6-1-1996

An Introduction to Railroad Crossing Technology and Safety

CUTR

Follow this and additional works at: https://scholarcommons.usf.edu/cutr_reports

Scholar Commons Citation

This Technical Report is brought to you for free and open access by the CUTR Publications at Scholar Commons. It has been accepted for inclusion in CUTR Research Reports by an authorized administrator of Scholar Commons. For more information, please contact scholarcommons@usf.edu.
An Introduction to
Railroad Crossing Technology and Safety
An Introduction to
Railroad Crossing Technology and Safety

Center for Urban Transportation Research
College of Engineering
University of South Florida

Principal Investigators
F. Ron Jones, Ph.D
Richard T. Stasiak, Ph.D.

June 1996
Acknowledgments

Several key individuals contributed to this project and report:

Mark Meana, Director of Safety (AMTRAK), Terry Bradigan, Safety Manager (CSX Transportation), Charles Smith, Manager, High Speed Rail Program (Florida Department of Transportation), Fred Wise, Manager, Rail Office (Florida Department of Transportation), Mark Simmons, Safety Manager (Florida East Coast Railway), Bruce George, Regional Manager (Federal Railroad Administration) and Dan Gilbert, Safety Manager (Norfolk Southern Railroad). Assistance in background research was provided by John Bradley. Report design and preparation were performed by Janet Becker. Graphic design was performed by Lisa Argiry.

The assistance and dedication to quality assurance in the completion of this project are appreciated.
# Table of Contents

List of Figures ................................................................. 4  
Background ........................................................................... 5  
Rail-Highway Crossing Treatments ........................................ 7  
Grade Crossing Technology .................................................. 9  
  Passive Devices ............................................................... 9  
  Crossbuck ........................................................................ 9  
  Conrail Crossbuck ......................................................... 10  
  Augmented Crossbuck .................................................. 11  
Rail Vehicle Conspicuity ..................................................... 12  
  Visibility ......................................................................... 12  
  Audibility ....................................................................... 13  
Active Devices ...................................................................... 13  
  Post-Mounted Flashing Light Signal ................................. 13  
  Cantilevered Flashing Light Signal ................................. 14  
  Automatic Gates ............................................................ 15  
Progressive Devices ........................................................... 16  
  Four Quadrant Gates ....................................................... 16  
  Barrier Gates ................................................................. 17  
Intelligent Transportation Systems ....................................... 18  
  In-Vehicle Information Systems .................................... 18  
  Proximity Alert Systems ............................................... 19  
  In-Cab Collision Sensors ............................................... 20  
  Video Based Traffic Enforcement ................................. 20  
Crossing Closure ............................................................... 21  
Grade Separation ............................................................... 23  
Policy Issues and Conclusions .............................................. 25  
  Highway Planning Issues ............................................ 25  
  Risk and Uncertainty .................................................... 25  
  Summary and Conclusions ............................................ 26  
References ......................................................................... 27
List of Figures

1 Crossbuck ................................................................................................................................... 10
2 Conrail Crossbuck ...................................................................................................................... 10
3 Augmented Crossbuck ................................................................................................................ 11
4 Post-Mounted Flashing Light Signal ........................................................................................... 14
5 Cantilevered Flashing Light Signal ........................................................................................... 15
6 Automatic Gates ......................................................................................................................... 16
7 Four Quadrant Gates .................................................................................................................. 17
8 Barrier Gates ............................................................................................................................... 18
9 Hypothetical In-Vehicle Information Display ............................................................................ 19
Background

In March 1993, an Amtrak passenger train struck a loaded Amerada Hess gasoline truck at the Cypress Creek Road crossing in Fort Lauderdale. The explosion and fire that followed killed the truck driver and five motorists stopped at the crossing. The accident location was the intersection of a busy arterial highway and a busy rail line, which was guarded by crossing gates and flashing lights.

In November 1993, a heavy-haul truck transporting a turbo generator became stuck on a private crossing outside Kissimmee. After futile attempts to free the truck and notify the railroad, it was struck by an Amtrak train. The results: millions of dollars of property damage, several minor and severe injuries, but, fortunately, no fatalities. The private crossing was marked by simple warning signs, installed at the discretion of the property owner.

