones and found that eVTOLs carrying a pilot and three passengers outperformed ground-based cars in all areas—even when accounting for the electricity generated in producing the vehicles’ batteries.

Five phases of flight—takeoff, climb, cruise, descent, and landing—were evaluated. Takeoff and climb used the most energy; longer trips were the most energy efficient because of a longer cruise time. According to the study, point-to-point eVTOL trips could result in an 80% time savings compared with ground-based vehicles. Researchers note, however, that eVTOLs are most sustainable in trips of more than 22 miles.

To learn more about the study, visit https://aashtojournal.org/2019/04/12/university-study-says-flying-cars-ideal-for-congested-cities-as-ride-share-taxis/.
Anne Goodchild
University of Washington

Anne Goodchild has led freight transportation research for nearly two decades and is an urban freight, international border, and port operations expert. At the University of Washington, she leads academic and research efforts in supply chains, logistics, and freight transportation as professor of civil and environmental engineering and as adjunct professor of industrial and systems engineering. She teaches transportation logistics and analysis, global trade, and transportation and logistics management, and advises graduate students in transportation engineering.

Goodchild is founding director of both the Supply Chain Transportation and Logistics master’s degree programs and the Supply Chain Transportation and Logistics Center. In 2016, the Supply Chain Transportation and Logistics Center launched the Urban Freight Lab to investigate cost-effective, high-impact solutions for businesses delivering goods in urban settings and cities trying to manage limited curb and parking space. The Urban Freight Lab uses a novel approach to research: public- and private-sector support to work collaboratively on shared goals.

“I like the challenge of translating among communities—whether students, research peers, public- and private-sector partners, administrators at the University of Washington, or people locally in Seattle who want to know what we are doing,” Goodchild comments. “It is an exciting intellectual challenge to translate what we are doing into their language, and to try to get people to communicate across environments.”

Goodchild’s research focuses on the intersection between supply chain management and freight transportation to better manage the delivery of goods and services, including evaluating the changing nature of e-commerce—in particular, how increased goods delivery may affect vehicle activity, carbon dioxide emissions, local pollutants, and vehicle miles traveled.

Goodchild has made significant contributions to transportation engineering in the United States and abroad and has been instrumental in bringing supply-chain concepts to freight model architectures. She has worked at the forefront of GPS data applications, identifying observable transportation characteristics that predict transportation behavior statistically. “I enjoy doing new things: building new ways of doing research, finding new spaces in research that are underserved, and thinking about why and whether I can take those on,” she notes.

Under Goodchild’s leadership, the Urban Freight Lab set two goals for the Final 50 Feet program: to reduce truck dwell time—that is, the time a truck is parked in a load–unload space in the city—and to reduce failed first deliveries. To meet these goals, Goodchild is studying common carrier parcel locker systems, which will allow carriers to leave packages in one secure, accessible area, as a way to create delivery density in a single location. The Urban Freight Lab recently led a pilot test of parcel lockers in an urban tower in downtown Seattle. The test—the first demonstration of a common carrier locker system in a public space in the United States—found that these locker systems could reduce total parcel delivery time by 78%, from 27 minutes to 5.6 minutes—and reduce the number of failed first deliveries to zero—compared with traditional delivery.

“In freight transportation, it is essential to work collaboratively with people who do that work—those who move freight or need freight moved—in order to do impactful, relevant research,” Goodchild observes. “I have tried to take on differences in culture, priorities, and objectives, and build those perspectives into my research.”

Goodchild has been active with TRB since 2001, when she was a graduate student at the University of California, Berkeley. In 2004, she joined the Freight Transportation Planning and Logistics Committee, which she served for nearly 10 years, including as committee secretary and paper review chair. She chaired the Intermodal Freight Transport Committee from 2013 to 2016. She also has served on National Cooperative Freight Research Program project panels, Second Strategic Highway Research Program expert task groups, and policy study committees.

