U.S. Automated Railroad Infrastructure Trespass Detection System Performance Guidelines

Marco P. daSilva

US Department of Transportation Research and Innovative Technology Administration

John A. Volpe National Transportation Systems Center

55 Broadway

RTV-3F, Advanced Safety Technology Division

Cambridge, MA 02142

Tele: 617-494-2246  Fax: 617-494-2995
ABSTRACT

Trespass on railroads’ rights-of way (ROW) has long been a safety concern in the United States (US) and globally. In the US alone, 518 people sustained fatal injuries as a result of trespass onto the ROW in 2006 [1].

The US Department of Transportation (USDOT) demonstrated an automated prototype railroad infrastructure security system on a CSX railroad bridge in the town of Pittsford, New York. The main objective was to demonstrate a stand-alone video-based trespass monitoring and deterrent system for railroad infrastructure applications using Commercial-Off-The Shelf (COTS) technology. The system was installed in the summer of 2001, maintained and evaluated for a period of four years, and then transferred to the railroad operator, CSX, during its fifth year of operation in November of 2005. The development of function-based performance guidelines for these types of systems was one of the recommendations delineated by the authors of the final report.

Function-based performance guidelines are defined as a set of recommendations that specify the expected outcomes of the technology performance and/or system but do not provide physical component specifications. The main areas addressed by these guidelines are:

- Atmospheric conditions
- Lighting
- Communications
- Sensor housing
Sensing functions

This paper summarizes the performance guidelines drafted from the analysis of the proven and effective trespass detection and deterrent system field-tested and evaluated in Pittsford. The various observations made throughout the four year course of the Pittsford project, along with the Pittsford system prototype results and lessons learned provide an excellent resource from which a set of performance guidelines can be developed for similar future railway safety and/or security systems. The purpose of these guidelines is to assist local authorities and railroads that are considering the use of such stand-alone systems to minimize trespass on the railroad’s ROW.
INTRODUCTION

The USDOT, under the direction of the Federal Railroad Administration (FRA), was tasked with demonstrating an automated prototype railroad infrastructure security system on a railroad bridge in the town of Pittsford in the state of New York. The main objective was to demonstrate a stand-alone video-based trespass monitoring and deterrent system for railroad infrastructure applications using COTS technology. The prototype system, which was installed in the summer of 2001 and evaluated over a three-year period, proved very successful. In fact, it was transferred to the private railroad operator during its fifth year of operation (November 2005) and has remained in operation as of March 2008. Many technical lessons were learned throughout the evaluation period of the system installed at Pittsford, NY and were documented in the final report, entitled *Railroad Infrastructure Trespassing Detection Systems Research in Pittsford, New York* [2]. The results indicated this interactive system could serve as a model or prototype railroad infrastructure security system for other railroad rights-of-way or bridges deemed prone to intrusion. Function-based performance guidelines for these types of systems were therefore developed for these systems. These guidelines are defined as a set of recommendations that specify the expected outcomes of the technology performance and/or system but do not provide physical component specifications.

A wealth of information was collected during the four-year duration of the Pittsford project. Much of it was used to enhance the operational capabilities of the system throughout the life of the project, especially in terms of increasing system component reliability and positive detection rate. The various observations made throughout the
course of the project, along with the Pittsford system prototype results and lessons learned provided an excellent resource from which a set of performance guidelines were developed for similar future railway safety and/or security systems. The purpose of these guidelines is to assist local authorities and railroads that are considering the use of such stand-alone systems to minimize trespass on the railroad’s Right of Way (ROW).