These accidents greatly increased public awareness of rail-highway crossing safety, ultimately leading the Florida Legislature to create the Commission to Study the Safety and Security of Railroad-Highway Grade Crossings. The Commission’s report focused on then-current Florida Department of Transportation (FDOT) practice in the area of crossing safety, especially as it pertained to the unique circumstances surrounding the Cypress Creek accident site. Among its other findings, the report indicated the need for additional research into how improved methods of protecting crossings could save lives and property in Florida as well as a need to continue the process of integrating rail-highway crossing issues into the overall planning process.

The Center for Urban Transportation Research was directed by its Advisory Board to perform research in the area of rail-highway crossing safety as a follow up to the Commission’s report. Discussions with federal, state, and local government officials and rail industry representatives identified the need to discuss both existing and emerging rail-highway crossing technology from a planning (as opposed to an engineering) perspective.

This study discusses the alternative treatments of rail-highway crossings available to FDOT and other transportation agencies and the policy and operating issues related to such treatments. The topics include crossing treatments, ranging from grade crossings to grade separations; grade crossing technology used to warn motorists of the presence of trains and to control vehicular traffic in the vicinity of such crossings; policy issues surrounding the choice of crossing treatments and technology given the Florida situation; and finally, conclusions and recommendations for further inquiry.
RAIL-HIGHWAY CROSSING TREATMENTS

Rail-highway crossing “treatments” refer to the methods by which intersections of the rail and highway systems are accommodated. Actual practice in Florida, in other states, and in other nations places crossing treatments on the continuum, shown below.

<table>
<thead>
<tr>
<th>At-Grade Crossing</th>
<th>Grade Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Closure</td>
<td></td>
</tr>
</tbody>
</table>

The continuum is constructed, left-to-right, on the basis of probable agency cost. At-grade (more commonly “grade”) crossings between railroads and highways are the least expensive and most common crossing option, yet entail the highest level of accident risk. The distinguishing safety feature of grade crossings is the type of warning device employed to warn and control highway traffic. Warning technologies range from the traditional “crossbuck” sign to high technology treatments that employ microprocessor technology and light-speed communications to mitigate crossing risks.

Crossing closure, in which an existing crossing is removed and road access is shifted to other points on the highway network, lies in the middle of the continuum. The logic of enhancing safety with crossing closure is to reduce accidents by reducing the opportunities for rail and highway traffic to conflict. Closure entails the removal of existing crossings, improvements to connecting roads and streets, and upgrades to other rail-highway crossings. Significant reductions in access to some properties may occur, entailing economic loss and potential agency cost for compensation.

Grade separation is clearly the most expensive alternative, yet leads to maximum safety and throughput on both the highway and rail systems. The initial capital costs for overpasses in urban areas can range from $15 to $25 million. Despite the cost, there are situations in which grade separation is strongly indicated by highway traffic volume and speed (interstates and expressways) or by rail traffic volume and speed (urban transit systems, rail yards and terminals, high speed rail). Each of these approaches is discussed in detail in the following section.
Grade Crossing Technology

This discussion deals with three classes of crossing technology:

• **Passive devices.** Inanimate warning signs, pavement markings, and tactile pavement treatments that serve to warn vehicular traffic to the potential approach of a train.

• **Active devices.** Animated warning devices including bells, flashing lights, and/or warning gates activated by the actual approach of a train; active crossing devices are controlled by track circuits. Signal control equipment passes a small electrical current to each of the rails. When a train enters this controlled trackage, its steel wheels and axles complete the circuit and the crossing signals are turned on. North American practice is to set up the track circuit so that a train operating at the maximum permitted track speed will activate the crossing signals 30 seconds prior to arrival. Higher (lower) train speeds translate into longer (shorter) length track circuits. When the train clears the controlled trackage, the circuit is broken and the signals are turned off.

• **Progressive devices.** Advanced variants of animated warning devices including annunciators, flashing lights, gates, and/or physical barriers activated by the approach of a train. This class of devices also includes intelligent transportation systems (ITS) technologies that use digital technology to warn of potential train/motor vehicle conflicts.

