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Railroad Crossing Safety

FINAL REPORT
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Submitted by

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16. Abstract

With nearly a quarter of millions of railroad grade crossings in the U.S., the daily inspection, maintenance, and improvement of these critical areas around railroad crossings rest on the shoulders of a selected group of railroad engineers and safety officers in various state Departments of Transportation (DOT). However, due to limited number of railroad crossing inspectors, only a small portion of the state agencies are able to complete the inspection cycle within one year, most inspection cycle with the highest work load inspections takes three to four years.

To improve the efficiency of railroad crossing inspections, New Jersey Department of Transportation (NJDOT) and Federal Highway Administration (FHWA) commissioned this study to develope an innovative approach consist of two steps: first, use web mapping applications to identify potential problem locations; second, use conventional survey procedures to identify vegetation blockage and delieate trimming boundaries. When implemented, the proposed approach will aid agencies to meet the mandates by the Railroad Safety Improvement Act (RSIA, 2008) and shorten the railroad crossing inspection cycles, which is critical to maintain and improve railroad crossing safety.

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1. INTRODUCTION

Highway-rail grade crossing safety is a critical issue. With more than 1600 grade crossings in New Jersey, improving grade crossing safety is an enormous challenge that will take the combined efforts of railroads, public safety officials and the general public. The daily inspection, maintenance, and improvement of these critical areas around railroad crossings rest on the shoulders of a selected group of railroad engineers and safety officers in the New Jersey Department of Transportation (NJDOT).

In order to enhance motorist safety at all railroad crossings through an improved approach to maintenance of critical areas, NJDOT is interested in developing an optimum approach to identify potential hazards at various locations and to propose an innovative approach for corrective action. The critical aspects of the clearance areas are twofold: first, the safe distance ahead to the crossing for an approaching vehicle; second, the safe distance, along the tracks in either direction for a vehicle stopped at the crossing, which is often referred to as the clearance triangle or visibility triangle as shown in Figure 1.

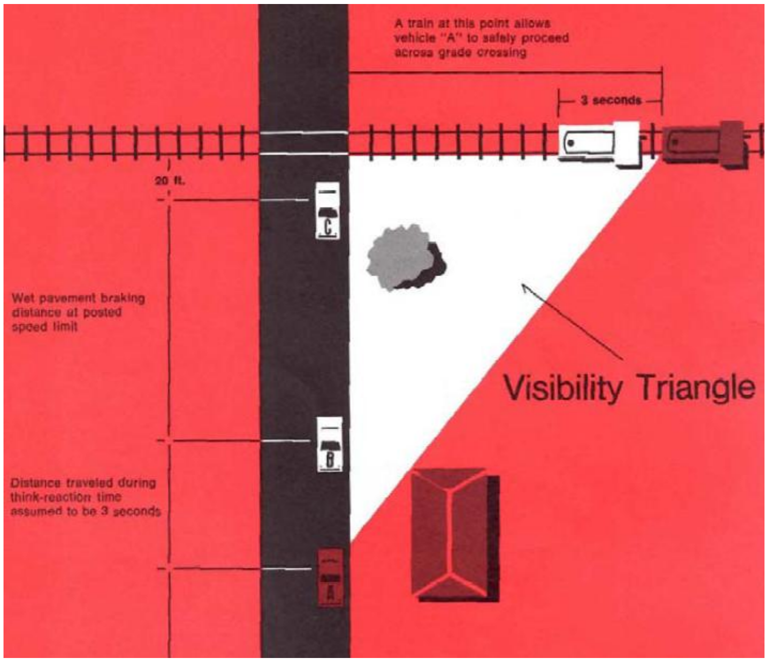


Figure 1. Clearance triangle

Source: Richard and Bridges, 1968.

2. RESEARCH OBJECTIVES

The purpose of this research is to improve motorist safety at railroad crossings through an optimal approach to identify vegetation blockage of the sight distances at the highway-railroad crossings. The project team works with the railroad engineers to explore solutions in identifying potential hazards at various locations and select the best innovative approach for corrective action. In order to produce a practical, implementable solution, the research team strives to accomplish the following objectives:

1. Review existing literature to identify potential solutions or best practices implemented by others;

2. Survey peers among state Departments of Transportations (DOT), railroad associations, and other related parties to acquire existing practices and potential solutions in the developing stages;

3. Evaluate current operations of the Railroad Engineering and Safety Division in NJDOT to establish the baseline for implementing potential solutions;

4. Coordinate with NJDOT staff and Research Project Selection and Implementation Panel (RPSIP) to select the optimal approach among various potential solutions to identify vegetation blockage of the clearance triangle at railroad crossings;

5. Demonstrate the practicality and implementability of the recommended solution by applying the process to selected locations.

3. LITERATURE REVIEW

This section documents the literature review effort performed under the subject of highway-rail grade crossing safety, particularly related to safety sight distance and vegetation clearances.

A highway-rail grade crossing is the area where a railway and roadway intersect (Association of American Railroads, 2008). As of December 2007, there were more than 227,000 grade crossings in the United States, including 140,000, about 62 percent, on public roads and 87,500, around 38%, on private roads. About 85-90 percent of grade crossing collisions and casualties occur at public crossings, since motor vehicle traffic is usually much higher at public than at private crossings. About half of the crossing accidents occur at the one third of the locations where only passive traffic control devices, such as cross bucks, are installed. The disproportionately high accident rates in these relatively lower volume locations beg for attention so as to ultimately improve overall safety around railroad crossings. As exhibited in Figure 2, the highest accident category in New Jersey includes automobiles, truck trailers and other vehicles, an indication of the importance of highway-rail crossing locations.

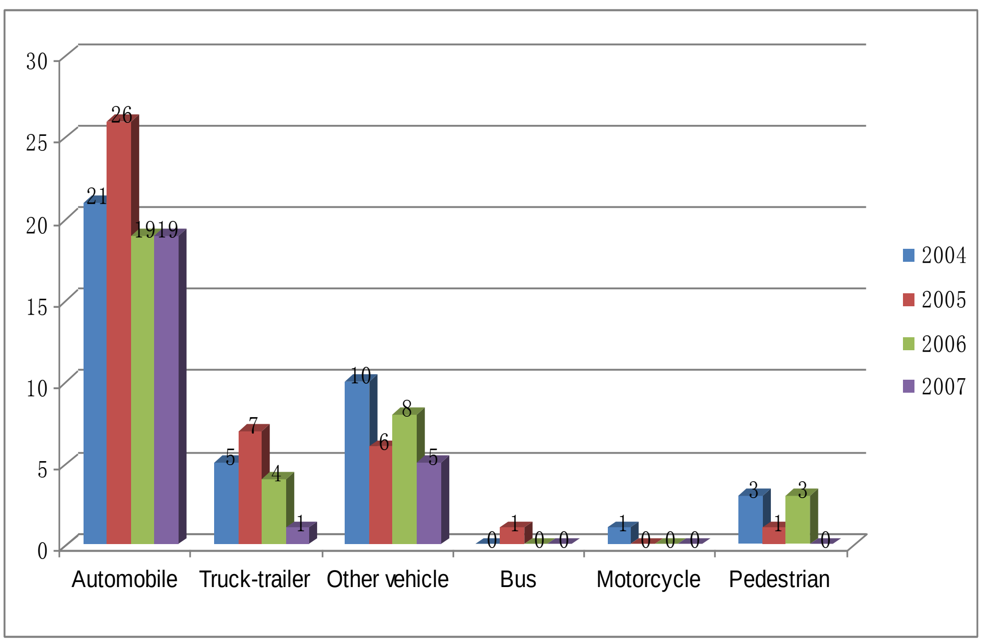


Figure 2. Number of accidents in New Jersey, 2004-2007

Source: Federal Railroad Administration, 2008.

New Jersey has no state law or regulation but it is generally assumed that railroad companies maintain their right-of-way free from grass, trees, bushes, shrubs, or other growing vegetation. Ideally a clearance triangle, as shown in Figure 1, should be maintained at all highway-rail crossings at all times. If the railroad companies are responsible to regularly inspect and maintain the vegetation clearance in the areas of railroad right of way, the areas that belong to the roadway right of way are generally accepted as the responsibilities of the state DOT. Affected by severe budget constraints, some railroad crossing divisions within the DOT simply do not have enough inspectors or engineers to inspect and maintain the vegetation clearance under traditional methods. As reported during the pre-proposal meeting, the DOT has only three field inspectors (down to one at the writing of this final report); it takes at least two years to complete the inspection cycle of more than 1600 railroad crossings in New Jersey (Hirt and Filipowicz, 2008).

The research team has conducted a thorough literature review in order to identify potential solutions or best practices implemented by other entities so we do not have to re-invent the wheel. The literature is organized into the following groups and presented in the following sections:

- Vegetation blockage regulations,
- Practices by various entities in maintaining sight distance triangles,
- Potential solutions to address safety in railroad crossing locations.

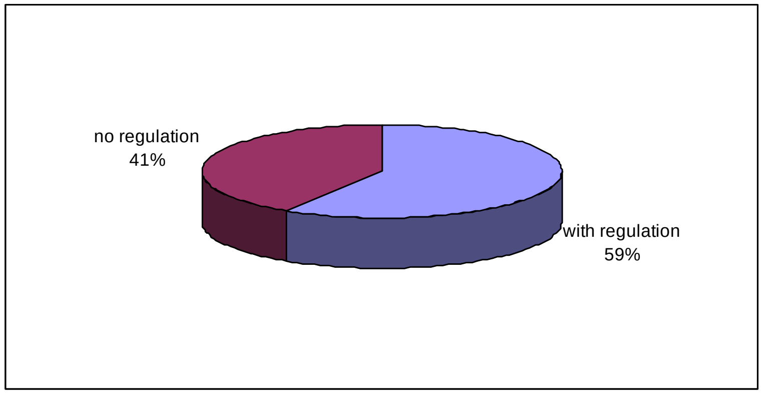
3.1 Vegetation Blockage Regulations

A few reports addressed general statewide approaches (Utah Division of Administrative Rules, 2008; Georgia Department of Transportation, 2008) and others focused on how to conduct effective crossing diagnostics (Anderson, 2008). Sifting through the large number of regulations and roadway and facility design manuals related to railroad crossings, the research team has identified some potential sources for guidance and further development of ideas.

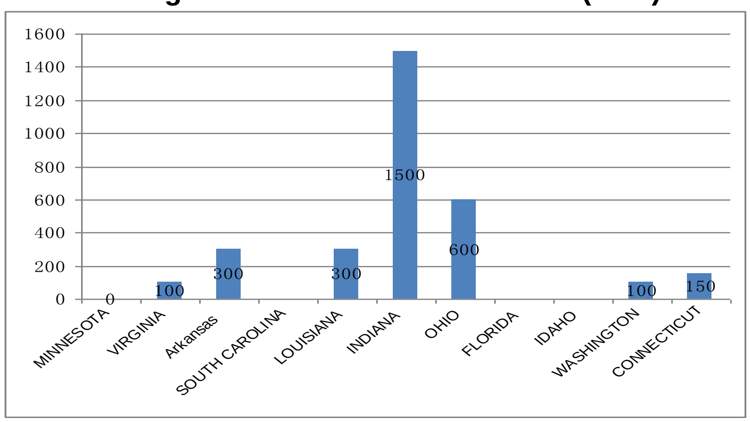
The Federal Railroad Administration (FRA, 2008) has provided a high level summary of laws and regulations covering responsibility for the removal of brush, shrubbery, and trees from a railroad right-of-way with a reasonable distance from the crossing. An excerpt of the chapter on Vegetation Clearance is attached in Appendix 1.

As demonstrated in Figure 3A, more than half of the states and the District of Columbia have no state law or regulation mandating vegetation clearance specifications; New Jersey is among the 30 states that fall into this category. Even when state laws and regulations specify vegetation clearance, the requirements and penalties, if any, vary a great deal, as shown in Figures 3B and 3C.

A. Portions of the states with and w/o regulation mandates



B. Vegetation Clearance Distances (Feet)



C. Ranges of Penalties (Dollars/Incident)

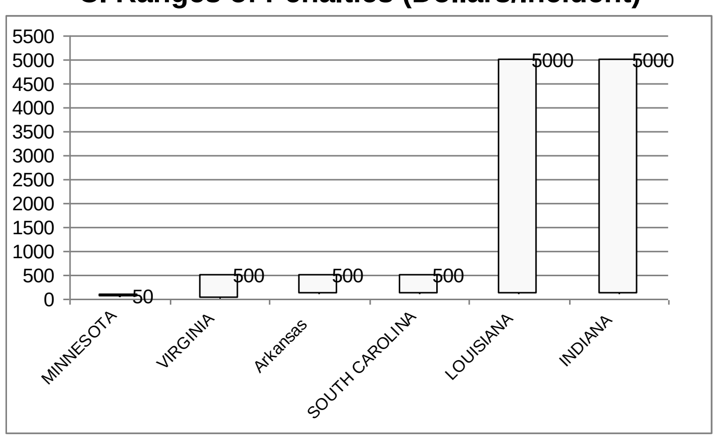


Figure 3. Vegetation clearance regulations by different states

Source: Federal Railroad Administration, 2008.

For example, Arkansas mandates that “the maintenance of the right-of-way must be for a distance of fifty feet on each side of the centerline between the rails for the maintenance width and for a distance of one hundred yards on each side of the centerline from the public road or highway for the maintenance length.” Indiana requires that “each railroad in Indiana shall maintain each public crossing under its control in such a manner that the operator of any licensed motor vehicle has an unobstructed view for fifteen hundred feet in both directions along the railroad right-of-way subject only to terrain elevations or depressions, track curvature, or permanent improvements.”

A limited collection of literature, available via the Federal Railroad Administration (FRA), the Transportation Research Forum (TRF), the American Railway Engineering and Maintenance Association (AREMA), the Federal Highway Administration (FHWA), and the Institute of Electrical and Electronic Engineers (IEEE), provides better understanding of the existing problems with identifying and clearing vegetation blockage to the sight distance around crossing areas. For example, the Office of Highway Safety, Federal Highway Administration (FHWA, 2008), has provided a summary of Vegetation Control for Safety targeting street and highway maintenance personnel. Goals for vegetation control are outlined as the following:

- Keep signs and vehicles visible to drivers, pedestrians, and bike riders in crosswalks, at street lights, at uncontrolled intersections, and on bike paths;
- Help pedestrians and bike riders see on-coming traffic easily;
- Improve winter road maintenance in snow and icy areas.

The same guide book also provided specific sight distances for difference types of signs as shown in Table 1. Critical signs include “STOP”, “YIELD”, “DO NOT ENTER”, “ ONE WAY”, “WRONG WAY” and other regulatory signs. None critical signs are destination guide signs, parking regulations, advanced warning signs, and similar warning or information signs.

Table 1- Clear distance for different types of signs

Speed Limit (MPH)	**Non-critical Signs (feet)**	**Critical Signs (feet)**
30	150	250
40	200	350
50	250	450
60	300	600

Source: Office of Safety, FHWA, 1990.