FACTORS CONTRIBUTING TO TRESPASSING ON RAILROAD ROWs

Trespass on the railroad ROWs occurs due to many circumstances. Perhaps the biggest deciding factor for trespass concerns included the layout and features of the railroad location, whether it is a crossing, bridge, tunnel, or somewhere else along the infrastructure. Aspects such as level of accessibility, remoteness, and lack of nearby crossings increase the probability of trespass on the ROW. Therefore, once a particular location of interest has been identified, an engineering study in the form of an initial site survey should be conducted. A site survey can identify conditions that may be present and contribute to trespass. Such conditions can include, but are not limited to:

- Accessibility (poor or no fencing, no landscaping, near school or other heavily trafficked attractions…)
- Poor visibility (curve/crest near accessible areas, location not easily visible from nearest road or developments)
- Shortcut potential (fastest way between popular destinations)

Anecdotal historic information about trespassing at the specific location should also be gathered from the local police, town representatives, and even the local media. However,
as denoted in the Pittsford Final Report [2], this information is not necessarily correct. In that study, local sources indicated that the trespassing was mostly done by teenagers loitering on the bridge. Upon review of three years worth of trespass data gathered by the system installed at the Pittsford location, it was evident that the anecdotal information was a misconception. It quickly became very clear that many of the trespassers were adults or a combination of adults and small children that were using the bridge as a shortcut between the two sides of the canal. Very few trespass events involved teenagers using the location to loiter. The correct information can be of great value, especially to local railroad safety campaigns.

ENGINEERING COUNTERMEASURES

The site survey results should be reviewed to determine the factors contributing to trespassing at that specific location and identify appropriate countermeasures that should be implemented to reduce/eliminate the trespass problem. A trespass detection/deterrent system is one of many countermeasures available that may be effective in preventing and/or mitigating the consequences of trespass. There may be other potential solutions, aside from installing a technology system that could ameliorate the trespass problem at the location. The site survey can also reveal factors that would make installing a technology-based system very difficult, such as the lack of power, communications and/or viable sensor placement locations. Other countermeasures can be initially more costly but can prove to be more cost-effective for longer durations of time. Some examples are:

- Better/more effective signage
Better fencing, landscaping (rows of bushes…)

- Dedicated pedestrian/cyclist path above/under/parallel to ROW

If these other methods don’t apply to the particular situation, then an infrastructure-based trespass detection and deterrent system should be designed specifically for the location. In some instances, it still may be beneficial to incorporate other countermeasures (such as fencing) along with the technology system. Once the decision is made as to the appropriate countermeasures, then the design phase of the project can commence.

**TRESPASS DETECTION/DETERRENT SYSTEM DESIGN**

Perhaps the most critical task in the development of these systems is the initial planning phase of the project. The first step in designing any system is to properly identify all stakeholders and include them throughout the entire process in the form of public-private-partnerships (P3) to resolve the safety concern. The Canadian Government developed such a P3 called “Direction 2006” aimed at reducing trespass and crossing incidents and published a very useful guide for community-involved trespass prevention on railroads [3].

The second step in the planning phase is a comprehensive site survey, which should be conducted along with a subset of the stakeholders (such as the operating railroad, city/town representatives, and utility companies). Perhaps the most important observation from the site survey is the definition of the detection zone. A well-defined detection zone should be identified before the system design process proceeds so that the
system design accounts for the specific requirements of the site. Great care should be taken to identify all of the entry/exit points as well as potential false alarm triggers. Such triggers could include: vegetation, boats or vehicle traffic (if at a bridge location), and large animals. Once the detection zone and all other observations have been gathered from the site survey, the system design process can commence.

A wide variety of technologies have been used for trespass detection in many operational environments including on railroad ROWs. Integrated systems have also been field-tested in recent years, including the system recently evaluated at the Pittsford, NY location. A report entitled, *State-of-The-Art Technologies for Intrusion and Obstacle Detection for Railroad Operations*, presents a synthesis of the state of the art research on intrusion and obstacle detection [4]. The report contains a comprehensive list of existing and potential technology solutions that could be considered for use as Intruder and Obstacle Detection Systems (IODS) or be capable of performing integral functions within such systems. The most common technologies currently in use throughout the transportation and security industries in obstacle and intrusion detection include radar, magnetic, infrared, and video motion detection sensors.