**Passive Devices**

**Crossbuck**

The traditional (unlit) crossbuck is the most common railroad warning sign in Florida and the U.S. It is accompanied by pavement markings, advisory signs, and advance warning signs.

Its major advantage is cost; at $1000 to $2000 per crossing, it is the least expensive device to erect. Its major disadvantage is that it places the complete responsibility for safe operation on vehicular traffic.

The crossbuck is only appropriate for low volume roads and/or rail lines. Some rail carriers require trains to stop at busier crossings thus protected and to proceed under protection of a crew member who “flags,” i.e., directs vehicular traffic on the ground. Lighted flares or “fusees” are sometimes placed at trackside to provide additional warning to motorists.
Conrail Crossbuck

A new variation on the traditional crossbuck is the Conrail crossbuck, developed jointly by Consolidated Rail Corporation and the Ohio Department of Transportation. This design incorporates a "zebra stripe" pylon with mirrored and retro-reflective material into the mast of the traditional crossbuck.

This device is an enhanced visibility variant of the traditional crossbuck discussed above. Beyond improved visibility, it is subject to the same advantages and disadvantages of the crossbuck. The Conrail crossbuck is an emerging technology that has been approved for widespread use. The state of Ohio is currently installing these devices at all crossings currently protected by traditional crossbucks.
Augmented Crossbuck

In addition to the Conrail crossbuck, several variants are the focus of contemporary research. These warning devices consist of the traditional crossbuck, augmented with additional markings, additional integrated signage (i.e., "STOP" or "YIELD" signs) or both.

This device is an enhanced visibility variant of the traditional crossbuck geared toward providing drivers with additional information as to what their actions should be nearer to the actual point of crossing. Beyond improved visibility and driver information, it is subject to the same advantages and disadvantages of the crossbuck. The augmented crossbuck was highly controversial. Some traffic engineers argued that the public's tendency to disregard crossbucks would be transferred back to "STOP" and "YIELD" signs as a consequence of their new association with the crossbuck. Ultimately, the Intermodal Surface
Transportation Efficiency Act (ISTEA) required the Federal Highway Administration (FHWA) to promulgate rules that would allow the states to place such devices at highway crossings with two or more trains daily. A final rule to allow this was adopted in 1993.

**Rail Vehicle Conspicuity**

Another area of potential safety improvement is in the area of locomotive and railcar conspicuity (the extent to which motorists perceive the presence of a train). Both active and passive measures can increase conspicuity.

**Visibility**

Locomotive and railcar color schemes do not always produce sufficient contrast relative to the crossing environment to clearly indicate the presence of a train and may actually contribute to crossing accidents. Visibility depends on myriad factors including sight distance, natural and artificial light conditions, locomotive lighting, and color schemes. Safety research has focused on each of these areas.

Sight distance and light conditions are somewhat easier to address because they are among the criteria for existing sign and signal upgrades. An alternative approach to the lighting problem is the illumination of grade crossings with street lights and high rise luminaires (high intensity street lights mounted on 100 foot masts). This is similar in concept to the illumination of problem street intersections and highway interchanges. Lighting solutions are currently the focus of engineering research.

Locomotive lighting has been identified as another contributing factor to crossing safety. The Federal Railroad Administration (FRA) has required that the locomotive fleet operating in the United States be outfitted with “ditch lights” in addition to traditional headlights and marker lights. Ditch lights are a pair of steady-burn lamps mounted on both sides of the locomotive pilot (front step assembly). These Canadian-developed lights derive their name from their original function, which was to allow train crews operating in mountainous terrain to identify fallen rocks and other debris in track side ditches that could potentially derail the train. These devices not only reduced collisions between trains and track side debris, but also seemed to reduce collisions with highway vehicles. Subsequent research verified this connection, and lead to their adoption as a standard safety appliance in Canada, and later, in the United States.