Another important specification provided by the FHWA guide is the stopping sight distance for both urban and rural environment as shown in Table 2.

Table 2- Stopping sight distances for urban and rural environment

Speed Limit (Mph)	Urban SSD (Feet)	Rural SSD (Feet)
20	125	
30	215	250
40	330	350
50	470	450
60	650	600
70	845	

Source: FHWA, 1990.

3.2 Practices of Maintaining Safety Triangles

Another major literature topic falls into the category of practices by various state or local government agencies, railroads, and other entities in maintaining the safety and clearance distances around railroad crossings. For example, a report published by the Iowa Department of Transportation (2005) has detailed the highway-railroad crossing treatments applied in the state, their effectiveness and correlation with accidents. Similar reports did not have specific information on the vegetation clearance subject, but do provide peer comparison and further contacts which would be useful in our research approaches.

A Research sponsored by the Florida DOT (Shah, 2005) explored the development of a video camera-based automated surveillance system that can detect moving objects like pedestrians or vehicles. The system is able to detect, track, classify, and analyze the movements and locations of the objects. It can also detect if the object is in a danger zone, trigger an audio alarm, and relay this information through a wireless data link where an operator can take appropriate action in real time.

Cooper and Ragland (2007) have studied driver behavior at rail crossings and have proposed cost-effective improvements to increase driver safety at public at-grade rail-highway crossings in California. The Virginia Department of Transportation (2008) has developed Northern Virginia Planting Guidelines to plant and maintain vegetation along roadways and railroad crossing areas.

3.3 Potential Solutions

The third category of literature covers innovative approaches in addressing rail crossing safety. A FRA report (FRA, 2007) has introduced various innovative techniques, such as alternative obstacle detection, intrusion detection systems and wireless sensor networks. Another FRA report (FRA, 2006) documented railroad infrastructure trespassing detection systems research in Pittsford, New York.

Robinson, Smiley, Caird, and Millen (2007) and Boxill (2007) used a driving simulator to assess a complex at-grade rail crossing design based on recommendations from a road safety-oriented peer review. The purpose of the simulation was to optimize positive guidance offered to drivers using the crossing and associated roadway elements by designing a more understandable, visible and driver-oriented environment. Nahate and Rys (2006) have developed a 3D method to calculate stopping sight distances from GPS data.

The innovation in the management of vegetation around railroad crossing locations is not limited to technologies but may also include institutional collaborations. As reported in 2002, BNSF (2002) and Kansas DOT are using an innovative joint agreement to improve sight distances on public railroad crossings in a cost-effective manner. BNSF and KDOT are sharing the cost of cutting and removing trees, bushes, and weeds at 261 public grade crossings on nearly 300 miles of BNSF right of way in south-central Kansas stretching from the Oklahoma border to the Chase / Lyon County line, and from Newton south through Wichita to Winfield, Kansas.

An article by Kunz (2003) describing a clearance-gauge measuring vehicle documents how DB Netz AG utilizes the vehicle and measures the corresponding parameters in its railway network. The targets set for the new system are to measure, while on the move, the distances of all fixed objects next to the track. There are a number of components included in the clearance gauge measuring process:

1. Two side-view scanners for establishing narrow points in the clearance gauge;
2. Four video measuring cameras for stereoscopic interpretations and two video documentation cameras. In addition, two forward-looking wide-view scanners for detecting narrow objects are given;
3. A rail-recognition system as a reference for all the measuring systems.

Another study (Directorate of Environmental and Natural Resources Management, 2001) covers new studies that evaluate alternative vegetation clearance methods. The methods are listed together since all of them involve physically cutting the vegetation:

1. Manual clearing;
2. Mechanical Clearing;
3. Remotely-operated equipment.

Three primary criteria were used to evaluate the vegetation clearance methods during the “screening” processing:

1. Effectiveness:
   A. Clearance to bare ground;
   B. Protection of public health and the community;
   C. Protection of the environment;
   D. Compliance with applicable or relevant and appropriate requirements.

2. Implement ability:
   A. Time and resources required to complete the work;
   B. Ability to comply with regulatory requirements;
   C. Availability of the needed tools, equipment, and staffing to employ each clearance method.

3. Cost.

A vegetation clearance handbook developed by Collins (2000) provides general guidelines for maintenance personnel in the field on how to carry out their job responsibilities safely. The handbook has listed ways to improve safety while mowing, cutting brush and controlling other vegetation to increase traffic safety. Consistent with the FRA guidelines, the handbook emphasizes and reinforces the purposes of vegetation clearance:

- Keeping signs and vehicles visible to all the passengers
- Helping passengers see on-coming traffic more easily.
- Improving winter road maintenance in snow and ice areas.

Some reports have focused on specific products that can be used for vegetation clearance, which might be useful to examine when the research team focuses on specific solutions. For example, Kunz (2003) has introduced a new technology named Demining Technologies, which has successfully responded to many of the demands of the demining community. The current product, D-1, is a lightweight, remote-controlled vegetation clearance vehicle for mine clearance assistance (MCA) work. It consists of an armored, V-shaped hull, which gives it very good resistance against antipersonnel blasts (APBs) and fragmentation mines.

The main activity of D-2, the second generation product, will continue to be vegetation clearance, but it will also manage tasks such as area reduction or spoiling debris with a shovel. The D-2 will be equipped with a more powerful engine. Most improvements will be made in the assembling techniques in order to reduce production time and costs. Specific equipment that may or may not have potential to contribute to the solutions of this research project is listed for future detailed examination.

As expected, literature on vegetation clearance for maintaining safety sight distances is very limited. However, given the large number of highway-railroad crossings in the US and other parts of world, and the high visibility of crossing safety, the research team is confident that some states, railroads, or local jurisdictions may have unique ways to maintain the safety sight distances. Therefore, a survey of the current practices by other states and related entities is necessary to uncover current best practices, which is the main scope of the next section.

4. SURVEY PEER STATE DOTS

To uncover current best practices, the first step is to conduct a survey of the current practices by other states and related agencies. The initial literature search revealed limited information on the practices applied by various entities in maintaining railroad crossings free from grass, trees, bushes, shrubs, or other growing vegetation which obstructs the view of pedestrians and drivers.

As summarized in the last section, more than 20 states have legislation mandating vegetation clearance at railroad crossing locations. Even in states without a legislation mandate, there are certain programs in place to ensure the safety and security of motorists, pedestrians, and railroads. Therefore, it is safe to assume that there are many practical strategies and tactics implemented by state and local agencies or railroads to maintain the sight distance in nearly a quarter of a million railroad crossings (Federal Railroad Administration, 2009) around the nation, and certainly many times more worldwide.

4.1 Survey Design

The project team was to conduct a survey of railroad engineering and safety divisions of the state Department of Transportation (DOT) or similar groups or agencies to gather information on practices and procedures used to maintain critical areas at railroad and highway crossings. The survey also gathers information on issues encountered, problems solved, and the effectiveness and efficiency of various practices.

4.1.1 Identify Survey Candidates

It is important for researchers to know the overall landscape of highway-railroad crossings in the US before diving into survey design and data collection. Using the highway and railroad crossing data collected by the Federal Railroad Administration (FRA) and posted on their website (http://www.fra.dot.gov/us/content/2280), the research team has obtained the general status of railroad crossings in the United States.

The total number of railroad and highway crossings varies a great deal among the 50 states and the District of Columbia (Washington, DC), ranging from eight in Hawaii to more than 15,000 in Texas, as shown in Figure 4. The overall split between public and private ownership of these crossings is roughly 60 versus 40 percent as exhibited in Figure 5. However, a closer look at each state indicated that the ranges are wide, from 100 percent all public in Hawaii to merely 15 percent public in Washington, DC. It is interesting to note that Illinois has the highest number of pedestrian crossings, followed by California, while Hawaii has no pedestrian or private vehicular crossings at all.

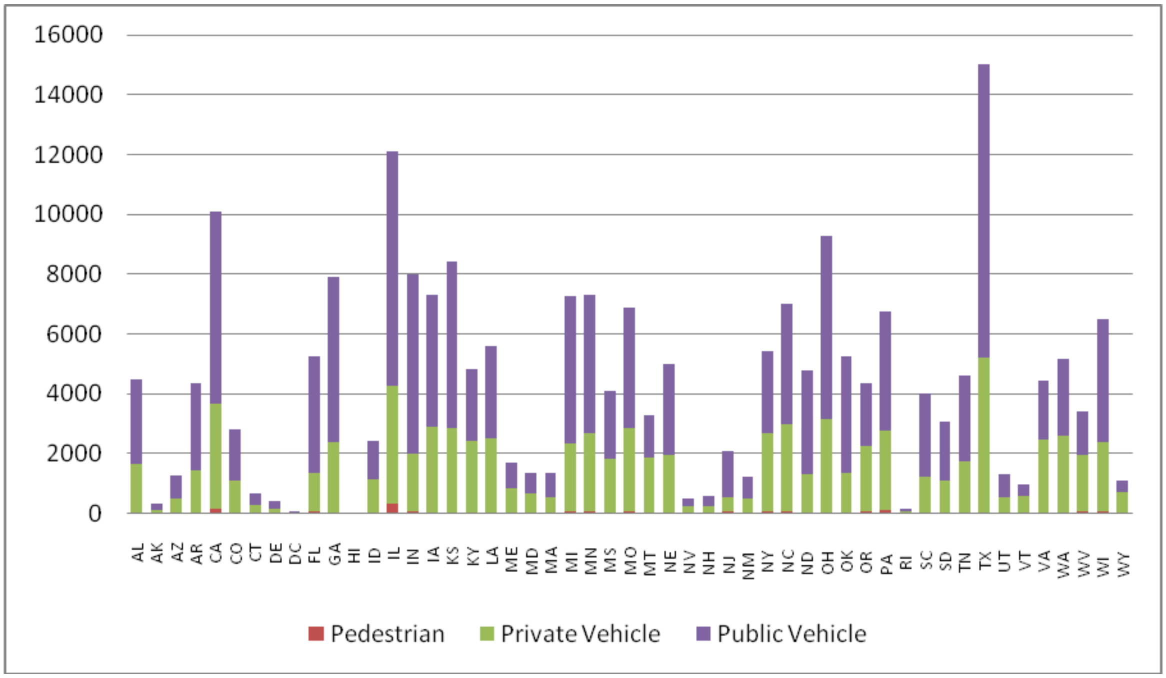


Figure 4. Total number of railroad crossings by states

Source: FRA, 2009.

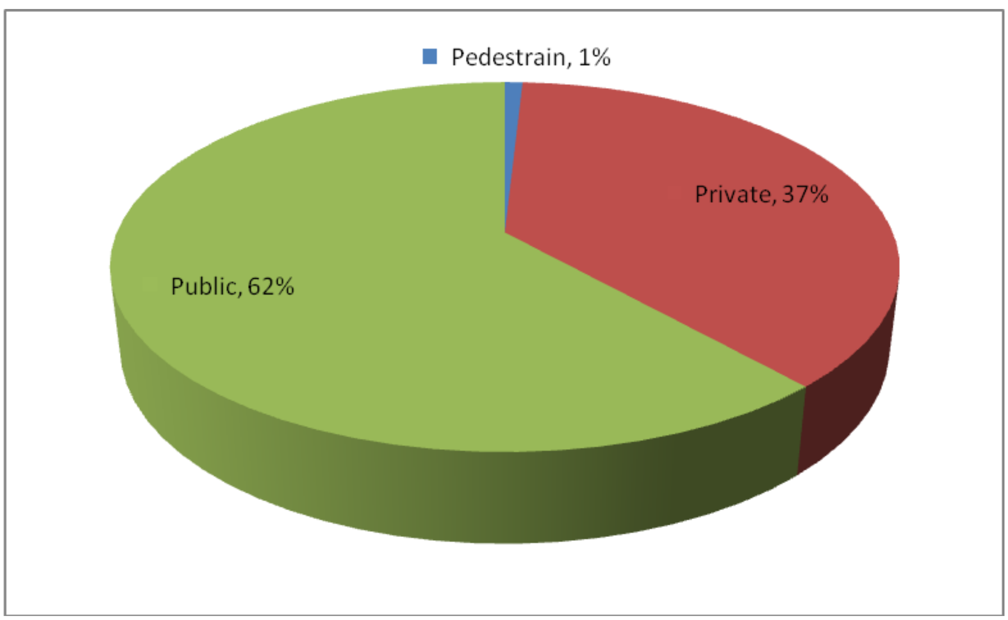


Figure 5. Overall ownership distribution of railroad crossings

Source: FRA, 2009.

One of the important characteristics of railroad highway crossings is the type of highway warning devices used. As depicted in Figure 6, the highest portion of highway warning types is “cross bucks,” about 40 percent, followed by “gates,” about 30 percent, when combining both regular and four quad gates. As gated crossings are generally labeled actively controlled crossings, it is concluded that the majority of the crossings in the US are passively controlled. Passively controlled crossings generally use “cross bucks”; “stop signs”; special warning signs, such as Highway Traffic Signals (HWTS), Wigwags (WW) and bells, and “flashing lights.” A very small portion of these crossings, about two percent, have no control at all or use certain special control devices, which may be very individualized.

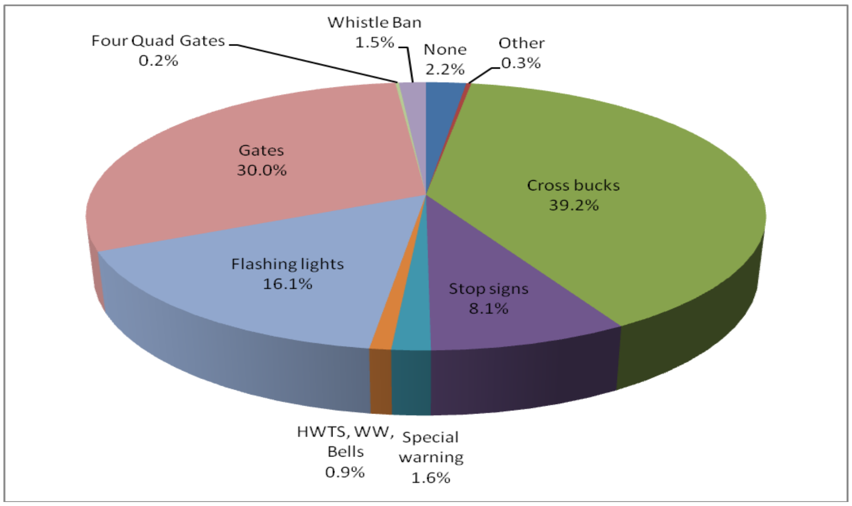


Figure 6. Distribution of highway warning types

Source: FRA, 2009

After a brief review of the general landscape of railroad crossings in the US, the research team compiled a list of potential organizations to be surveyed. Each state has an organization to administer railroad safety related to railroad and highway crossings. Most of them are under the administration of the state Department of Transportation (DOT), while a few have different hierarchical arrangements. The research team has located the appropriate person or division to contact within the organizations to reach our survey candidates as shown in Appendix 2.