In 2016, Goodchild became chair of the Freight Group and in that position served on the Technical Activities Council. “There are very few unbiased voices in delivering a transportation system; the city, the port, transportation consultants, and private companies each have their own perspectives,” she adds. “To me, being a researcher means being a voice for the entire region. As researchers, our job is to provide accurate data, consider all stakeholders’ perspectives, and honestly characterize the trade-offs. Where would we be if we didn’t have anyone to play that objective role?”

Goodchild muses that her aim is to conduct relevant research—and not to shy away from the practical and sometimes tedious challenges of trying things on the ground: “As academics, we can sometimes hide in our models. When what we study is a real system that is implemented daily, we have to tackle those implementation challenges to get to solutions, and I want to incorporate that into my research.”
As Director of the Transit Safety and Workforce Development Programs at the University of South Florida’s Center for Urban Transportation Research (CUTR), Lisa Staes leads a highly successful and motivated team that manages programs and projects related to transit safety, transit training, and workforce development. She has conducted research on such topics as decreasing collisions and other bus incidents, bus operator assaults, transit safety standards, bus operator simulator training and its role in reducing transit incidents, training certificate programs and elements of success, other transit safety-related research and technical assistance, alternative mobility strategies, rural and senior mobility initiatives, and coordinated transportation system planning.

After graduating from Florida State University with a bachelor's degree in geography, Staes joined the Tallahassee-Leon Metropolitan Planning Agency as a transportation planner in 1991. She served as regional manager at the Florida Commission for Transportation before joining the Florida Department of Transportation (DOT), where she worked as grant programs administrator from 1996 to 1998. She then joined the University of South Florida and became program director at CUTR in 2003.

“Advancing safety management systems—and improving the overall safety and reducing risks in the public transportation industry—must be supported and directed by rigorous research and demonstration programs,” Staes comments. The most successful of these safety management systems (SMS) research programs would identify areas of safety risk, research to validate and refine those risks, specific critical focus areas, standards or recommended practices, and mitigation measures utilized by transit agencies; review risk-based analyses performed by sample agencies to understand and frame methods that could be utilized across the industry; provide a structure both for research on standards and for technical research to test and evaluate technologies; and offer relevant findings.

Staes affirms the role of research in safety assurance through the continuous collection, monitoring, and analysis of performance data, as well as via formulation of safety targets and performance measures to gauge the effectiveness of safety interventions and to support oversight and performance monitoring. Research findings also may lead to significant data reporting and analysis process improvements and may help promote and improve organizationwide safety performance, she notes.

“The importance of research in the ever-evolving safety climate and in the areas of most significant risk to the transit industry cannot be overstated.”

Staes points out that effective implementation of the SMS framework relies on a structured, robust research strategy, which is supported by TRB’s standing committees and task forces, the Transit Cooperative Research Program (TCRP), and federal research partners: “A balance of research methods will ensure the efficacy of the research program and will include actionable transit safety research priorities, executed through foundational research, demonstration projects and deployments, and synthesis research projects.”

As chair of TRB’s Transit Safety and Security Task Force, Staes coordinated the content for this issue of TR News, which examines the theme of rail trespassing. She also has served on the TCRP Project Panel on Updated Methodology for Estimating Demand for Rural Passenger Transportation. She chairs the American Public Transportation Association’s (APTA’s) Bus Safety Committee and serves on several other safety-related APTA committees.

A research strategy to better understand the state of the industry should include benchmarking efforts and should establish a baseline knowledge of the safety climate at transit agencies, Staes notes: “The type of research methods used by TRB and federal programs—and the corresponding outcomes—can help transit agencies set appropriate safety policies and procedures, by identifying effective safety practices and principles, determining whether agencies are implementing recommended practices, and evaluating the impact of those practices on transit safety.”