Railroad color schemes range from attention-grabbing rolling advertisements for carriers or products to drab, minimum-cost treatments. Some carriers and fleet owners have voluntarily modified their color schemes to include high visibility colors, patterns, stripes, reflector strips, and reflector panels. Current FRA research is investigating the effectiveness of various reflector materials, placement, and patterns.
Audibility

Locomotives, by federal law, must be equipped with warning horns or whistles and bells which must be activated when approaching grade crossings. Federal law is ambiguous on the rights of states and their localities to regulate the use of such warning devices for the purpose of noise abatement. Local ordinances that limit the use of horns and whistles have been given the nickname “whistle bans.” Tremendous controversy, liability, and tragedy surrounds this subject.

Florida’s experience with the “whistle ban” was along its Atlantic coast. The object of the ban was the Florida East Coast Railway (FEC) whose operations are entirely within the state of Florida. Federal Railroad Administration analysis indicated that the “whistle ban,” combined with FEC’s traffic density and track speeds, and the population and vehicular traffic density of Florida’s southeastern and south-central regions proved to be a deadly combination, accounting for more than a 50 percent increase in crossing accidents. This finding was the formal basis for an emergency order that preempted local “whistle bans” along the FEC. FDOT worked to revise pertinent statutes (S. 351.03 F.S.) so that future “whistle bans” may be imposed only where other safety enhancements have been made to the satisfaction of state and federal authorities.

Research in this area centers around the use of ground-mounted rather than train-mounted horns that alert motorists while minimizing disturbance to nearby residences. These horns are installed as a portion of an actively signalized crossing and are activated in concert with bells, lights, and gates. The direction, tone, and intensity of the horns are maximized along the roadway and minimized elsewhere. The sound pattern is thus more focused than locomotive mounted horns.

Active Devices

Post-Mounted Flashing Light Signal

This active crossing device is appropriate under conditions of moderate vehicular and/or train traffic with few restrictions on roadway sight distance. These warning devices consist of two pairs of flashing lights, augmented with the traditional crossbuck. Advance signage, auxiliary signage, and pavement markings usually accompany such installations.

The major advantage of flashing lights is an active indication of actual train presence at a relatively low cost, about $65,000 for installation. Their major disadvantage is the lack of a symbolic barrier within the traffic lane, which places most of the responsibility for safe operation on vehicular traffic.
Cantilevered Flashing Light Signal

This flashing light signal is appropriate under conditions of moderate vehicular and train traffic with restricted roadway sight distance. Other conditions that may lead to the use of cantilevered signals include multiple traffic lanes on the highway, curbside parking lanes, and excessive background distractions.

These warning devices consist of multiple pairs of flashing lights, some of which are centered over the traffic lane(s), augmented with the traditional crossbuck. Advance signage, auxiliary signage, and pavement markings should accompany such installations.

The major advantage of these signals is active indication of train occupancy with enhanced visibility within the traffic lane. Their major disadvantage is the lack of a symbolic barrier within the traffic lane, again placing a significant portion of the responsibility for safe operation on vehicular traffic. Cantilevered flashing lights cost about $110,000 to install.
Automatic Gates

The next increment in crossing protection is the use of automatic gates. Gates are used in conjunction with post-mounted or cantilevered flashing lights, as well as advance signage, auxiliary signage, and pavement markings.

The gates are made from wood, aluminum, or fiberglass. Automatic gates are not meant to serve as a true physical barrier to the movement of vehicular traffic in that the gates are designed to "break away" on impact with motor vehicles. This feature allows vehicles trapped by the gates within the crossing to escape, and also prevents the gates themselves from turning into bludgeons that could potentially crush motor vehicles trapped beneath them. Additionally, gates do not span opposing traffic lanes or the medians of multilane highways.

Gates are appropriate when some or all of the following conditions are present: multiple tracks; high speed train operation; moderately high volumes of rail and highway traffic; passenger train traffic; limited rail or highway sight distance; presence of transit buses, school buses, and trucks carrying hazardous materials in the traffic mix; and continuance of accidents in the presence of flashing lights. Automatic gate installation cost ranges from $95,000 to $150,000.
The major advantage of automatic gates is that they physically obstruct the travel lane(s) when activated, giving positive indication that vehicular traffic must stop. The major disadvantage of gates is that they serve as symbolic barriers only—gates cannot physically prevent an out-of-control vehicle from entering a crossing. Automatic gates may also be willfully circumvented through median gaps or by crossing over into oncoming traffic lanes. Many of Florida's most severe grade crossing accidents—including the Cypress Creek accident discussed in the introduction—have occurred at gated crossings.