4.1.2 Design Survey Questionnaire

Concurrent with the process of identifying survey candidates, the research team worked with the New Jersey DOT Railroad Engineering staff to produce a survey questionnaire as shown in Appendix 3. The purpose of the survey was to answer basic questions, such as

- How is the vegetation blockage to the sight distance or clearance triangle treated?
- What is the current practice in maintaining the sight distance triangle at the railroad crossing locations in terms of vegetation clearance?
- How effective are these practices and how is the effectiveness measured?
- How is the success of a program evaluated?
- Have the states previously done studies on this issue?

To fully use modern communication technology and save time for data processing, the research team designed a questionnaire that can be filled in both electronically and on paper. The electronic questionnaire was hosted on the New Jersey Institute of Technology (NJIT) website and sent to the survey candidates via an e-mail link (http://telus-national.org/RailroadSurvey/index.asp). The website contains an explanation of the survey and information requested as well as a link to the actual survey.

Previous surveys have been conducted in a similar manner for NJDOT projects at NJIT. The research team has also kept a mail-in version of questionnaires as part of the survey techniques, but the electronic version was certainly preferred for the following reasons:

- Each question can be explained or elaborated via a “Help” button so the persons who fill out the questionnaire can be clear on what they are asked.

- The survey design may use various response types, including single choice, multiple choice, matrix questions, text, date, free-form text, numeric, sliding scale and pull-down lists.

- The web version of the questionnaire provided unlimited space for narrative answers, an ideal format for some of the data we are interested in, such as other practices and their evaluations.

- The answers can be channeled into a database as soon as the questionnaire is filled out. This procedure will reduce or eliminate data entry and processing time. It also ensures the accuracy of the data.

- When web based surveys are used, the data processing becomes straightforward. The major effort can be concentrated on the statistical analysis, categorical summary, and policy abstraction.

4.1.3 <u>Conduct Survey</u>

Once the questionnaire was designed and survey candidates identified, the research team contacted the potential survey agencies via e-mail and telephone. Initial contacts were made to explain the nature of the survey and information requested. An e-mail message was then sent to each agency providing a link to the website. Most respondents completed the survey directly on the website. The submitted results have gone immediately into a database that is also located and maintained at NJIT. Based on the nature of the data we collected, it was necessary to talk with a few key persons via telephone interviews. Contact information is available through our personal contacts and the Internet in various DOT websites.

4.2 Survey Results

After two months of extensive communication with various State DOTs and utility commissions, the research team had received 36 valid responses, which resulted in a response rate of 72%. The following section presents the overall survey summary, systematic characteristics, and individual descriptions of various programs.

4.2.1 <u>An Updated Overview</u>

The general magnitude of highway railroad crossings reflected in the survey responses is very similar to that obtained from the FRA database even though the individual numbers may not match due to the age of the FRA data and continuous changes of the railroad crossing landscape. As shown in Figure 7, the total number of railroad crossings range from 137 in Rhode Island, Hawaii did not respond to our survey, to more than 16,000 in Texas. The private and public split varies a great deal. While almost half of the responding state agencies included only public vehicular crossings in the survey, the rest of the responding state agencies have reported private crossings also, ranging from 45 to 90 percent of their respective statewide crossing totals.

Focusing on public vehicular crossings, the survey responses revealed that less than one fifth of the highway and railroad crossings are grade separated, which leaves the majority of the crossings, 83 percent, at grade. Since the scope of this study focuses on the vegetation clearance of passive controlled highway and railroad crossings, the research team zoomed into the latter category for more detailed examinations.

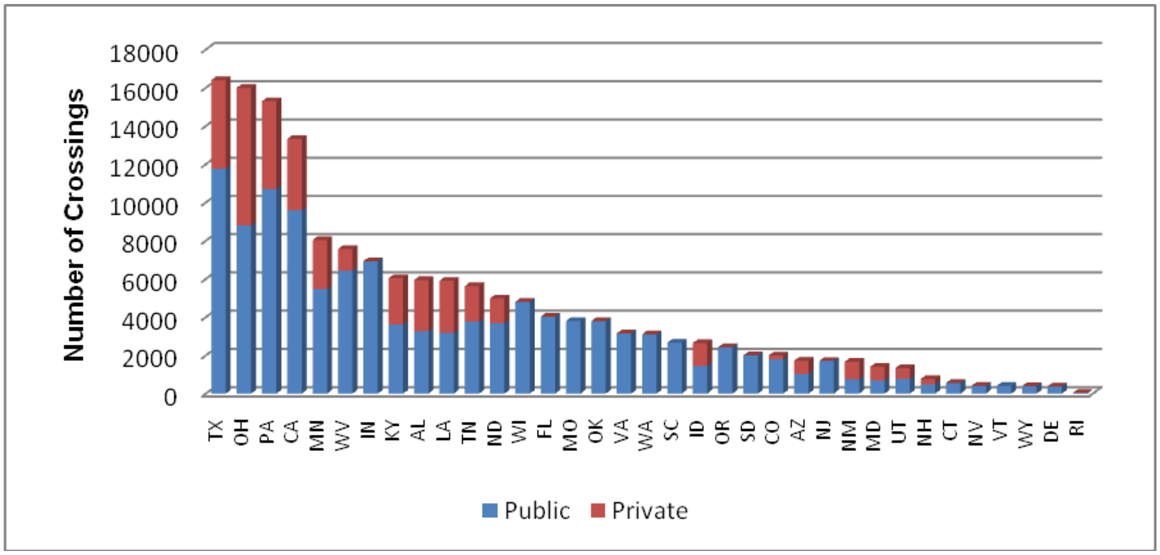


Figure 7. Total number of railroad crossings by responding states

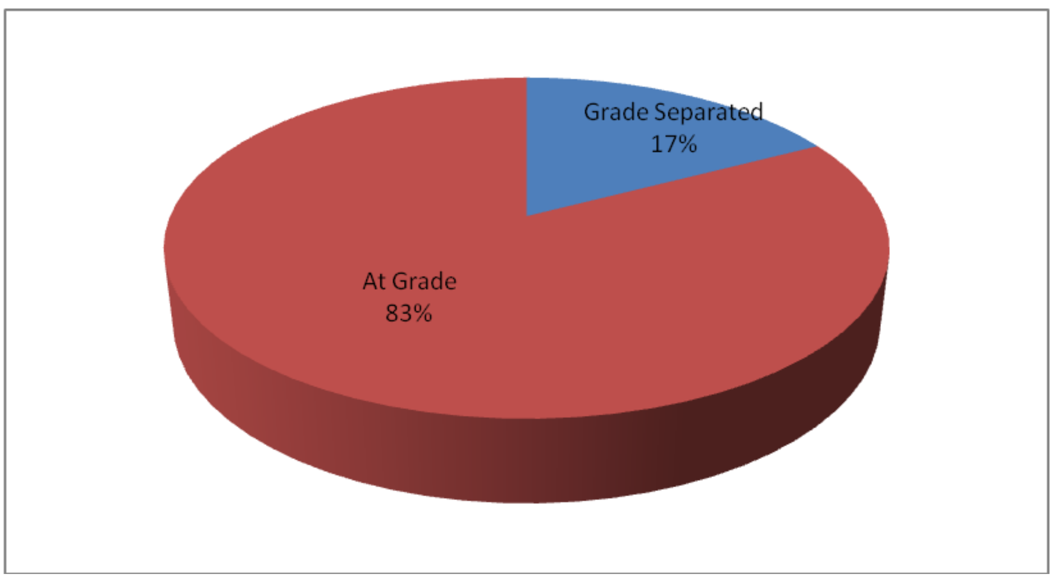


Figure 8. Type of crossings according to survey responses

The types of railway entities range from local to Class I freight railroads while passenger transit and Amtrak tracks are also present. All the states that responded to our survey indicated the presence of local railroads; about 90 percent of them also interact with Class I freight railroads as depicted in Figure 9. Amtrak traverses more than 85 percent of the responding states, and regional railroads have territory in nearly 70 percent of the responding states. As shown in Figure 9, the smallest presence belongs to passenger/transit rail, 56 percent, which may be explained by the fact that not all metropolitan areas have passenger rail services. Even when transit services are present, the mileages of transit service systems are much shorter and occupy less territory to interact with highways.

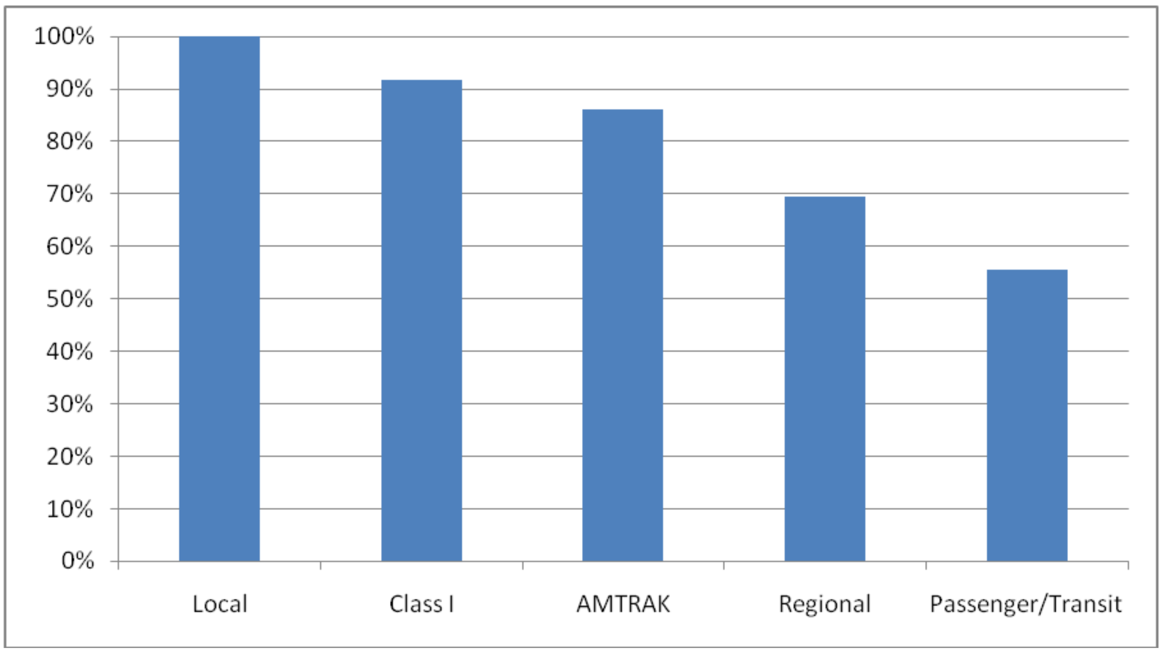


Figure 9. Various types of railroad crossings

4.2.2 <u>Passively Controlled Crossings</u>

According to our survey, about 40 percent of the total at grade crossings is gated while the rest of the 60 percent are passively controlled as shown in Figure 10.

The most prevalent passive control devices are “cross bucks,” “advance warning signs,” and “pavement marking signs.” As demonstrated in Figure 11, more than 90 percent of the responding states use “cross bucks” and more than 80% use “warning signs” and “pavement markings” at highway and railroad crossing locations. Both red and yellow flashing lights are used by various states, but the aggregated total shows that more states, about 38%, use red flashers while less than one fifth, 16%, use yellow flashers. No state reported constant red or yellow lights for highway and railroad crossings. Both “flag waving railroad personnel” and “law enforcement personnel” are reported to be used in railroad crossing locations. While almost half of the states, 49%, reported using railroad flag personnel, only less than one fifth, 16%, of the states reported to use law enforcement officers.

About 15 percent of the responding states mentioned some “other” types of passive control device/practices used in their states. Certain types of devices mentioned in the survey include a combination of cross bucks and stop or yield signs, traffic signals, and Ida-Shield, a type of object marker tested and adopted by the state of Idaho in recent years (Russell, 1999).

As for the effectiveness of these passive control devices, the overall average ratings are depicted in Figure 11 while the distribution of ratings for each type is documented in Figures 12 and 13. Only a few agencies use law enforcement personnel and flag waving railroad personnel at their grade crossings, the two categories were rated to be most effective. Of the agencies that have such practices, 57% score the flagman and law enforcement officer the highest, averaging 4.0 and 3.9 out of 5, respectively. It is not surprising that it is most effective when a real person is at the location but it is also very expensive and not used for daily operations.

A similarly higher ranking is reported on the red flashing light, 3.8 out of 5, while the rating for the yellow flasher is only 2.6 out of 5. It is interesting to note that even though no state has reported usage of red or yellow constant lights, many respondents have rated the effectiveness of such devices, which may be treated as professional opinions or educated guesses. The rating for a constant red light is 3.2 while a yellow constant light is 2.2, which is similar to that of flashers. “Stop signs” fared well in the effectiveness evaluations as many states rate it “3” or “4” resulting at an average 3.1 of 5. In comparison, the most prevalent signs, such as “cross bucks,” “warning signs” and “yield signs” are rated low, 2.5, 2.6, and 2.2 respectively.