Staes affirms the role of research in safety assurance through the continuous collection, monitoring, and analysis of performance data, as well as via formulation of safety targets and performance measures to gauge the effectiveness of safety interventions and to support oversight and performance monitoring. Research findings also may lead to significant data reporting and analysis process improvements and may help promote and improve organizationwide safety performance, she notes.

“The importance of research in the ever-evolving safety climate and in the areas of most significant risk to the transit industry—such as reducing collisions, rail-highway grade crossing events, transit operator and passenger assaults, and suicides, for example—cannot be overstated,” Staes comments. “It must also be recognized that research results drive safety improvement across the industry. The industrywide adoption of tools such as voluntary standards, guidance documents, or recommended practices will only occur through well-documented, well-disseminated evidentiary processes and research reports and findings that extol the benefits of those standards and guidelines.”
Systemic Pedestrian Safety Analysis
NCHRP Research Report 893

In recent years, transportation crash data reveal increasing numbers of pedestrian crashes and fatalities. This troubling trend has challenged transportation agencies to redouble their efforts to improve safety for these vulnerable users.

One promising approach is the use of systemic pedestrian safety analysis. Unlike the more traditional method of site or “hot spot” analysis, which identifies locations where past crashes have occurred, a systemic approach proactively identifies sites based on specific features and factors known to be associated with prevalent types of crashes, especially more severe types. This process creates an opportunity for identifying higher-risk locations even if historical crash data are sparse. Because the analysis focuses on identifying specific elements associated with target crash types, results can help agencies fine tune their countermeasure selections.

Systemic safety analysis offers a data-driven, proactive approach to addressing safety across the transportation network by focusing resources toward effective countermeasures that are selected to target prevalent risks. The analysis also supports prioritization of locations by relative risk using crash prediction metrics or other weighting methods that account for pedestrian exposure. This process also allows agencies to bundle locations with similar risks and context together to improve cost effectiveness and to accelerate delivery of appropriate safety countermeasures.

National Cooperative Highway Research Program (NCHRP) Research Report 893: Systemic Pedestrian Safety Analysis offers guidance for developing a systemic approach to identifying priority safety improvements for pedestrians. Produced by a research team led by the University of North Carolina Highway Safety Research Center with Kittelson and Associates and independent consultant Robert Schneider, the guidebook provides steps to implement a systemic approach: how to define the scope of a systemic analysis, which data are required, how to identify risk factors and sites needing treatment, and how to select countermeasures that address risk factors. The report also describes how to augment the analysis with community priorities and economic assessments and outlines ways to evaluate and maintain a systemic safety process over time. Four case examples from transportation agencies illustrate real-world applications of a systemic approach.

The guidebook was developed from an extensive literature review and interviews with practitioners. Information on the risk factors associated with pedestrian crash frequency and severity was enhanced with additional, original analysis of risk factors associated with two types of midblock collisions. These risk factors are combined with information about available pedestrian crash countermeasures and their known effectiveness in different contexts.

The guidebook and accompanying technical report are available at www.trb.org/Publications/Blurbs/178087.aspx.

—Ann M. Hartell, Transportation Research Board, National Academies of Sciences, Engineering, and Medicine, Washington, D.C.; Libby Thomas and Laura Sandt, University of North Carolina Highway Safety Research Center, Chapel Hill

GUIDE FOR SNOW AND ICE CONTROL OPERATIONS

When the AASHTO Guide for Snow and Ice Control was published in 1999, it was intended as a training tool to help operators, supervisors, and managers select and implement methods or technologies to effectively deal with snow and ice conditions and to provide road users with safe conditions and timely information to make trip decisions.

Since the publication of the guidebook, advancements in plowing equipment, materials handling and storage, communications, technology, and strategies, and other aspects of snow and ice control and management have changed the industry state of practice. A new guide is needed, one that recognizes environmental issues, budgetary and workforce constraints, and the new research findings.

Texas A&M Transportation Institute has been awarded a $300,000, 21-month contract (NCHRP Project 06-18, FY 2019) to develop a guide that will serve as the primary source for guidance on all aspects of snow and ice control operations.