![Automatic Gates](image)

**Progressive Devices**

**Four Quadrant Gates**

This variation on traditional automatic gate technology uses additional pairs of gates to block opposing lanes of traffic. The advantages of this approach is that it prevents "drive-around" accidents and uses existing technology, more and slightly longer gates. Its major disadvantage is that the gates remain symbolic as opposed to physical barriers to passage. In addition, this approach requires additional expense (about $35,000 per gated crossing) for the extra gates, mounts, and actuators. Another consideration is potential exposure to retroactive liability, in which the adoption of new technology or procedures is interpreted by the courts as a tacit admission of past negligence in pending claims against a railroad or government agency. This may make highway agencies, railroads, and suppliers reluctant to adopt the technology. A final issue is the need to provide for motor vehicle escape, with entrapment sensing devices, breakaway gates or actuating delays for the downstream or "left lane" gates.
Barrier Gates

This technology was first developed in Europe where train speeds and frequency are quite high compared to U.S. practice. These crossing devices consist of retractable collision barriers, covered with high visibility markings, flashing light signals, auxiliary signage, and pavement markings. The barriers provide both symbolic visual warning of the presence of a train as well as a physical barrier against intrusion into the crossing.

Barrier systems by their very nature not only impede entry into a crossing, but also restrict exit. Thus, to achieve maximum safety, barrier systems must include measures that deal with entrapped vehicles. Two practical measures may be employed to this end. An array of sensor loops or other devices may prevent activation of the barrier until the crossing is cleared. The sensors are also used to activate track signals, cab signals, or automatic train control devices that would either alert the locomotive crew to the blocked crossing or stop the train outright. These sensing devices are discussed below in a separate section dealing with ITS.

There are a wide variety of prototype and commercial barrier systems available for adoption by the U.S. today. These include:

- hard barriers, in which a gate constructed of steel or composite materials physically halts an errant motor vehicle, preventing intrusion into the crossing.
- soft barriers, in which an energy-absorbing barrier made of flexible material or an inflatable barrier is deployed to prevent entry into the crossing.
The approximate cost of this technology ranges from $400,000 to $1,000,000 per installation. Although none of the existing barrier systems have been approved for widespread use in the U.S. as of this writing, the U.S. Department of Transportation’s Volpe Transportation Systems Center is currently conducting engineering evaluations of several barrier systems.

**Intelligent Transportation Systems**

Intelligent transportation systems technology represents another potential source of enhanced crossing safety. ITS refers to the use of high speed computer and communications technology to obtain information about the status of transportation systems (roads, railroads, and vehicles). This information is used to safely and effectively manage the operation of these systems. A simplified form of ITS is an integral part of four quadrant gates and barrier systems. ITS also has stand alone capabilities that may greatly enhance crossing safety.

**In-Vehicle Information Systems**

Prototype in-vehicle information systems developed during the late 1980’s and early 1990’s consisted of on-board information systems coupled to satellite global positioning systems and low volume telemetry links for text data. The primary focus was on motorist orientation and highway traffic information conveyed through a dashboard mounted video monitor and through the vehicle’s speaker system. Map displays and other messages conveyed location, routing, and traffic advisory information to the driver. Similar systems have already been developed, tested, and deployed for use in the railroad industry as a dispatching and traffic control tool known as Advanced Train Control Systems (ATCS).
Automobile-based prototypes displayed detailed street map information, but did not include any information on the location of railroad lines and rail crossings. Florida’s own experiment, the TravTek system in Orlando was typical in this regard. TravTek, developed in 1990, did not include rail crossing information. Inclusion of this information would have been quite appropriate in Orlando, where grade crossings punctuate the CSX Transportation main line from Sanford to Kissimmee. Presumably, future prototypes of in-vehicle information systems would include rail crossing information in the locator map and in traffic advisories.