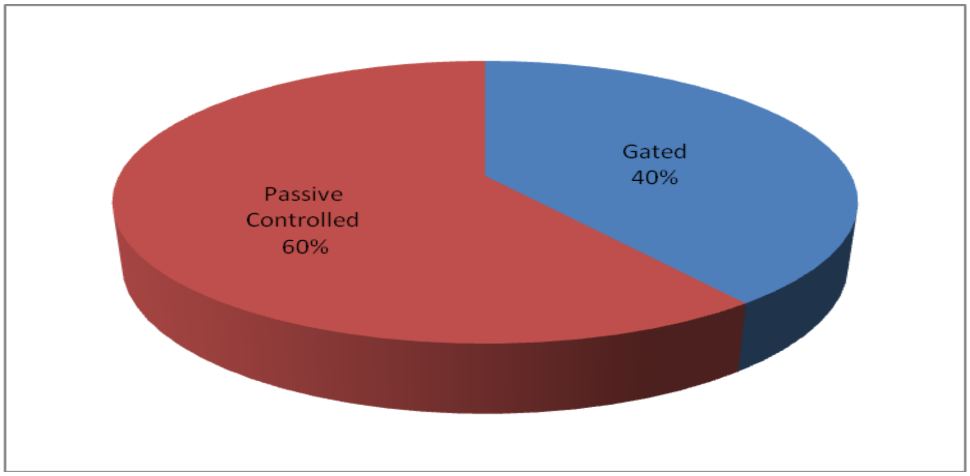


Figure 10. Gated versus passive controlled railroad crossings

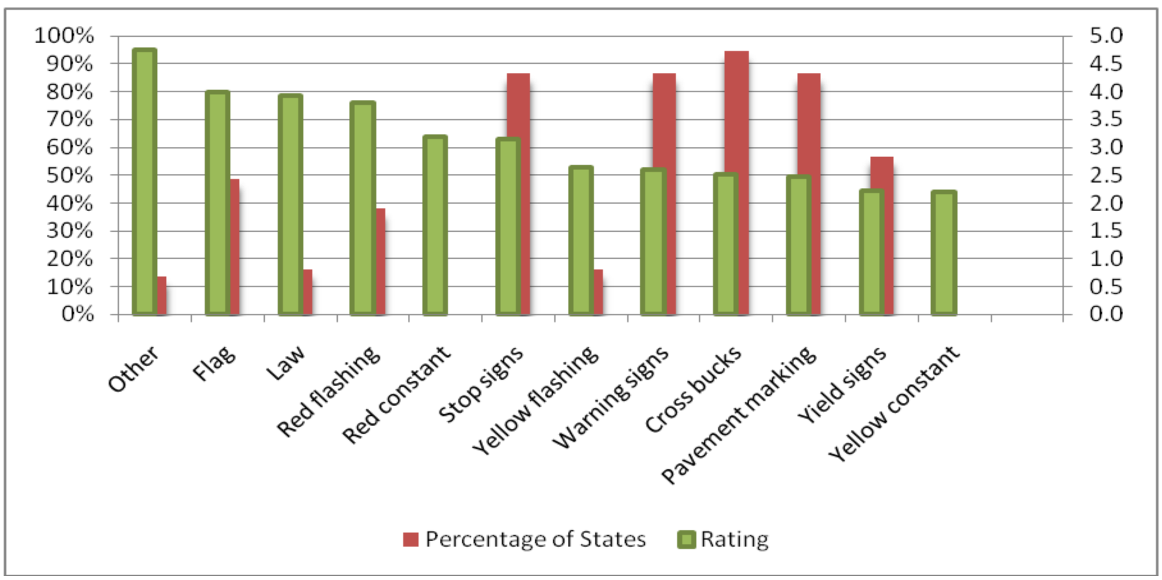


Figure 11. Various passive controls used and their ratings by responding states

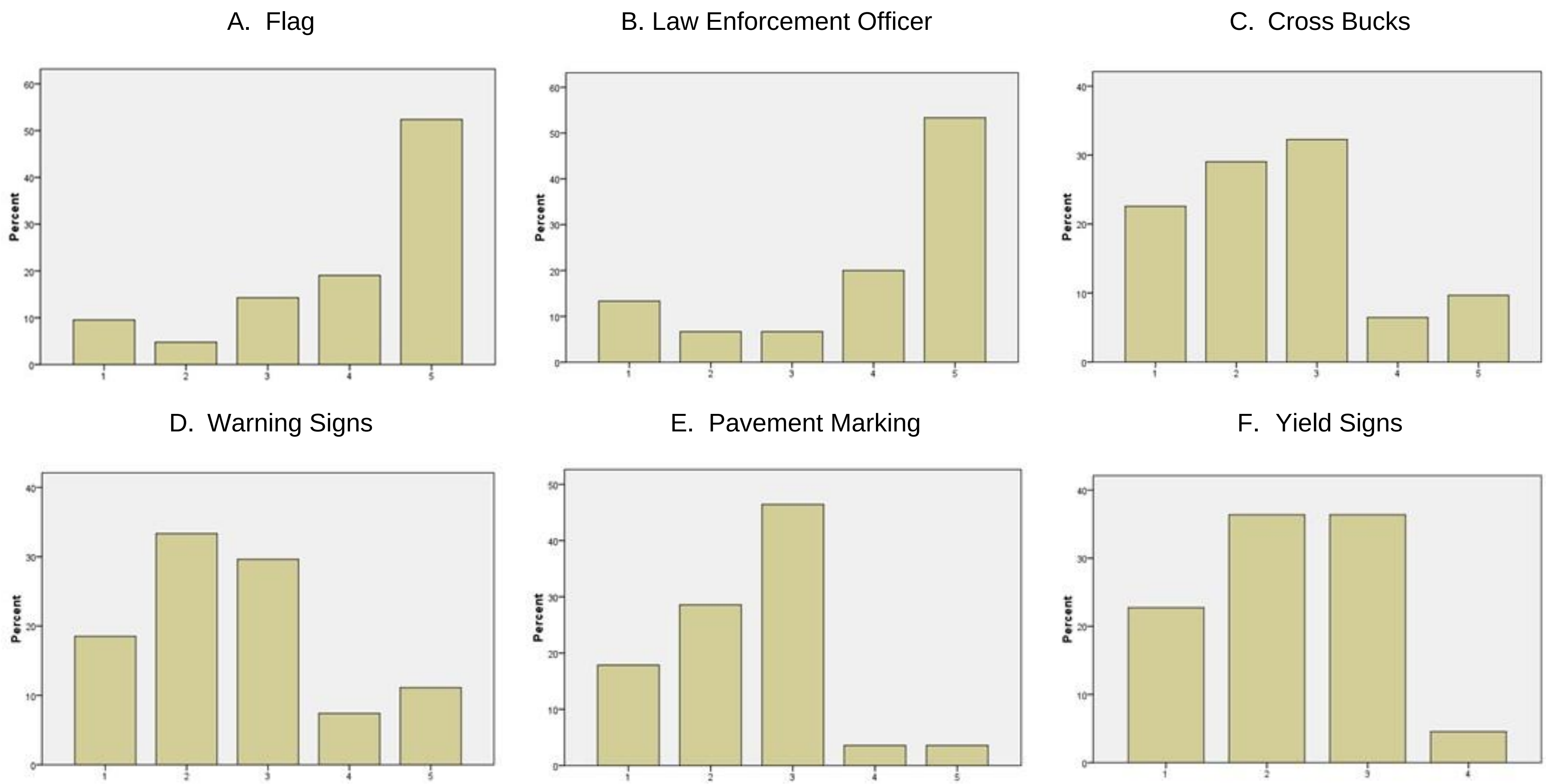
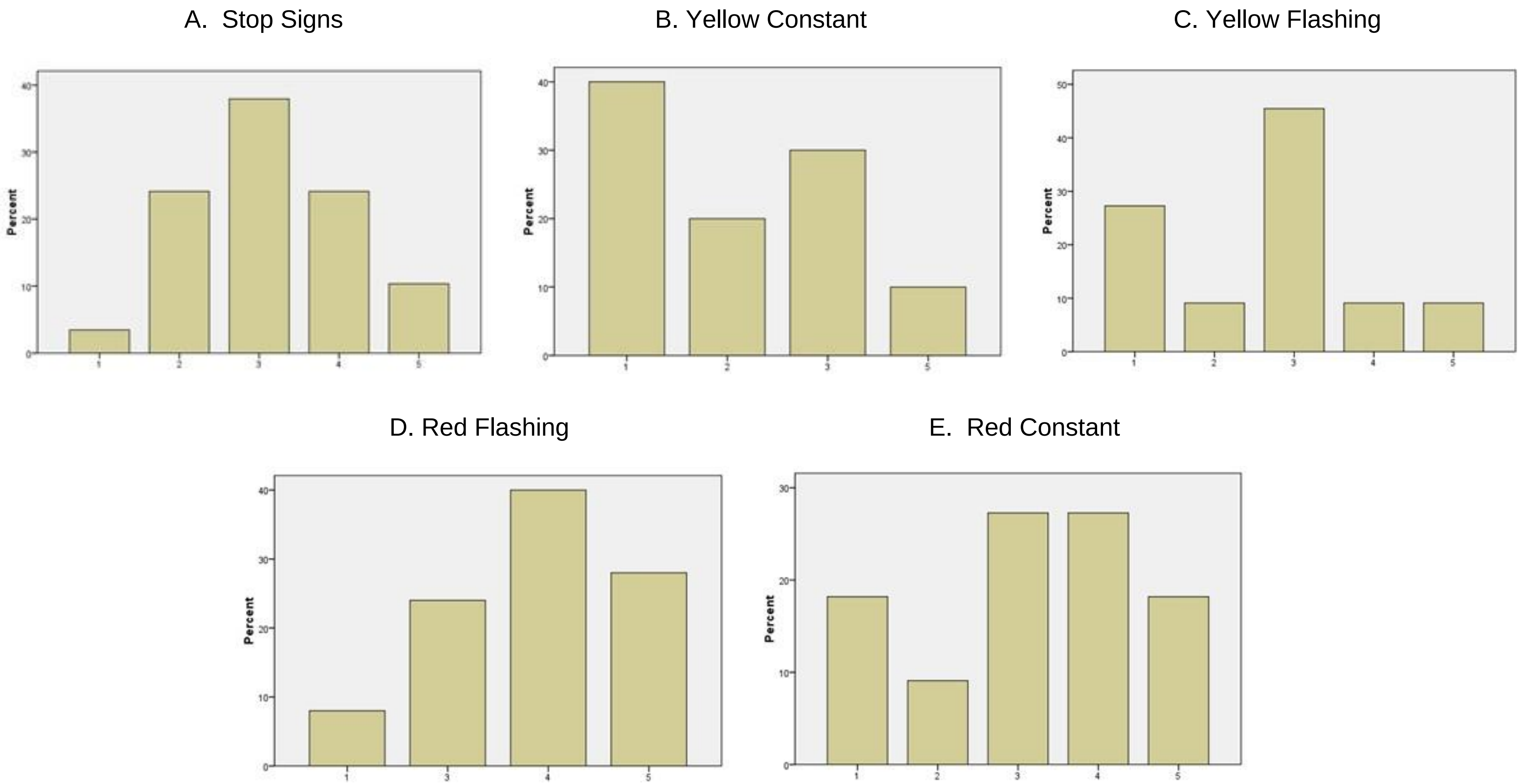


Figure 12. Effeciveness of signs and personnel presence



Fgiure 13. Effectiveness of red and yellow light

4.2.3 Crossing Inspection and Work Load

As demosntrated in Figure 14, the majority of states, 78 percent, are staffed with a small number of railroad crossing inspectors, between 1 to 5. Texas is the only state DOT that has more than 20 railroad crossing inspectors as it also has the most railroad and highway crossings. When the total number of crossings in each state is distributed among the total number of inspectors, as shown in Figure 15, each inspector is responsible for a very large number of crossings, ranging from more than 5000 crossings for each inspector in Ohio to about a few dozen or so in Rhode Island. The average number of crossings that an inspector is responsible for is more than 1000 crossings.

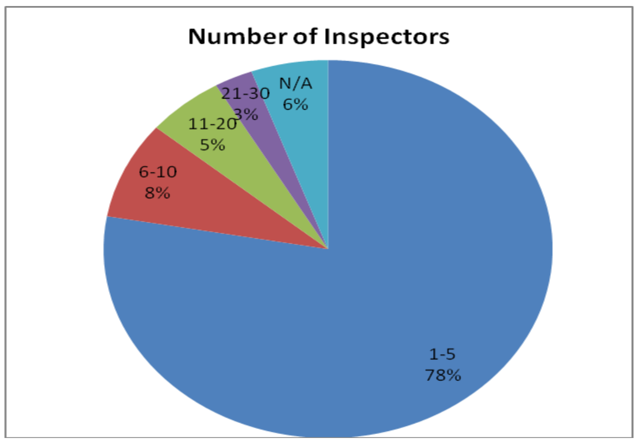


Figure 14. Distribution of inspectors

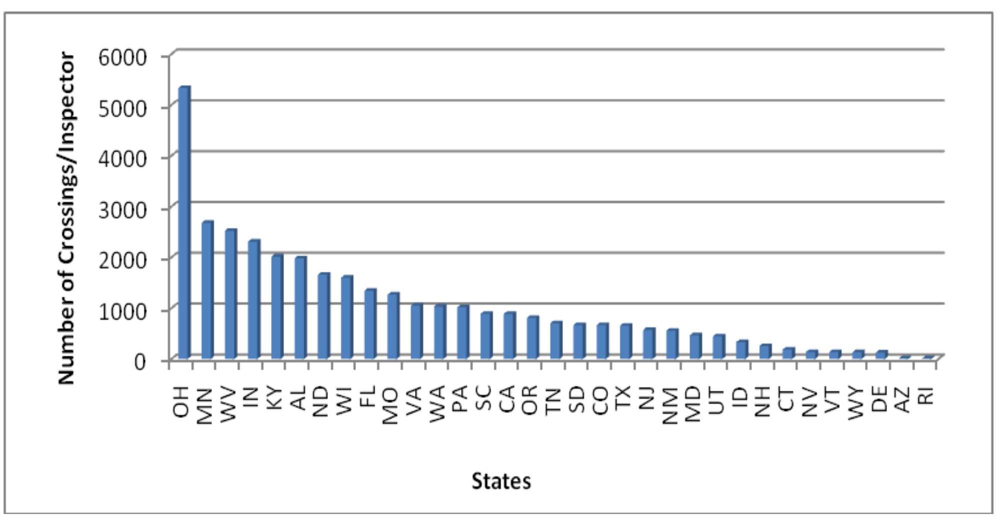


Figure 15. Average load for each inspector

As the work loads mount, the inspection cycle can get very long. As depicted in Figure 16, among all responding states, only a small portion, 15%, are able to complete the inspection cycle within one year. Slightly more than one quarter of them, 27%, can complete the inspection cycle within one to two years and another quarter of the states run the cycle more than five years. The highest portion of the inspection cycle is between three to four years.

In terms of grade crossing inspection procedures, as displayed in Figure 17, about two-thirds of the responding states use a typical checklist of railroad crossing inspections. A few respondents submitted their typical inspection lists, which are attached in Appendix 4.

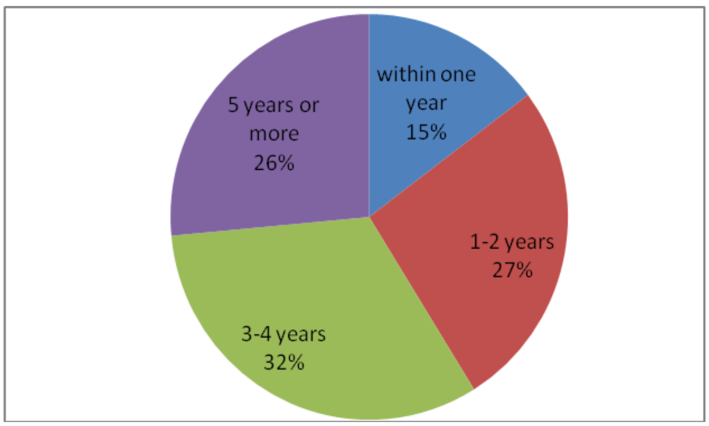


Figure 16. Average lengths of inspection cycles

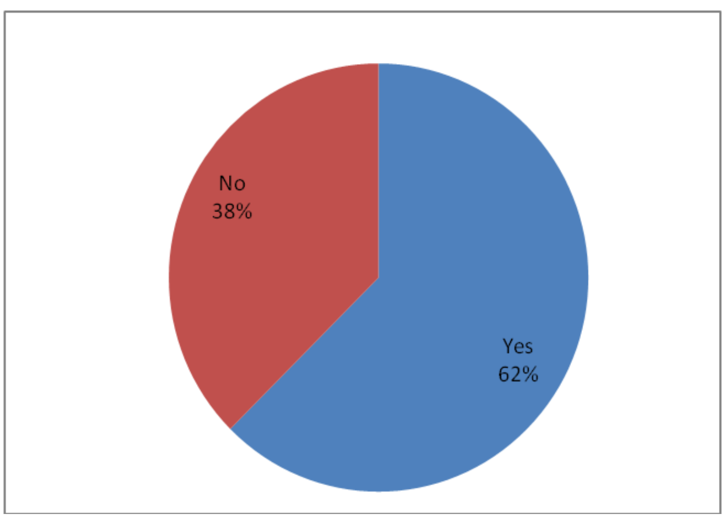


Figure 17. Agencies with and without typical inspection procedures

Gleaning from the few sample inspection sheets received, the research team gathered that the highway and railroad crossing inspection checklists are largely developed around the Program 130 in terms of variables covered and necessary data to be submitted to FRA. Section 130(g) is a statutory mandate that requires each State to submit an annual report to the USDOT Secretary on the progress being made to implement the railway-highway crossings program, the effectiveness of such improvements, an assessment of the costs of the various treatments employed, and subsequent crash experience at improved locations. Certain variables are common to most of the check lists, such as locations, types of control devices on sites, and general conditions of various features. Others, such as pictures of the site and vegetation coverage, are not all present throughout the samples, which are not usually fed to the FRA database but are helpful to improve the safety of railroad and highway crossings.