For more, contact Amir N. Hanna, TRB, at 202-334-1432 or ahanna@nas.edu.
GUIDELINES FOR CORROSION PROTECTION OF STEEL BRIDGES USING DUPLEX COATING SYSTEMS

Bridge coatings greatly contribute to the longevity of steel bridges and reduce the total life-cycle cost by protecting steel bridge members from corrosion. For many steel bridges across the nation, the most popular practice is to provide a three-coat, zinc-rich primer system. This system generally requires regular maintenance, which often is a maintenance challenge for bridge owners.

Research indicates that the synergetic life of duplex coatings—hot-dip galvanized or metallized with a coating system—will extend the bridge service life beyond the traditional coating systems. Bridge owners have had mixed experience with duplex coatings, however.

Elzly Technology Corporation has received a $430,000, 34-month contract (NCHRP Project 12-117, FY 2019) to develop AASHTO guidelines for corrosion protection using duplex coating systems and to plan and conduct a workshop for transportation agency staff and other stakeholders to demonstrate the use of proposed guidelines.

For more, contact Waseem Dekelbab, TRB, at 202-334-1409 or wdekelbab@nas.edu.

UPDATE OF HIGHWAY CAPACITY MANUAL: MERGE, DIVERGE, AND WEAVING METHODOLOGIES

Freeway congestion usually occurs at freeway merge, diverge, and weaving segments that have the potential for bottlenecks. To alleviate or mitigate the impacts of congestion at these segments, active management operational strategies have been implemented—ramp metering, hard-shoulder running, managed lanes, and more.

The freeway merge and diverge methodologies in Chapter 14 of the Highway Capacity Manual, 6th Edition (HCM 6) were developed more than 25 years ago using limited field collected data. Although weaving segment analysis was updated more recently, its relationship with the merge and diverge methodolo-

gies has not been addressed clearly. The HCM 6 methodology does not conform to the fundamental relationship of traffic flow—namely, that flow is the product of speed and density—and does not offer any methodology for lane drops or additions.

Kittelson & Associates has received a $400,000, 30-month contract (NCHRP Project 07-26, FY 2019) to develop methodologies to update the HCM related to merge, diverge, and weaving methodologies, and to demonstrate the full range of applicability of the proposed updates in a pilot project.

For more, contact Waseem Dekelbab, TRB, at 202-334-1409 or wdekelbab@nas.edu.

Inaugural African Linear Infrastructure and Ecology Conference

Many drivers have, at some point, accidentally hit an animal on the road. The consequences can include not only an injured or dead animal but also an insurance claim or even a visit to the emergency room. The inaugural African Conference for Linear Infrastructure and Ecology 2019 (ACLIE) was held in March in South Africa’s iconic Kruger National Park to identify and discuss solutions to prevent wildlife roadkill and improve driver safety. Cosponsored by TRB’s Ecology and Transportation Committee and cohosted by the Endangered Wildlife Trust (EWT) and Eskom, the national power company of South Africa, the conference featured many fascinating presentations, such as a look at Canadian initiatives to build wildlife bridges over or under roads—simple, effective measures to help animals to cross over the road and avoid an interaction with a vehicle.

NEW KIND OF CONFERENCE

Centered around the environmental impacts of linear infrastructure such as roads and rail, energy, power lines, canals, pipelines, and fences, ACLIE was the first conference of its kind—not only in Africa but also as a single forum addressing transportation and energy and outlining multiple common threats to the environment. Instead of following a more traditional international conference framework, focusing on each form of linear infrastructure in isolation (for example, roads only), ACLIE introduced a less-siloed approach, combining all forms of transportation and energy. These necessary transportation and energy

As part of a demonstration at ACLIE, a rubber snake was placed in the road to see how drivers would respond.