The drawback of this approach is that this form of ITS will be of limited practical value if only a small fraction of vehicles is so equipped. The added cost of on-board equipment (between $2000 and $3000 per vehicle for installation) suggests limited market appeal. Widespread adoption of the technology through regulation or mandate seems doubtful.

Proximity Alert Systems

A related area of emerging technology is in the area of motor vehicle annunciator systems that replicate the indications of crossing signals. A traditional track circuit would activate both roadside signals and a radio control unit; the radio control unit would then activate a dashboard signal, giving audible and visual warning of the approach of a train. The basic scheme is based on railroad technology for “cab signals,” an electro-mechanical system in which track signal indications are replicated on board a train’s locomotive. An audible alarm is also triggered as the locomotive passes by signal locations to cue the engineer to check signal indications and act accordingly. An on-board warning system for motor vehicles simply substitutes digital for electro-mechanical technology. The U.S. Department of Transportation is currently evaluating a prototype on-board warning system for motor vehicles at this time.
An Introduction to Railroad Crossing Technology and Safety

The drawback of this approach is that a significant proportion of highway vehicles, crossings, and railroad vehicles must be equipped with the technology to achieve meaningful increases in crossing safety. This technology is considerably less complicated and less expensive (less than $100 per motor vehicle) than the in-vehicle systems discussed above. As such, its marketability as an option or its potential for widespread adoption through regulation seems more plausible than more complicated systems.

In-Cab Collision Sensors

Another ITS application is the use of sensors and short haul radio links to give locomotive engineers an in-cab indication of motor vehicles and other obstructions within a crossing during the approach of a train. As was mentioned above, such sensors are an important secondary safety feature for barrier technology and four quadrant gates. Electromagnetic, optical, or ultrasonic sensors determine whether a crossing is blocked or clear. If blockage is detected, the “downstream” barriers are lowered to allow the vehicle or obstruction to escape the crossing. The system also sends a signal to the locomotive, which decelerates to a stop under manual and/or automatic control.

This technology is being adopted by the Swedish National Rail Administration as part of its system wide upgrade to high speed rail (HSR) technology. The Texas Transportation Institute is currently conducting research into the coordination of similar crossing warning technology with North American-style Advanced Train Control Systems (ATCS). ATCS is a computer based train dispatching system that uses in-vehicle information systems on locomotives to dispatch trains and control rail traffic. The traffic situation is displayed graphically to both dispatcher and engineer, leading to higher performance levels than those supported by traditional signal and dispatching systems. ATCS may also include automatic train control, which automatically stops a train when danger of collision with other rail traffic is imminent; this feature may be extended to potential collisions with motor vehicles.

Video Based Traffic Enforcement

Another technological tool with the ability to enhance crossing safety is the use of camera systems to detect and photograph motor vehicles that ignore or evade traditional crossing devices. These devices simplify the detection, apprehension, and conviction of those drivers who bypass these signals. These devices increase driver awareness of railroad crossing signals in an indirect fashion by increasing driver awareness of the financial and legal penalties of disregarding crossing signals. A video enforcement scheme has produced dramatic results on the at-grade segments of the Los Angeles urban rail system, leading to an 80 percent decline in crossing violations.

However, this approach is not without drawbacks. At $25,000 to $50,000 installation cost per crossing, video enforcement is an expensive safety upgrade. The use of videotaped evidence in traffic cases is not universally accepted in all state courts. Fortunately, Florida’s use of video enforcement on toll facilities has proven highly successful, with high compliance rates and no legal challenges thus far. Extension of this enforcement technique to rail crossings would require statutory authority.
Crossing Closure

Crossing closure lies in the middle of the cost continuum shown on Page 7. Closure means that an existing crossing is removed and road access is shifted to other points on the highway network. Closure promotes safety through the reduction of potentially hazardous opportunities for rail and highway traffic to interact.