As highlighted by the survey responses and exhibited in Figure 18, a majority of the responding states examine the conditions of control devices, pavement marking status, and crossing surface grades. More than two-thirds of the responding states check the crossing angles, vegetation clearance and speed limits for both trains and automobiles. About half of the survey respondents document the width of the roadway and railroad right-of-way. Almost half of the responding agencies record the crossings' global position locations with latitude and longitude. A small group of states suggested additional features included in their inspection routine, such as approaching and track sight distances, sign locations, and sight distance obstructions.

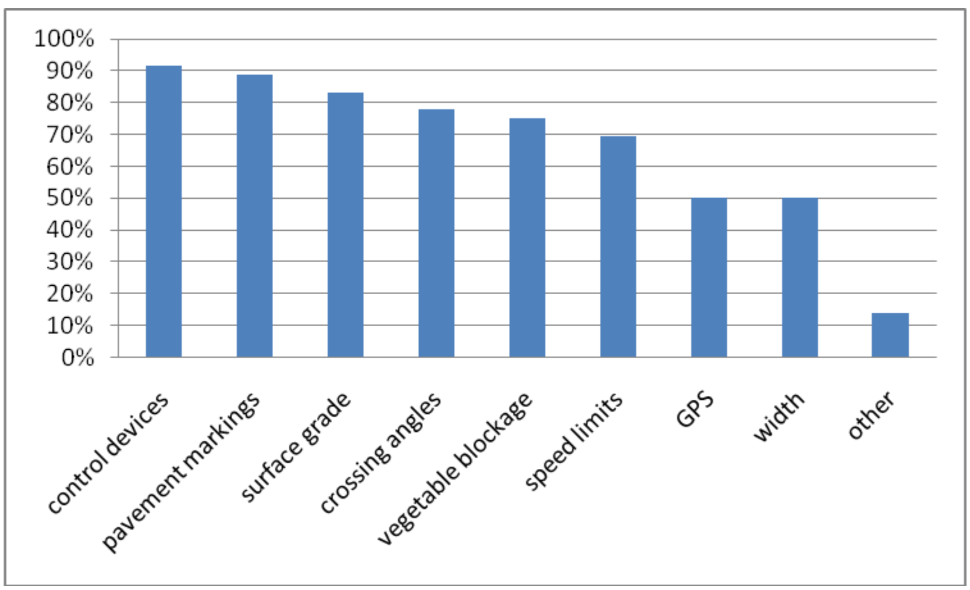


Figure 18. Inspected features at crossings

Among all the survey respondents, about two thirds of the states, 64%, have an overall rating system for each crossing while the rest the one-third do not, as depicted in Figure 19. The general principle for overall ratings of the crossings may be categorized into the following groups:

- Simple rating based on surface conditions;
- Direct applications of FRA formula or hazard index; (see below)
- Stated modified procedures based on the FRA formula;
- Evaluation of particular studies.

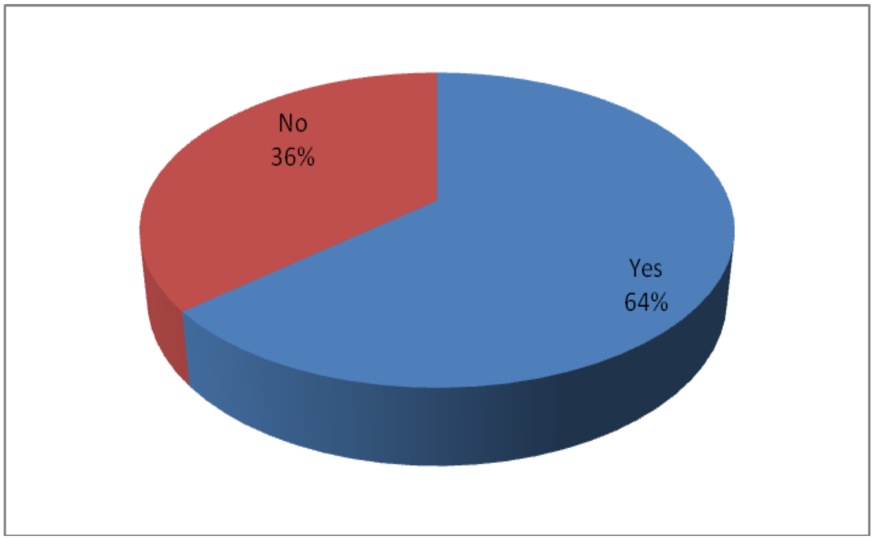


Figure 19. Overall rating for crossings

While only one state with a very small number of crossings has conducted their own study evaluations, the majority of the responding states choose to implement the FRA formula or the Hazard Index, which is defined the following formula:

$$HI = (V)*(T)*(Pt)$$

Where:

HI = Hazard Index;
V = annual average daily traffic;
T = average daily train traffic;
Pt = Protection factor, for example:
0.1 for automatic gates;
0.6 for flashing lights;
1.0 for signs only.

4.2.4 Practices in Vegetation Clearance

As stated earlier, one of the objectives of this study was to identify best practices used by other peer agencies in maintaining the sight distance triangle, especially clearing the vegetation blockage at crossing locations. As shown in Figure 20, two states, Indiana and Wisconsin, use fixed numbers. A state law in Wisconsin defines “330 feet from the crossing along the highway and along the railroad” as the safety sight distance, but Indiana does not mention the particular number they are using. More than half of the state agencies estimate the stopping sight distance using the operating speed and the geometry of the crossings. After examining the rest of the “other” category, researchers found that most of the agencies belong to the same category to “estimate using operation and geometric characteristics” as by the Railroad/Highway Grade Crossing handbook. The MUTCD formula and Hazard Index models all use the general principles of stop sight distances based on speed and geometry.

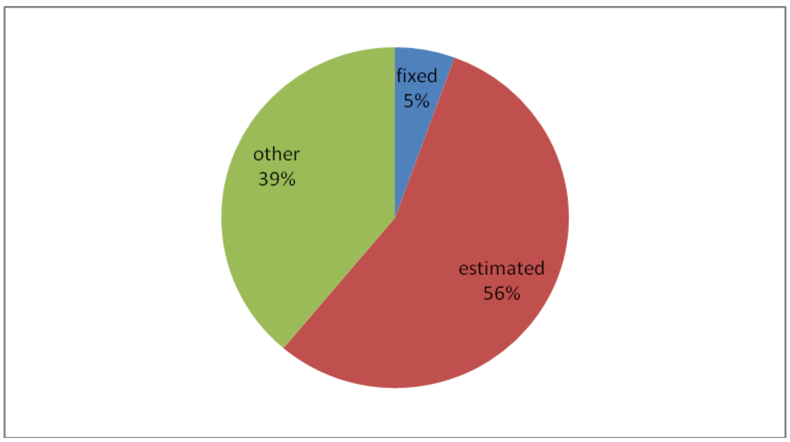


Figure 20. How stopping sight distance was determined

The second question related to the stopping sight distance is directly on the practice in maintaining vegetation clearance within sight distance triangles. As shown in Figure 21, about two-thirds of the state inspectors estimate the clearance of sight distances in the field while about one quarter of the states actually measure the distances using rollers. Less than one fifth, 17%, of the states use conventional survey methods to measure the sight distance and vegetation clearance, and only two states, Colorado and Wisconsin, use a Google map to estimate the vegetation coverage. Among the 20 percent or so state agencies that marked “other” approaches, the most prevalent answer is to identify the parties who are responsible for the vegetation clearance or enforcement of safety sight distances. The parties include local government and railroad companies.

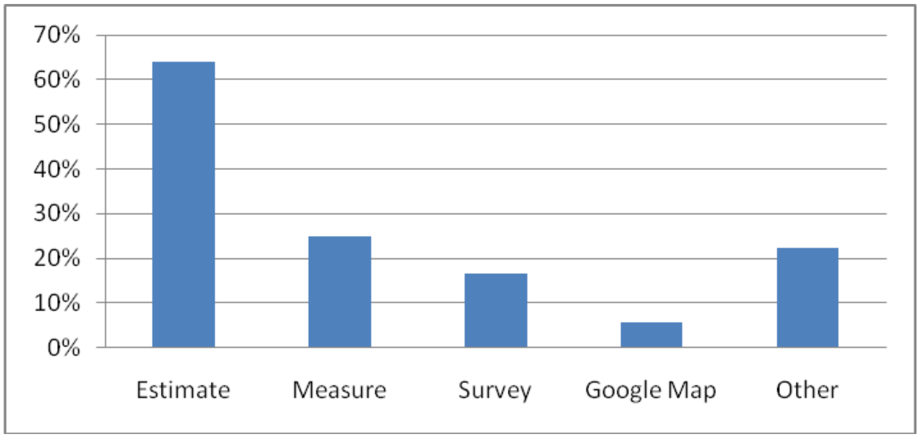


Figure 21. Practices in maintaining vegetation clearance

When asked about the effectiveness of the practices used by various agencies, conventional survey approaches and measuring with rollers were rated the highest, an average 4.4 and 4.2 out of 5 and Google mapping the lowest, 2 out of 5, as depicted in Figure 22.

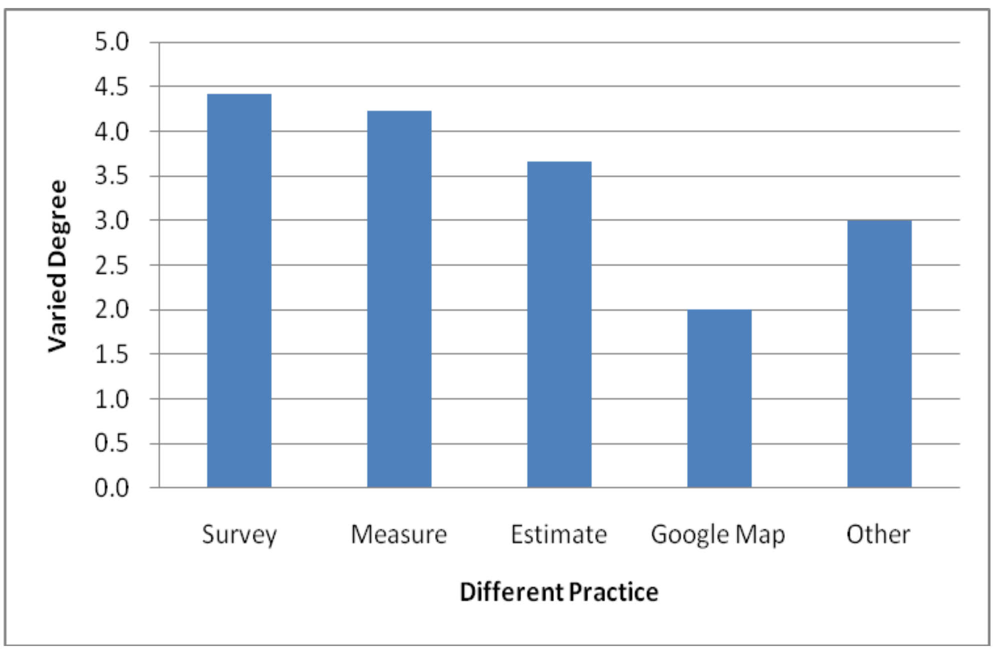


Figure 22. Effectiveness of various approaches

When it comes to the responsibility of maintaining the vegetation clearance, the answers are quite diverse. As shown in Figure 23, the railroad is the largest entity to cover the expenses of maintaining the vegetation clearance around railroad and highway crossings. The basic assumption is that most vegetation blockage appears along the railroad right-of-way. The second largest group who foots the vegetation clearance bill is the local governments. State Department of Transportation covers about one quarter of the vegetation clearance cost when the vegetation blockage originated from the right-of-way of state roads. When the vegetation blockage occurs on private property owners or other entities, which are less than ten percent, the financial responsibility may fall on the shoulders of private property owners. In some of these cases, there are difficulties in enforcement of the vegetation clearance due to lack of jurisdiction or statutory power.

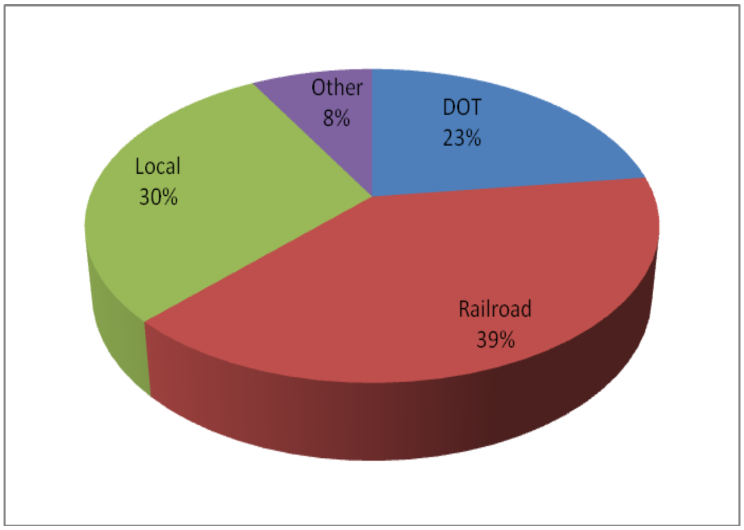


Figure 23. Cost allocation of vegetation clearance

Connected with the financial responsibility of vegetation blockage clearance, there came the task of physically maintaining the vegetation clearance within the safety stopping distance triangles. As seen in Figure 24, the general proportions are very similar to those of financial distributions but slightly different. They reflect the arrangement among various railroads, local governments, and state DOTs. During detailed interviews, the research team found that certain DOTs have worked with private railroads to maintain the vegetation clearance when it is convenient for the highway maintenance crew to carry out the field work. The railroad entity would receive an invoice for the services rendered by the DOT crew. In these arrangements, it is efficient for the state DOT to carry out the physical activity and invoice the private railroad when there are isolated crossing locations spread along stretches of state highways. It was also possible for the railroad crew to clean up the vegetation blockage located within the right-of-way of state highway and invoice the DOT accordingly.