Photo: Christine Gerencher
modes usually coexist and have multiple negative impacts on biodiversity; for example, the loss of wildlife from roadkill and electrocution on power lines.

For years, EWT’s Wildlife and Transport and its Wildlife and Energy programs have addressed these impacts and developed solutions, spearheading the international gathering of experts at ACLIE to expand the knowledge pool. The impacts of transportation and energy on wildlife are not unique to South Africa—they are a threat worldwide.

PRESENTATIONS
Presentations ranged from global perspectives to case studies from individual countries and encompassed current scientific research, policy, legislation, and best practice. A common thread among many presentations was the threat posed by current and future development across Africa. Major developmental projects have been planned for Africa in the coming decade, with development corridors comprising networks of power lines, roads, railways, pipelines, and ports to facilitate the movement of commodities. More than 30 development corridors—spanning more than 53,000 km—are taking shape across Africa, potentially affecting protected areas with high conservation values and multiple threatened species. The conference attracted many key players, including the World Bank and the U.S. Agency for International Development’s Power Africa partnership, to facilitate discussions and influence decision makers regarding future developments on the continent.

Case studies included ways to prevent electrocution of martial eagles by power lines, reducing the deaths of Samango monkeys on roads in South Africa, and the design of North American bridges constructed over roads to assist wildlife in crossing. Keynote speakers included EWT CEO Yolan Friedmann; Deidre Herbst, Eskom Holdings; and George Ledec, World Bank.

Wendy Collinson-Jonker, EWT Wildlife and Transport Programme and member of the Ecology and Transportation Committee, elaborated: “We were extremely proud to be able to showcase our projects to the rest of the world at ACLIE, as well as to share potential solutions for the proposed linear infrastructure developments across the African continent. The challenge will be implementing many of these solutions, but the input and support from experts who attended ACLIE may well assist us in ensuring development that is more resilient and ultimately benefits the economy but conserves the environment.”

—Christine Gerencher, Transportation Research Board, National Academies of Sciences, Engineering, and Medicine, Washington, D.C.
Uniformity of Transport Law Through International Regimes
Olena Bokareva. Lund University, 2019; 360 pp.; $130.50; 978-1-78643-744 0.
Addressing problems in the uniformity of transport law, this book examines concerns and solutions for carriage of goods by sea and multimodal transport in the European Union and internationally. In particular, the Rotterdam Rules are explored as one of the solutions to the complexity of transport jurisprudence.

Manual for Bridge Element Inspection, 2nd Edition
American Association of State Highway and Transportation Officials (AASHTO), 2019; 124 pp.; AASHTO members, $125; nonmembers, $169; 978-1-56051-723-8.
This reference for standardized element definitions, element quantity calculations, conditions state definitions, element feasible actions, and inspection conventions is designed for use by state transportation and agencies that provide bridge inspections. The book captures bridge conditions in a simple way that can be standardized nationwide.

Sustainable Asphalt Pavements: A Practical Guide
Each year, 70 million tons of asphalt pavement are removed during resurfacing and put to use in new asphalt pavements, reducing the need for raw materials and keeping material out of landfills. This book outlines 92 specific actions to boost sustainability for asphalt pavement projects as well as in production and construction operations.

The titles in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS

Developing Countries Transportation Research Record 2672, Issue 31
Emergency medical service response issues, student pedestrian walking speeds, and a crash risk-scoring tool for pedestrian and bicycle projects are a few of the topics examined in this issue.
2018; 119 pp. For more information, visit http://journals.sagepub.com/home/trr.

Transportation Safety Management 2018 Transportation Research Record 2672, Issue 32
Papers in this issue include latent hazard anticipation in young drivers, virtual reality headset training, and distracted driving behavior among older adults.
2018; 108 pp. For more information, visit http://journals.sagepub.com/home/trr.