Crossing closure may be initiated through the redirection of rail traffic. Significant consolidation of rail operations has taken place over the last 50 years and continues even today. This affords public highway agencies and rail carriers the potential opportunity to rearrange traffic patterns in such a way that track routes with a preponderance of grade crossings may be de-emphasized (or even abandoned) in favor of routes with fewer and better protected crossings. Major public works, including hydroelectric projects, flood control projects, and expressway projects, have occasionally been the catalyst in this type of grade crossing elimination, often involving significant amounts of shared costs by railroads and the public sector.

Closure can be a significant cost for highway agencies and the public at-large. When existing crossings are removed, public road and street agencies bear the direct costs of roadway (and sidewalk) demolition and debris removal within railroad right-of-way limits, removal of advance traffic control devices and signage, erection of reflective barricades at both new "dead ends," and erection of advance "dead end" signage at the nearest intersecting through streets. Agency cost can be further increased by a variety of roadway contingencies. Additional improvements such as the construction of cul-de-sacs to permit the safe turning of vehicles or the installation of curbing at the end of the pavement may be required to accommodate traffic or to meet street design standards, respectively. Roadway drainage may also need to be substantially reworked. Other road improvements including upgraded intersections, upgrades to connecting streets, and upgrades to other rail-highway crossings must often be provided.

When crossings are eliminated, highway traffic must be redirected over a more circuitous route, bypassing the two new "dead ends." This loss of direct access may be quite damaging to the utility of parcels located on the roadway segment from which the crossing has been eliminated. The elimination of through traffic may be fatal to businesses dependent on "drive by" customers. In other cases, the loss of convenient access may only inhibit commercial activity on a more limited scale. The closure of a crossing could reduce the marketability of residential and commercial property to the point where development is no longer feasible. It can also delay the travel time of emergency vehicles.

Both federal and state laws require the payment of compensatory damages to landowners whose access has been adversely impacted by transportation improvements. State statute and court precedents such as Palm Beach vs. Tessler and Florida DOT vs. Lakewood indicate that Florida has a much lower threshold for compensation of landowners whose access has been adversely affected than the traditional federal standard of "reasonable access." As a consequence, Florida's cost of crossing closure are likely to be somewhat higher than the national norm.
Other elements of society also incur portions of the cost of crossing closure. Railroads bear the cost of removing the crossing surface (atop the crossties) and the crossing signals. Track and grade repairs may also be required. Motorists, truckers, and emergency vehicles may face additional delays and increased fuel consumption owing to travel over more circuitous highway routes.
Grade Separation

Grade separation, the use of overpasses and underpasses to physically isolate rail traffic from highway traffic, lies at the high end of the cost continuum. Nonetheless, this alternative leads to maximum safety and throughput on both the highway and rail systems. Based on the recent experience of FDOT and others, initial capital costs for overpasses can range from $15 to $25 million, the same order of magnitude as a highway interchange. Florida’s relatively flat, near sea level topography virtually eliminates opportunities for lower cost underpasses in coastal regions where rail and highway traffic are heaviest. Current research is focusing on the use of metal culverts rather than bridges as low-cost grade separation alternatives.

Despite the cost of grade separation, there are some instances in which such measures are necessary. For example, interstate and expressway design standards require grade separation due to the speeds and volumes of vehicular traffic. Likewise, the typical design standards for urban (heavy rail) transit systems call for grade separation due to the volume of rail and vehicular traffic. When highways cross railroads at or near rail yards and terminals, the volume of rail movements would block grade crossings for an unacceptable amount of time. Some railroad main lines with extremely heavy traffic levels may also be grade separated following similar logic.