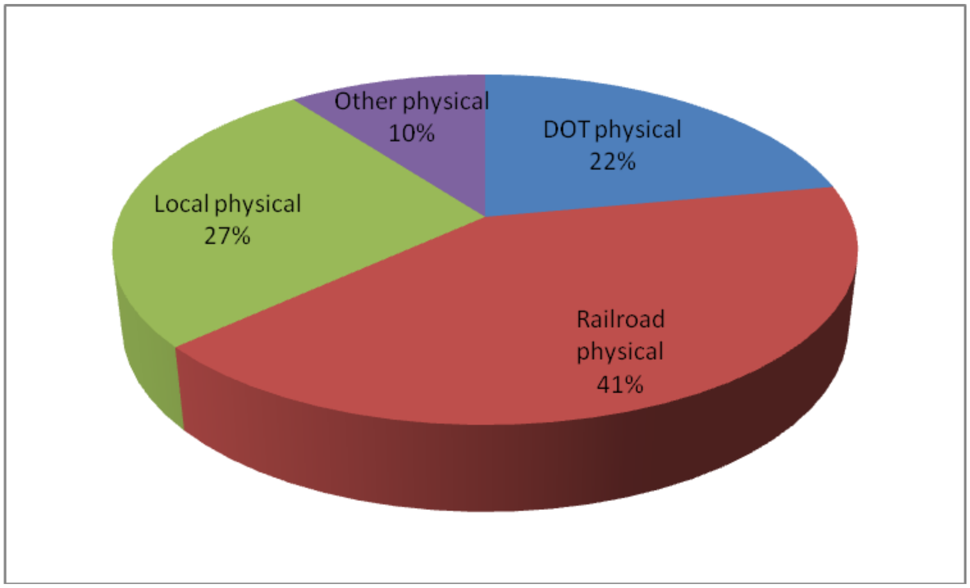


Figure 24. Distribution of physical maintenance

4.2.5 <u>"Operation Lifesaver" Program</u>

"Operation Lifesaver" is a non-profit, international, public education program first established in 1972 to end collisions, deaths and injuries at highway-rail grade crossings and on railroad rights-of-way (Operation Lifesaver, 2010). The programs are supported by a wide variety of partners, including federal, state, and local government agencies, highway safety organizations, law enforcement, the nation's railroads and their suppliers. Operation Lifesaver's trained and certified volunteer speakers to provide free safety presentations for people of all professions and age groups to help them make safe decisions around tracks and trains.

All survey respondents have participated in the "Operation Lifesaver" program and have rated the effectiveness of the program on various aspects. As shown in Figure 25, the average perception of "Operation Lifesaver" is very positive. The highest benefit of "Operation Lifesaver" lies in the area of educating drivers. The second highest rating is to reduce accidents, followed by identifying problem locations for the diagnostic team. Other associated benefits of operation lifesaver include creating opportunities for collaboration among DOTs, MPOs and DMV departments.

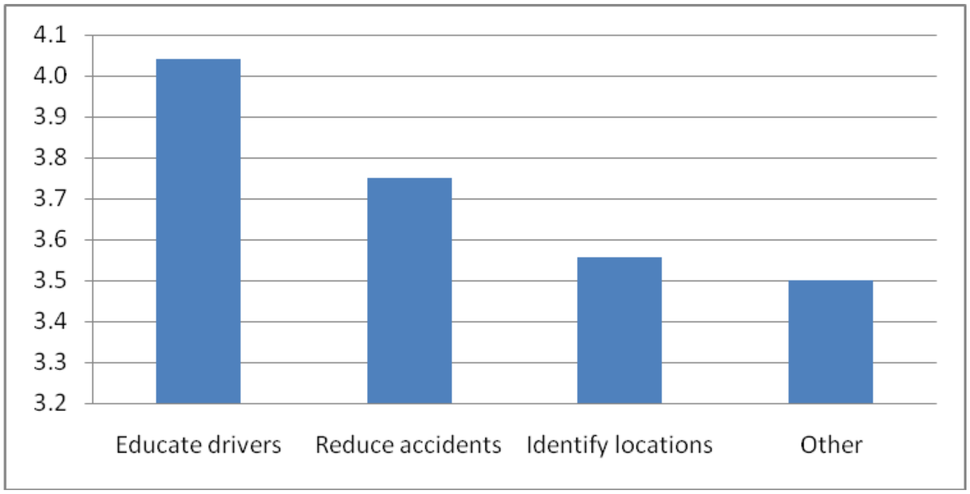


Figure 25. Evaluation of "operation lifesaver" programs

4.3 Critical Issues Revealed by the Survey

As stated earlier, the main objective of this task was to survey peer state agencies to identify best practices and optimal approaches to improve the railroad crossing safety, especially those passively controlled locations. The research team not only focused on the multiple choice questions selected but also sought in-depth dialogs with key persons during the survey so that the unique and complete process of vegetation blockage identification, and clearance and maintenance practices is preserved and presented. Through detailed review and analysis of peer state agencies' practices, the research team has gleaned useful information and uncovered some key issues in improving railroad and highway crossing safety.

4.3.1 <u>Information Timeliness</u>

One particularly frustrating issue the research team experienced in the early stages of the survey was to validate the data from different sources. As presented earlier, the survey instrument included the total number of railroad crossings, private and public distributions, and passive and actively controlled portions as a way to identify valid responses as the statistics are easily obtainable from the FRA website. However, the responses, mainly the discrepancies between the individual state responses and the summaries in the FRA database have certainly brought large surprises. While it was anticipated that a small portion of the responses may be different due to rounding, it was totally unexpected that almost none of the state responses matched the FRA statistics exactly.

Further exploration revealed that except for a few states that have only listed crossings under their jurisdiction, i.e. public crossings, the majority of the responding states reported the current status, but the FRA database is behind in data update. A brief conversation with Ron Ries, the Director of Railroad Crossing Safety, FRA, confirmed that there are no hard deadlines for the state DOTs to update their crossing information. The main reason is that because most of the state DOTs are constrained in railroad inspection resources, it is impossible to enforce an annual or biennial update of the information. Mr. Ries hopes that the newly enacted "Railroad Safety Improvement Act (2008)" will provide much needed resources and a mandate to update the FRA railroad crossing data.

4.3.2 Shared Responsibilities

Another issue associated with railroad and highway crossing safety is the clear identification of shared responsibilities. Crossings, where both highways and railroads intersect, have inherent complications when highways are usually owned and maintained by the state and the railroads by private companies. A small number of states, such as Wisconsin, have relied on state regulations to identify the responsible parties and enforce the clearance of vegetation and other blockage to the safety triangle at highway and railroad crossings.

Quite a few states have not worked out any arrangement, so the vegetation clearance at highway and railroad crossings is often disputed and difficult to enforce. Another group of states, with Georgia as an example, actually worked out their own arrangement with railroad companies, local municipalities, and private property owners to carry out the physical maintenance of safety triangles and financial burdens. Their basic practice is to have one party, either the railroad or the state DOT, mow the lawns or cut the branches of trees that block the sight lines of crossings; the responsible party will pay the expenses so, for example, the overlap of multiple parties dispatching crews to the same location to clear vegetation will cease.

4.3.3 Financial Resources

As presented in the last section, the number of inspectors in state DOTs is usually much smaller than the actual need to carry out adequate annual or biennial inspection cycles. The financial or labor constraints are the main cause for the incomplete information sources and inadequate or extremely long inspection cycles.

The Railroad Safety Improvement Act enacted in 2008 calls for biennial updates of highway and railroad crossing data while our survey indicated that only less than half, 43%, of responding states can complete the inspection cycle within two years. About one quarter of the states need five or more years. The largest group fell in the three to five year range. To meet the mandate by the new legislation, a few approaches are needed:

1. Dramatic improvement in inspection procedures and techniques
2. Increase of inspectors in the field
3. Reduction of the number of crossings.

The number of crossings in each state is largely dictated by the railroad and highway network and maybe difficult to reduce. It may also be hard to increase crossing inspectors under the current economic conditions. Therefore, it leaves the first approach, improving inspection procedures and techniques so a large number of problem free crossings maybe identified in the office via virtue maps while the limited crew may be dispatched to crossings that may have potential blockage issues and identify solutions.

4.3.4 Adequate Guidelines

In connection with the idea of improving inspection procedures and techniques, an adequate guideline in terms of data collection, processing and submission might be helpful for state agencies and the federal government. As seen from various state responses, a good portion, 38%, of the states do not even have a standard inspection procedure or check list, which makes it difficult to keep track and to improve the inspection processes.

A general guideline or template should be developed to guide each state in inspecting highway and railroad crossings, conducting diagnostic meetings, and processing and maintaining crossing data.

5. BENCHMARKING CROSSING INSPECTIONS IN NEW JERSEY

Building on the results of earlier works, the research team has derived benchmarks for New Jersey in the areas of railroad crossing safety. With more than 1600 grade crossings in the state, improving grade crossing safety is an enormous challenge that will take the combined efforts of railroads, public safety officials, and the general public. The daily inspection, maintenance, and improvement of these critical areas around railroad crossings rest on the shoulders of a selected group of railroad engineers and safety officers in the New Jersey Department of Transportation (NJDOT).

In order to improve the safety of railroad crossings in New Jersey, it is important to benchmark the current status of railroad crossing inspection and safety improvement processes. Benchmarking is one of the effective approaches to compare the practices in New Jersey to those of the rest of the nation. Based on the survey conducted previously, the following sections provide a general description of highway and railroad crossings, the work load of railroad crossing inspectors, and the current status of crossing information collection, which is the baseline for further improvement solutions.

5.1 General Landscapes of Railroad Crossings in New Jersey

As one of the most densely developed states, New Jersey has a rather high number of crossings per square mile as shown in Figure 26, even though the total number of crossings is not the highest in the nation.

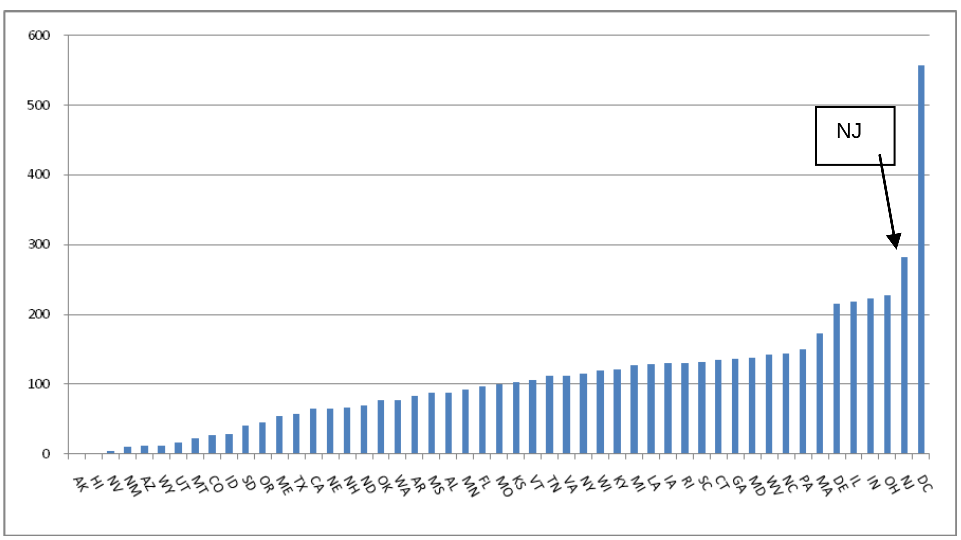
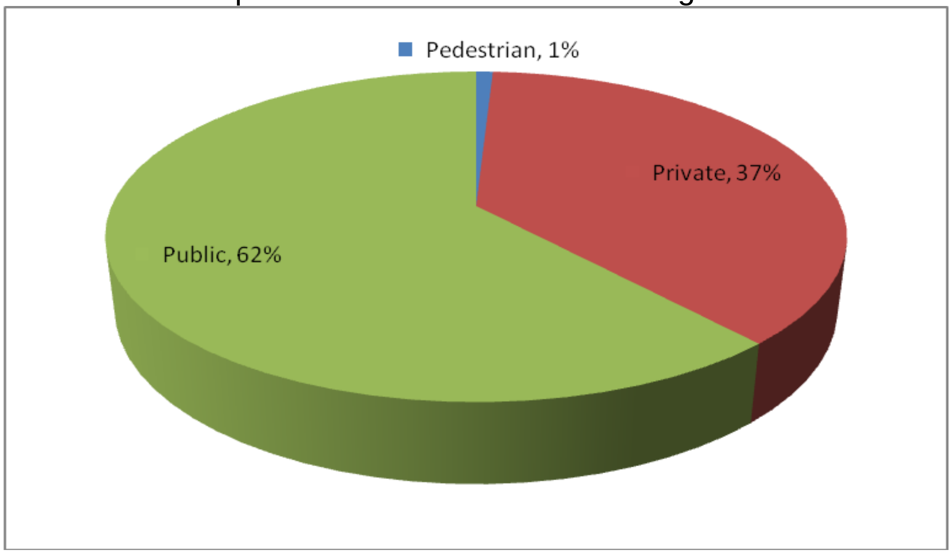


Figure 26. Number of crossings per thousand square miles by states

When zoomed into the particular types of crossings, such as public, private, or pedestrian, the proportion of the public crossings in New Jersey is higher than that of the national average as demonstrated in Figure 27. The share of pedestrian crossings in New Jersey, three percent, is also higher than the national average, one percent.

A. Ownership distribution of railroad crossings in the US



B. Ownership distribution of railroad crossings in New Jersey

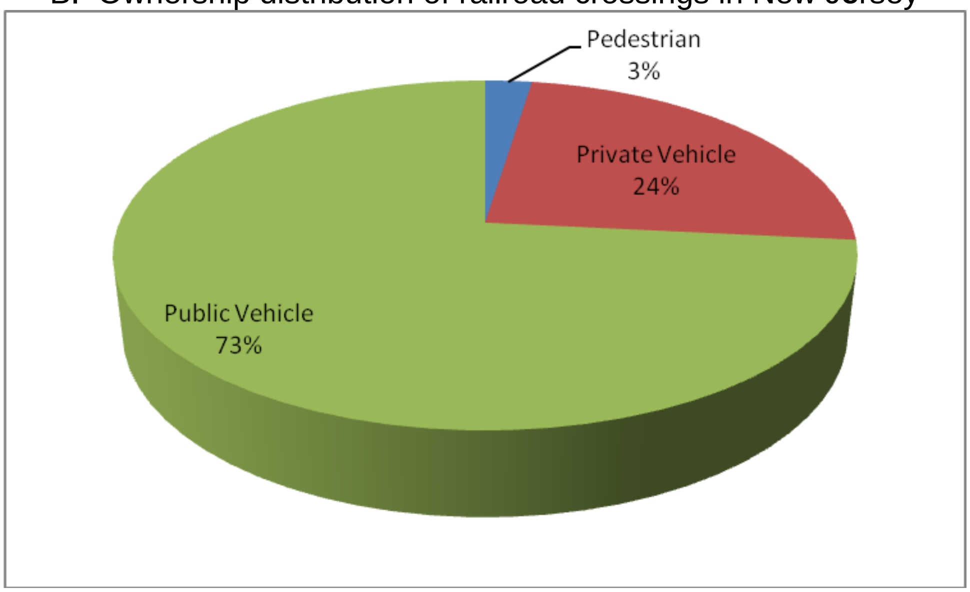


Figure 27. Ownership comparison

Source: FRA, 2009.