2018 Fred Burggraf Award: Safety and System Users Transportation Research Record 2672, Issue 34
This volume includes research from winners of the 2018 Fred Burggraf Award, on such topics as the utilization of gaps at single-lane roundabouts, roadway-related truck crash risk analysis, and the challenges in hazard detection for commercial motor vehicle drivers.
2018; 134 pp. For more information, visit http://journals.sagepub.com/home/trr.

To order the TRB titles described in Bookshelf, visit the TRB online bookstore, www.TRB.org/bookstore, or contact the Business Office at 202-334-3213.
Pedestrians 2018
Transportation Research Record 2672, Issue 35
This issue presents research on pedestrians, including behavior at signalized intersection crosswalks, the effect of cellphone use on walking behavior, and walkability in the era of connected and automated vehicles.
2018; 160 pp. For more information, visit http://journals.sagepub.com/home/trr.

Bicycle Transportation 2018
Transportation Research Record 2672, Issue 36
Research on bicycle travel—including perceived safety of separated bike lanes, bicycle share program equity, and mixed-fleet bike-sharing systems—are explored in this issue.
2018; 166 pp. For more information, visit http://journals.sagepub.com/home/trr.

User Performance 2018
Transportation Research Record 2672, Issue 37
This issue presents research on driver exiting behavior at complex interchanges, the impact of distracted drivers, in-vehicle passing collision warning systems, and other topics.
2018; 180 pp. For more information, visit http://journals.sagepub.com/home/trr.

Safety Data, Analysis, and Evaluation 2018
Transportation Research Record 2672, Issue 38
Developing a comprehensive road safety index, enhancing prediction performance of real-time crash prediction models, and revisiting hit-and-run crashes are some of the topics explored in this issue.
2018; 312 pp. For more information, visit http://journals.sagepub.com/home/trr.

Highway Design 2018
Transportation Research Record 2672, Issue 39
Highway design research examined in this issue include uses of lidar in highway cross-slope measurement and automated extraction of horizontal curve attributes, transitions between freestanding and reduced-deflection portable concrete barriers, and the mitigation of impacts to groundwater quality from highway runoff.
2018; 176 pp. For more information, visit http://journals.sagepub.com/home/trr.

Pavement Management 2018
Transportation Research Record 2672, Issue 40
This issue explores pavement management research, including highway performance monitoring system data, estimation of gravel roads ride quality, full-depth patching identification methods, and pavement risk assessment for future extreme weather events.
2018; 462 pp. For more information, visit http://journals.sagepub.com/home/trr.

Structures 2018
Transportation Research Record 2672, Issue 41
Presented in this issue is research on section idealization of corrugated thermoplastic pipe, the influence of thermal sweep on girder stability during construction, and performance of skew reinforcing in inverted T-bridge caps, and more.
2018; 220 pp. For more information, visit http://journals.sagepub.com/home/trr.

Prioritization Procedure for Proposed Road–Rail Grade Separation Projects Along Specific Rail Corridors
NCHRP Research Report 901
This report provides a comprehensive way to compare similar project alternatives within a specific rail corridor. Factors include economic, environmental, and community livability factors. A railroad crossing assessment tool is included.
2019; 76 pp.; TRB affiliates, $51.75; nonaffiliates, $69. Subscriber categories: highways, railroads, planning and forecasting.

Using GIS for Collaborative Land Use Compatibility Planning Near Airports
ACRP Research Report 200
This report includes a description of perspectives, goals, responsibilities, and concerns of the federal government, airports, and local communities and examines the benefits that geographic information systems might have on fostering collaboration for compatible land use around airports.
2019; 134 pp.; TRB affiliates, $60; nonaffiliates, $80. Subscriber categories: aviation, design and information technology, planning and forecasting.
November
4–7 Geostuctural Aspects of Pavements, Airfields, and Railways 2019*
Colorado Springs, Colorado
5–6 9th International Visualization in Transportation Symposium: Visualization in Action
Washington, D.C.
10–14 GeoMEast International Conference: Sustainable Civil Infrastructures—Beyond the Horizon*
Cairo, Egypt

December
11–12 Conference on Health and Active Transportation
Washington, D.C.
11–13 International Accelerated Bridge Construction Conference*
Miami, Florida
18–21 5th Conference of Transportation Research Group of India*
Bhopal, Madhya Pradesh, India

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar, or by e-mail at TRBMeetings@nas.edu.