If international experience is used as a guide, the development of high speed rail concepts in Florida will lead to yet another rationale for grade separation: train speed. European and Japanese design standards require grade separation on those lines operating above the range of 100 to 125 miles per hour. The guiding principle here is that high speed rail operates in a performance envelope that equals the takeoff speed of the typical turbojet airliner (about 150 - 160 statute miles per hour). The sheer magnitude of destructive forces released during a crash would be so catastrophic that only grade separation is acceptable. A secondary consideration is that barrier systems at grade crossings backed up by sensors and automatic train control would produce too great a number of service interruptions, leading to degraded train speed and performance on such lines, which would also have an impact on highway traffic. Thus, safety and performance circumscribe the use of at-grade crossings on true high-speed rail segments.
Policy Issues and Conclusions

Highway Planning Issues

As a result of the recommendations made by the Commission to Study the Safety and Security of Railroad-Highway Grade Crossings, FDOT and the Florida Department of Community Affairs (DCA) have intensified their efforts to better integrate the effects of rail-highway crossings into the planning process. This process consists of the overall Local Government Comprehensive Plan (LGCP) as well as the site-oriented Development of Regional Impact (DRI) process. An additional factor has been included in the land use review process: the likely effects of increased vehicular traffic through nearby rail-highway crossings.

The effects of rail-highway crossings have always been included in the detailed engineering design of highways and in traffic engineering. However, consideration of rail-highway crossings is generally absent from highway planning methodology. For example, rail-highway crossings were not included in either the original 1985 Highway Capacity Manual (HCM) or its 1994 update. This omission is significant because HCM techniques form the basis of highway planning in Florida and elsewhere.

At grade crossings of high density, rail lines generate substantial delays to vehicular traffic. Highway capacity (stated in vehicles per lane per hour) is reduced to the extent that a crossing is blocked or in the process of clearing throughout the day. Delay and reduced highway capacity may be an issue even when trains are not present (or on less active rail lines) because buses and those trucks carrying hazardous materials are required to come to a full stop at crossings at all times. This would tend to produce additional vehicular delay and further reduce highway capacity.

When highway capacity is overstated, highway needs will likely be understated. This means that some traffic problems will persist even after highway expansion projects have been completed. The potential for success of many highway projects may be compromised by crossing delays and accident exposure.

Risk and Uncertainty

Uncertainty about rail traffic patterns complicates the analysis of rail-highway crossings. Since 1965, about 25 percent of the Florida rail system has been abandoned. Abandonments, consolidation, changing traffic levels, and questions about the fate of current and future passenger rail service contribute to a climate of uncertainty, particularly on railroad branch lines. This tends to cast doubt on the economic wisdom of making substantial investments, such as grade separations, in many rail corridors.

The possibility of reductions in (or absence of) future rail traffic would tend to reduce any net benefit to the public from grade separation projects. There are numerous examples of grade-separated crossings of highways and subsequently abandoned rail lines across Florida and the other states. Higher levels of risk and uncertainty tend to favor the less expensive approaches of closure and improved signalization.
Summary and Conclusions

Public awareness of rail-highway crossing safety has increased in the aftermath of a number of widely publicized train/motor vehicle crashes in Florida and elsewhere. This report discussed existing and emerging methods of protecting crossings. Existing crossing protection technologies are heavily dependent on driver attentiveness and compliance. Emerging crossing protection technologies are less dependent on the motor vehicle operator, but require expensive retrofitting of crossings, the motor vehicle fleet, or both. In addition, the report indicated a number of instances in which the effects of rail-highway crossings were difficult to integrate into highway planning.

The topics discussed in this study suggest a number of directions for future research:

1. Research needs to be conducted into the effectiveness "in the field" of more modern, passive devices (such as the "Conrail Crossbuck" now being deployed in Ohio) on accident rates. A limited deployment of some form of the augmented crossbuck in Florida might also be included as a part of this research.

2. Research needs to be conducted into the integration of accurate rail-highway crossing information (location, at-grade or not, etc.) can be integrated into paper and digital map products. A pilot implementation in a single Florida county could be used to help determine the cost of widespread coverage. Focus groups of drivers could be used to measure driver comprehension and acceptance.

3. Research needs to be conducted on the impact that grade crossings and grade separations have on highway traffic flow and speed. The analysis should be consistent with the methods and degree of rigor contained in the Highway Capacity Manual. The focus of the research would be on the speed and flow effects of different levels and time-of-day distributions of highway and rail traffic.

Continued research and continued awareness of the effects of rail-highway crossings in the planning and operation of Florida's transportation system are solid investments in public safety.
References


Highway and Rail Safety Newsletter, Richards and Associates, various issues.