Many technical lessons were learned throughout the evaluation period of the system installed at Pittsford, NY. Some of these issues were based on current railroad operational procedures and directly apply to the technology concepts considered for use around the railroad environment. The two major technology-related issues, described in detail in the Pittsford report [2], are denoted below.
• *The use of proven technology increases the probability of success.* Many technology solutions currently exist throughout the transportation and security industries. Some have been successfully used for extended period of time, while others are newer concepts that may still prove to be less effective. Therefore, the use of proven technology, even if not cutting-edge, may prove better for the project.

• *The use of a broadband communications infrastructure (or better) for communication of trespass detection events if video is used as part of the system increases the probability of success of the detection of the event.* A broadband connection between the wayside equipment and monitoring station enables constant live surveillance and instantaneous alarm notification, and enables a good image refresh rate. Anything less than broadband, including dial-up and DSL, may cause delays in video transmission due to significantly slower video refresh rates as well as inferior video quality. Wireless data transmission options should be considered if no existing communications infrastructure exists or if dial-up is the only option at or near the location.

This paper does not provide guidance on system design or the use of specific technologies. However, some general procedural recommendations are presented herein. The system’s design and installation plans should be presented to the stakeholder committee for comments, especially from the local authorities, affected utilities, and railroad companies. These plans should be in accordance with all local and State design guidelines (building codes) as well as per the product manufacturers’ specifications.
They should detail the physical placement of all sensor and communication components, all associated conduit and utility service connection points, and any other physical design components. Revisions recommended by the committee should be incorporated into the design and again presented to the committee for approval. Once the committee is in agreement, proper local construction permitting should then be sought for the installation. The system’s installation should only commence after stakeholder committee approval and issuance of the proper permitting.

There exists a number of alternatives for the development and operation of trespass detection systems. The local authority (Town/City/State) can elect to be responsible for the system operations or outsourcing this activity to a private contractor. If the latter is chosen, the local authority should establish a well-drafted contract delineating the contractor’s responsibilities and requirements as well as clear operation and maintenance plans and protocols.

**PERFORMANCE GUIDELINES**

Various system performance issues were identified throughout the operational period of the trespass detection and deterrent system installed at the railroad bridge location in Pittsford, NY. The results from that research aided in the development of function-based performance guidelines delineated herein. These guidelines are not designed to address specific types of devices or component technologies. They refer, however, to the basic functionality and operation of trespass detection and deterrent systems.
If the site survey results indicate that an infrastructure-based trespasser detection and deterrent system should be installed, then the following should be considered:

**Atmospheric Conditions**

The system should be designed to withstand the rigors of year-round environmental conditions at the location. It should function in all weather and ambient lighting conditions, including day, night, sunrise, and sunset conditions. The wayside cabinet should be well ventilated, especially if inside temperatures reach above 80 degrees Fahrenheit. The wayside cabinet should also be heated if temperatures are expected to reach below freezing, less than 32 degrees Fahrenheit. The Pittsford System experienced both of these conditions and therefore the wayside cabinet was equipped with both a heater and fan and these were activated accordingly as part of the seasonal maintenance procedures.

**Lighting**

Determine lighting conditions at the location to be monitored. Specific attention should be given to the monitored area and whether there exists sufficient nighttime lighting for the proper operation of image-based sensors, if such are used. If not enough lighting is available, determine if it can be provided from existing curbside/overhead lighting poles. If this is not feasible, then determine whether floodlighting should be incorporated into the design of the system or if Infra-Red (IR) illumination should be used instead. Particular attention should be given to placement of extra lighting so as not to interfere with railroad operations.
Communications

Depending on the concept of operations laid out for the trespass detection system, the appropriate communications component should be incorporated into the system design. A reliable communication link should be established using the most suitable option available at the location. The system’s design and concept of operations should indicate the necessary bandwidth needed for relaying all of the necessary information to the appropriate channels, whether they are the local authorities, a local monitoring station, the maintenance personnel, or the railroad company as well as for real-time audible warning notification to the trespasser(s). Common options are telephone lines (DSL), broadband, fiber-optic, and microwave. (The site survey should have noted the availability of the first three options.)