The types of control devices installed in New Jersey are generally similar to those around the nation but the proportion may be very different. As exhibited in Figure 28, the proportion of gated, with special warnings, and where highway traffic signals (HWTS), wigwag (WW) signs or bells are used, is identical to the national average. New Jersey has a larger share of flashing lights, 38%, than the national average of 16%. Its share of cross bucks is actually smaller, 19%, than the national average, 39%. Only about one percent of crossings in New Jersey use stop signs, while the national average is about four percent. The proportion of crossings without any control devices is almost twice that of the national average, four percent to two percent. While gates at crossings, four quad or regular, are generally classified as active control devices, this research focuses on passive controls, such as cross bucks, flashing lights and stop signs, which may require different safety sight distances.

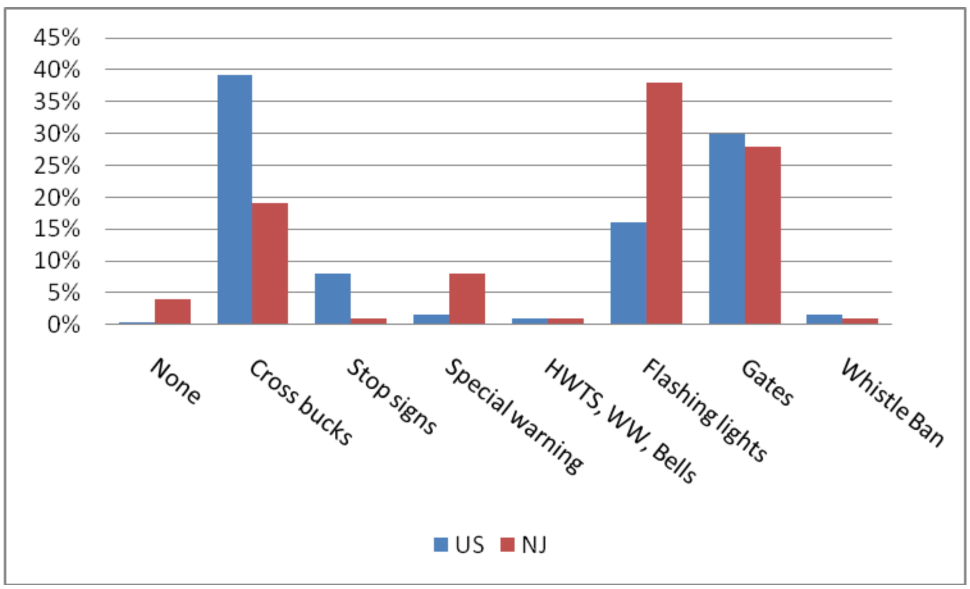


Figure 28. Types of control devices in the US and NJ

As documented by existing statistics and previous studies (FRA, 2009), the majority, about 85-90 percent, of grade crossing collisions and casualties occur at public crossings, since motor vehicle traffic is usually much higher at public than at private crossings. About half of the crossing accidents occur at the one third of the locations where only passive traffic control devices, such as cross bucks, are installed. The disproportionately high accident rate in these relatively lower volume locations begs for attention in order to ultimately improve overall safety around railroad crossings, which is the logic for this study: to focus on the public crossings with passive control devices.

As exhibited in Figure 29, the general trend of railroad highway crossing accidents is dropping nationwide. When compared to the national downward trend, the accident rates in New Jersey fluctuate even though the general trend is going down. A recent spike in the total number of accidents since 2000 deserves a closer examination. The highest accident category in New Jersey includes automobiles, truck trailers and other vehicles, which highlights the importance of highway-rail crossing locations.

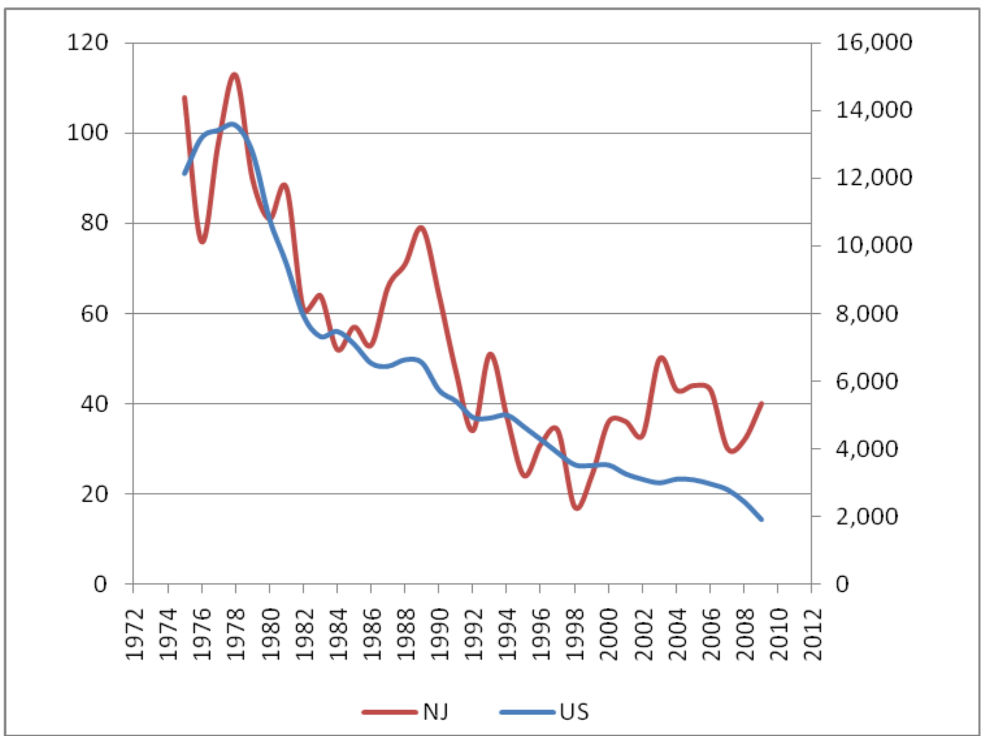


Figure 29. General trends of railroad crossing accidents in the US and NJ

Source: FRA, 2009

Another unique characteristic of railroad and highway crossings in New Jersey is its diversity of interacting railroad infrastructure. As documented in Figure 30, while only about 55 percent of surveyed states interact with passenger transit rails and 70 percent with regional railroads, New Jersey interacts with every rail category, which includes local, regional, Class I, AMTRAK, and passenger transit rails.

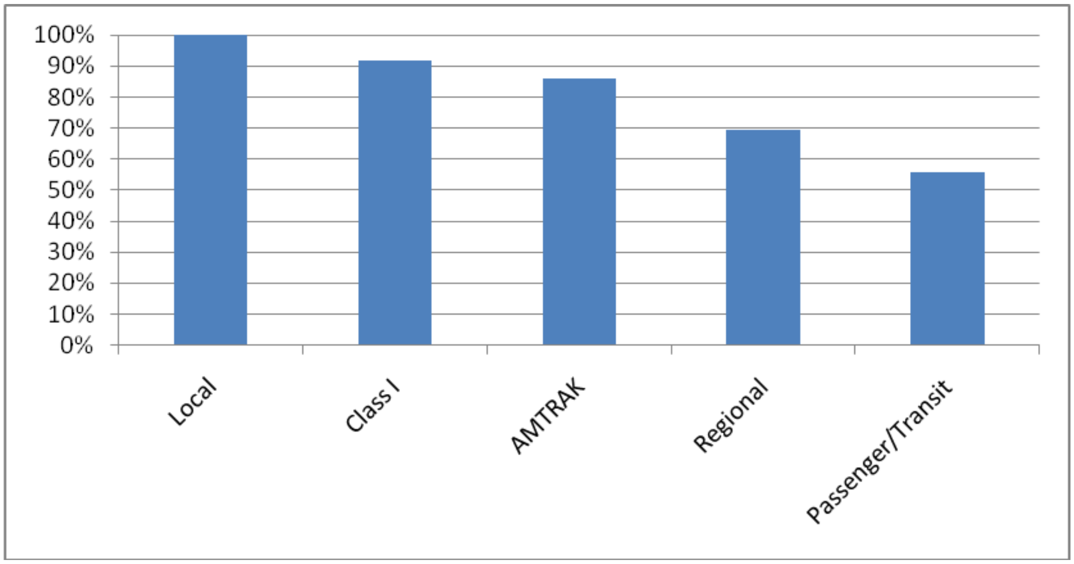


Figure 30. Types of railroad interacting with highways by surveyed states

5.2 Crossing Inspection Practices

All railroads operating within the State of New Jersey supposed to maintain their right-of-way at or around any crossing of a public road or highway free from grass, trees, bushes, shrubs, or other growing vegetation which obstructs the view of pedestrians and drivers, even though there is no statutory language. Ideally, a clearance triangle, which will be explained later, should be maintained at all highway-rail crossings at all times. Affected by severe budget constraints, some railroad crossing divisions within DOT simply do not have enough inspectors or engineers to inspect and maintain the vegetation clearance under traditional methods. As reported by the railroad engineers in New Jersey (Liu, 2010) New Jersey’s three field inspectors take at least two years to complete the inspection cycle of more than 1600 railroad crossings in New Jersey.

As part of the peer state agency survey, the research team has collected data on the total number of crossing inspectors and derived the average workload of each inspector. New Jersey DOT Railroad Safety Division with three full time railroad crossing inspectors has a similar size to that of most survey respondents; that is, 78 percent of all responding states have 1-5 inspectors. The average workload for crossing inspectors in New Jersey ranks at 22 out of the 38 responding states. Averaging more than 500 crossings per inspector, it is 46 times of the lightest load, 12 crossings per inspector in Rhode Island, and one ninth of the heaviest load, more than 5000 per inspector in Ohio. A note of caution is that the survey questionnaire asked for the number of inspectors in a range, such as between 1-5 or 6-10. When calculating the average load, the medium number was used, which may create some discrepancies from the actual number of inspectors in the state. The positive impact is that New Jersey is still placed in the group that can finish the inspection cycle within two years as shown in Figure 31.

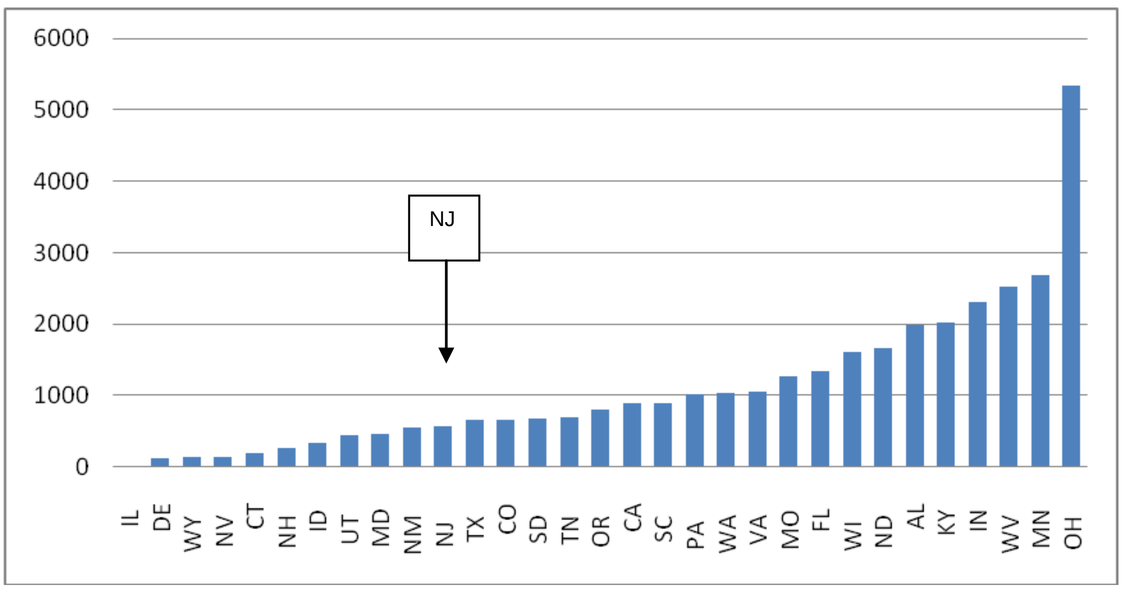


Figure 31. Average working load for each inspector by surveyed states

Another important piece of information the survey has acquired is a typical inspection check list, if the responding state uses it. As documented in the survey results, more than 60% of the responding states use a typical check list for railroad crossing inspections; a few them have sent the sample of their inspection sheet. When compared to the check lists used by other states, the research team noted that the inspection records used in New Jersey, attached in Appendix 4, include general information on crossing locations, control devices, and inspection results. The research team was informed that New Jersey DOT is in the process of moving the crossing inspection record into a new database system, which will include some additional features, such as digital photographs and computer aided design (CAD) drawings for each location.

5.3 Evaluation of Control Devices

As documented earlier, one of the objectives of this study is to identify potential solutions or best practices implemented by other entities so New Jersey does not have to reinvent the wheel. The survey results provided a general evaluation of control devices used by peer agencies in the US and their effectiveness, which is useful when compared to those implemented or proposed in New Jersey. It is also the foundation for the research team to build upon in order to derive the most effective and efficient solutions for New Jersey.

As reported earlier, New Jersey has used most of the passive control devices to various degrees in different locations. As shown in Figure 32, the ratings are higher in New Jersey for law enforcement officers and cross bucks while warning signs, yielding signs, and pavement markings are significantly lower than the national average ranking. The rest are almost identical.

Similar to the measures of passive control devices, the survey also collected information on the effectiveness of various approaches used to identify the safety sight distances around railroad and highway crossings. While most states have used the conventional survey, measure, or estimate approaches, a few states have used modern imaging data, such as Google mapping, to aid their verification or confirmation process. The ratings of various approaches are almost identical when comparing New Jersey to the national average, as exhibited in Figure 33.