To subscribe to the TRB E-Newsletter and keep up to date on upcoming activities, go to www.trb.org/Publications/PubSTRBENewsletter.aspx and click on “Subscribe.”
**COOPERATIVE RESEARCH PROGRAMS**

National Cooperative Highway Research Program (NCHRP) Innovations Deserving Exploratory Analysis (IDEA) Program proposals are due **Wednesday, September 4**.
For more information, visit www.trb.org/IDEAProgram/IDEAHighway.aspx.

Rail Safety IDEA Program proposals are due **Sunday, September 15**.
For more information, visit www.trb.org/IDEAProgram/IDEASafety.aspx.

Airport Cooperative Research Program Synthesis Program topic ideas are due **Friday, September 20**.
To submit a topic idea, visit IdeaHub at https://ideahub.trb.org.

**NATIONAL ACADEMIES EVENTS**

**September**

3–4  **Standing Committee on Advancing Science Communication Research and Practice**
Keck Center, 500 Fifth Street NW, Washington, D.C.
For more information, contact Leticia Garcilazo Green at lgreen@nas.edu or 202-334-3212.

10–12  **Climate Intervention Strategies that Reflect Sunlight to Cool Earth: Research Governance Workshop**
Stanford Woods Institute for the Environment, California
For more information, contact Katie Thomas at reflectingsunlight@nas.edu or 202-334-3512.

16–17  **Role of Authentic STEM Learning Experiences in Developing Interest and Competencies for Technology and Computing Committee Meeting**
Keck Center, 500 Fifth Street NW, Washington, D.C.
For more information, contact Leticia Garcilazo Green at lgreen@nas.edu or 202-334-3212.
TR News welcomes the submission of manuscripts for possible publication in the categories listed below. All manuscripts submitted are subject to review by the Editorial Board and other reviewers to determine suitability for TR News; authors will be advised of acceptance of articles with or without revision. All manuscripts accepted for publication are subject to editing for conciseness and appropriate language and style. Authors receive a copy of the edited manuscript for review. Original artwork is returned only on request.

FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, marine, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, security, logistics, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 words (12 double-spaced, typed pages). Authors also should provide charts or tables and high-quality photographic images with corresponding captions (see Submission Requirements). Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader’s understanding of the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

LETTERS provide readers with the opportunity to comment on the information and views expressed in published articles, TRB activities, or transportation matters in general. All letters must be signed and contain constructive comments. Letters may be edited for style and space considerations.

SUBMISSION REQUIREMENTS: Manuscripts submitted for possible publication in TR News and any correspondence on editorial matters should be sent to the TR News Editor, Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, telephone 202-334-2986, or e-mail lcamarda@nas.edu.

◆ All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word, on a CD or as an e-mail attachment.
◆ Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi. A caption should be supplied for each graphic element.
◆ Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

NOTE: Authors are responsible for the authenticity of their articles and for obtaining written permissions from publishers or persons who own the copyright to any previously published or copyrighted material used in the articles.
Join more than 13,000 transportation professionals at the TRB Annual Meeting, January 12–16, 2020, in Washington, D.C.

The program will cover all transportation modes, with more than 5,000 presentations in nearly 800 sessions, addressing topics of interest to policy makers, researchers, administrators, practitioners, and representatives of government, industry, and academic institutions.

Also, many sessions and workshops will focus on the spotlight theme for the 2020 meeting, “A Century of Progress: Foundation for the Future.”

The full 2020 program will be available online in November 2019.

Plan now to attend. For more information, visit www.trb.org/AnnualMeeting.