Sensor & Other Components Housing

All wayside-mounted processing and communication equipment should be housed in National Electrical Manufacturers Association (NEMA) weatherproof outdoor enclosures intended to house electrical circuits and components. These weather and damage resistant cabinets should also be equipped with a locking mechanism to ward off potential vandalism. The cabinet should also be grounded and equipped with surge suppressors. Consideration should also be given to installing a lightning rod above all equipment poles especially if the area is prone to lightning strikes or the poles stand higher than the surrounding structures and landscape.
All external sensors should be pole-mounted out of reach of potential trespassers, at least 10 feet off the ground, and installed in weatherproof and damage-resistant enclosures if not already manufactured to those specifications. This guideline should also be in accordance with sensor performance specifications, especially in relation to each sensor’s field-of-detection. The sensors should be placed at a suitable location to both satisfy this guideline and also provide adequate coverage of the detection zone.

**Sensing Functions**

The trespass detection sensing package of the system, which is composed of all of the wayside sensors, should adhere to the following recommendations:

- Achieve one hundred percent trespass detection rate within the detection zone, which should be well defined per the site survey.

- Minimize false alarm rate (mask out trains, hi-rail vehicles, boats, animals).
  - Due to the nature of the local environment and sensors used, there may be a significant false alarm rate. If so, care must be taken to minimize its occurrence and determine the effect on the system’s operation, especially if human operators are involved.

- Issue a warning to monitoring station and trespasser if trespassing is detected within the detection zone.
  - Auditory warning to the trespasser should be focused in the direction of the detection zone and loud enough to be heard within the entire detection zone. The auditory warning should not be a nuisance to nearby homes or businesses.
• Objects outside the detection zone must not cause an alarm or warning to be issued.

• System design should incorporate local recording as well as sensor and system data transmission.
  o This capability is critical for remote system maintenance. It is also invaluable for reviewing system and alarm activity, analyzing system performance, and to perform forensic research.

• Failsafe Design.
  o System should be able to self-diagnose a failure.
  o System should have a means to alert the monitoring station when a system failure condition is detected.
  o System should have a reboot utility that can be remotely activated. The remote reboot capability should be applied to both the wayside system controller as well as individual sensor components. As evidenced throughout the Pittsford, NY system evaluation, components sometimes failed but regained their functionality after a reboot.

• Component Redundancy.
  o Redundancy should be incorporated into as many components as possible. A typical system relies on various sensors and other components that are each an integral part of the overall system. Failure in any of these parts may render the whole system inoperable. The system’s design should incorporate redundant sensors and other components. This ultimately increases the reliability of the overall system.
• Public Safety.
  o System must pose no threat to human safety and must meet or exceed all regulations for the provided technologies.

• Avoidance of Interference.
  o Sensing subsystem should not interfere electronically (emit electromagnetic interference that would interfere with normal railroad operations) or visually with any other system on the ROW or on authorized railway users (locomotives, hi-rail vehicles) – especially IR lamps that may glow red at nighttime, which may interfere with the railroad visual signaling system cues.

• Operation plan.
  o Protocols must be developed to address the range of operational situations from the positive detection of intruders or obstacles on the ROW to false detection or failure of the warning system. These protocols must be shared with all entities that interact with the system (railroad companies, monitoring station, police, and others). This core group of stakeholders should provide input to the initial operational plans as well as feedback while the system is in operation since some situations might only reveal themselves during the system’s operation. Therefore, a periodic review of the operation plan should be conducted and any revisions made accordingly.

• Maintenance plan.
A site-specific system maintenance plan should be developed that includes plans for regular inspections as well as for preventative maintenance and cleaning.

CONCLUSION

The purpose of the performance guidance detailed in this paper is to assist local authorities and/or railroads that are considering the use of stand-alone trespass detection and deterrent systems similar to the one installed and evaluated at a railroad bridge in Pittsford, NY. The various observations made throughout the course of the operation and evaluation of that prototype system, which has been in operation since 2001, provided an excellent resource from which this set of performance guidelines were developed for similar future railroad safety and/or security systems. These guidelines, ranging from overall system operation to specific sensor issues, should provide a valuable tool for future work in the area of public safety within the railroad operating environment.

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REFERENCES