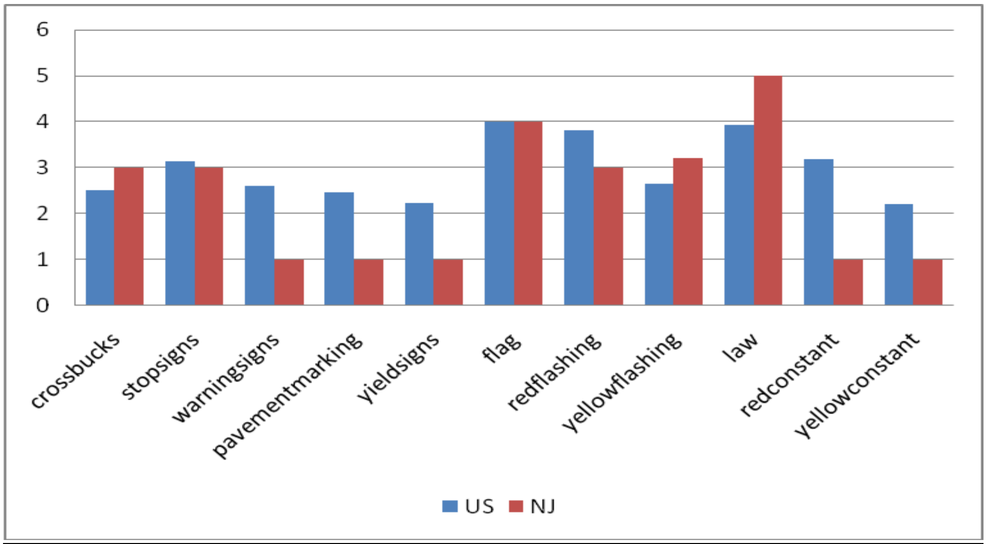


Figure 32. Rating comparison of passive control devices

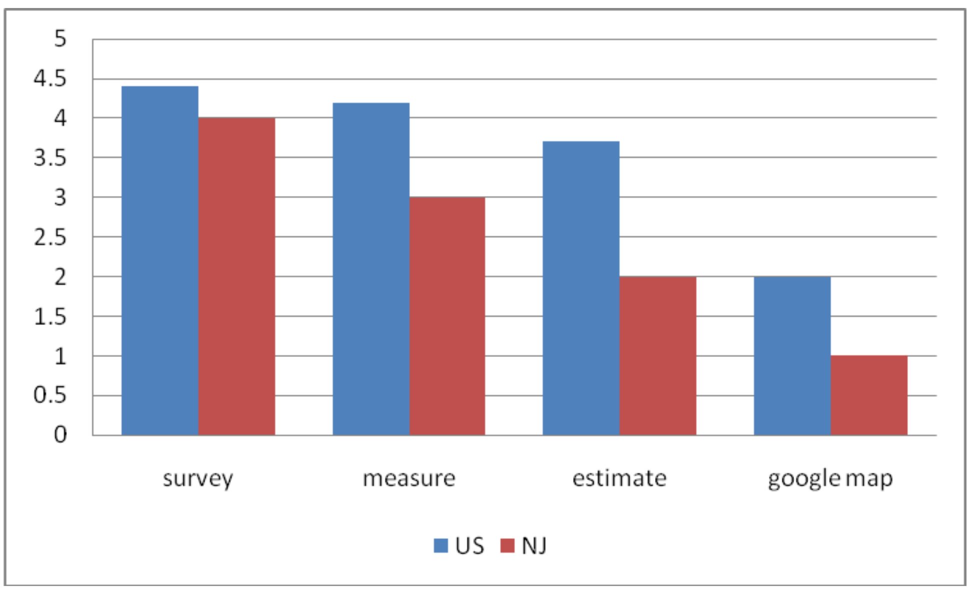


Figure 33. Effectiveness of safety sight distance identification processes

As shown above, the number of railroad crossings in New Jersey is very much in line with peer states. The total number of crossings is in the middle rank while the density of crossings in a unit area is fairly high, which brings certain challenges to maintain crossing safety. New Jersey has used almost all of the crossing control devices, even though some of these have higher proportions, such as flashing lights and special warning signs, while others have a lower percentage, such as cross bucks and stop signs, when compared to peer states.

The brief summary of railroad and highway crossing inspection practices in New Jersey and comparison with peer states provides a baseline for the research team to explore solutions that have potential to improve the railroad crossing safety, reduce cost, or increase efficiency, which will be addressed in the next section.

6. VEGETATION CLEARANCE IDENTIFICATION AT RAILROAD HIGHWAY CROSSINGS

Previous studies may have identified a few approaches or a combination of approaches used in identifying vegetation blockage to the safety sight triangle at railroad highway crossing locations. The survey results indicated no consensus or commonly accepted practices. The research team has focused on the photogrammetric and survey approaches and tried to combine them as a two-stage process: to identify vegetation blockage at crossing locations and improve railroad crossing safety.

6.1 Conceptual Framework

As understood in the beginning of this study, there are two important decisions that a driver must make on approaching a grade crossing. First does the driver have sufficient visibility of the crossing and/or approaching train in order to stop safely short of crossing? Second, does the driver have sufficient visibility of approaching trains in order for him or her to proceed safely over the crossing? More specifically, as illustrated in Figure 1, does the driver at point A has adequate time to stop his or her vehicle?

The distance travelled along the highway includes reaction time, braking time, and distance between the driver and the railroad track after the vehicle is stopped. This distance may be computed by:

$$D_t = D_p + D_b + D_c \qquad [1]$$

Where:

D_t = total distance for the crossing
D_p = distance traveled during thinking, reacting time
D_b = distance traveled during braking
D_c = final clearance between driver's eyes and the crossing

In the second scenario, a driver at a point A must be able to see along the track a sufficient distance to allow him or her to make a decision as to whether or not the driver can proceed safely over the crossing. The time required for the vehicle at point A to safely proceed may be calculated by:

$$T_p = (D_t + D_v)/1.47V \qquad [2]$$

Where:

T_p= time required for a highway vehicle to safely proceed
V= speed of highway vehicle in miles per hour
D_v= additional distance required for vehicle to clear to opposite side of tracks

The two distances, one measured on the railroad and the other on the highway, define the “visibility triangle” as shown in Figure 1. Table 3 provides distances for defining the visibility triangle for selected highway vehicle and train speeds. Where actuated protective devices are not available, such as a passive controlled crossing, it is recommended that the visibility triangle in each quadrant of the crossing be clear of sight obstructions. Sight obstruction may be caused by vegetation, street furniture or structures.

Table 3 - Stopping sight distance

Metric					US Customary				
			Stopping sight distance					Stopping sight distance	
Design speed (km/h)	Brake reaction distance (m)	Braking distance on level (m)	Calculated (m)	Design (m)	Design speed (mph)	Brake reaction distance (ft)	Braking distance on level (ft)	Calculated (ft)	Design (ft)
20	13.9	4.6	18.5	20	15	55.1	21.6	76.7	80
30	20.9	10.3	31.2	35	20	73.5	38.4	111.9	115
40	27.8	18.4	46.2	50	25	91.9	60.0	151.9	155
50	34.8	28.7	63.5	65	30	110.3	86.4	196.7	200
60	41.7	41.3	83.0	85	35	128.6	117.6	246.2	250
70	48.7	56.2	104.9	105	40	147.0	153.6	300.6	305
80	55.6	73.4	129.0	130	45	165.4	194.4	359.8	360
90	62.6	92.9	155.5	160	50	183.8	240.0	423.8	425
100	69.5	114.7	184.2	185	55	202.1	290.3	492.4	495
110	76.5	138.8	215.3	220	60	220.5	345.5	566.0	570
120	83.4	165.2	248.6	250	65	238.9	405.5	644.4	645
130	90.4	193.8	284.2	285	70	257.3	470.3	727.6	730
					75	275.6	539.9	815.5	820
					80	294.0	614.3	908.3	910

Note: Brake reaction distance predicated on a time of 2.5 s; deceleration rate of 3.4 m/s^2 [11.2 ft/s^2] used to determine calculated sight distance.

Source: Garber and Hoel, 2008.

Both Figure 1 and Table 3 illustrate the ranges of a visibility triangle when the travel speeds of both highway vehicle and railroad trains are known. Further variation in crossing angles and vertical and horizontal profiles of the roadway and railroad may add complexity to the visibility triangle. In general, each crossing location has its own distinctive, unique visibility triangle in each quadrant.

The railroad crossing database maintained by the NJDOT will play a significant role in demonstrating the “visibility triangle”. As mentioned earlier, the Railroad Safety Division of NJDOT is in the process of moving the crossing database into a new platform. Once completed, the database will have the capability of including the geometry of each crossing location, visibility triangles, and some field photographs. The research team will explore and develop vegetation clearance approaches based on the assumption that the NJDOT RR crossing database will provide sufficient data for the visibility triangle at railroad crossing locations. The field inspectors shall follow the visibility triangle to delineate the vegetation blockage.

Our communication with the field inspector and site visits indicated that in most cases in New Jersey the computed safe distance for approaching vehicles at a railroad crossing is much longer than the actual ability to see the train traveling on the railroad. It means that it is almost impossible for some locations to define a full range of visibility triangles. What is possible is to determine the actual field of view of an approaching vehicle; in other words, the distance from the railroad track to a point on the road from which the approaching train can be visible. Assuming that the field of view is not obstructed and that the safe distances to the railroad crossing for an approaching vehicle and for an approaching train were determined, the geometry of a railroad crossing is depicted in Figure 34.

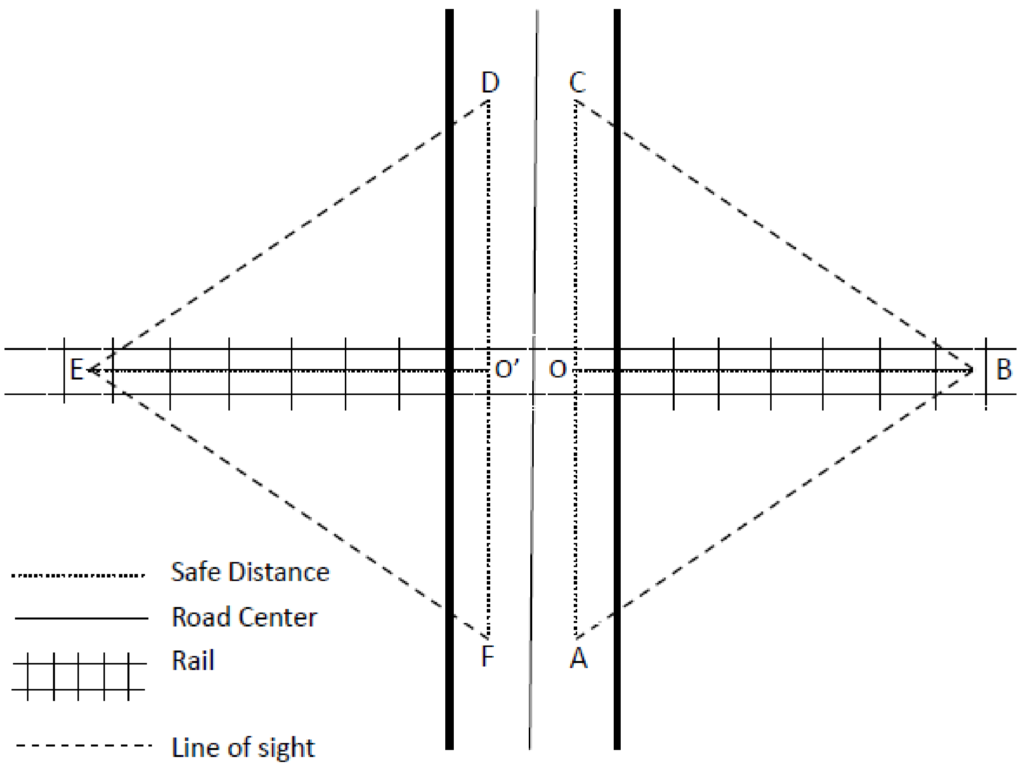


Figure 34. Geometry at a railroad crossing

The objective is to determine whether there are any obstacles inside the triangles AOB and EO'F. In other words the inspection objective is to determine if there are trees, bushes, shrubs, or other growing vegetation that obstruct the view of pedestrians and drivers. One possible solution to this problem is to establish at every railroad crossing the locations of points A, B, C, D, E and F. In most cases the locations of points C and F may not necessary because they are reached only after the vehicle has already crossed the intersection. Once these points are located in the field, an inspection is carried out to check whether there are any obstacles inside the triangles AOB and EO'F. However, it is neither practical nor safe to permanently mark these points on the roadway or on the railroad tracks. The objective of this task is to explore the potential of photogrammetric, survey, or combination of functions to delineate the visibility triangle, such as AOB and EO'F, and identify any obstacles inside these triangles.

6.2 Photogrammetric Solutions

As suggested in the proposal, one of the promising techniques in identifying safe sight distance is to use "Google Earth" images. Google Earth is a proprietary virtual globe program that maps the earth by superimposition of images obtained from satellite imagery, aerial photography, and Geographic Information System (GIS) 3D globe. It is available under three different licenses: Google Earth is a free version with limited functionality; Google Earth Pro, at $400 per year, includes additional features such as comprehensive geospatial data; and Google Earth Enterprise, at a starting price of $85,000 per year depending on services, is intended for commercial use and can be customized for various functions. As explained by a Google representative, the difference among the three Google versions is not the image quality or update frequency but a couple of additional features such as "GIS Date & Spreadsheet Import", "Radius & Area Measurements", and certain Application Programming Interface (API) support.

Similar to "Google Earth," a few other virtual imaging packages, such as "Bing Map" by Microsoft and "Yahoo Map" by Yahoo Inc.; have also occupied portions of the user market. The research team has communicated with a large number of vendors who provide data or service to these platforms, to explore and verify the capability of photogrammetric or orthophotography in order to evaluate their potential as media to evaluate the vegetation blockage at railroad crossings in New Jersey.

"Google Earth," "Bing Maps," and "Yahoo Maps" are some of the largest and most popular web mapping service providers. After a quick scan and evaluation of all existing packages, the research team decided to focus on "Google Earth" and "Bing Maps" due to their superior quality of images.

"Google Earth," a free version accessible from the internet via a PC, provides sky modes, street views, and various zoom levels. Most land areas are covered in satellite imagery with a resolution of about 15 meters per pixel (MPP), which is far too coarse for the purpose of vegetation identification. However, some population centers are also covered by aircraft imagery, i.e., orthophotography, with several pixels per meter, which is sufficient for the identification of vegetation blockages and has the potential to meet the objectives of this research.

"Street views" displays images taken from a fleet of special cars. It provides panoramic views along various streets and was thought to be an ideal solution due to its high resolution. Further exploration discovered that no GIS coordination or location measure is incorporated in the street view so it is impossible to delineate the boundary of vegetation blockage except with a visual cue. Furthermore, the location of the street view images are random but most are located in populated areas, which may or may not correspond with railroad crossing locations. It is concluded that the “street view” feature from Google Earth has limited value to the identification of vegetation blockage at railroad crossings.

Google periodically updates map data, but these updates do not occur on a set schedule. Also it is noted that the image sets are stitched together regardless of the times of various parcels; therefore, updates to the photographic database can occasionally be noticed when drastic changes take place in the appearance of the landscape. For example, the updates for New Orleans following Hurricane Katrina are incomplete in Google Earth, and place marks may shift unexpectedly when the images are stitched together incorrectly.

“Bing Maps” has similar features to those in Google Earth except a special feature called “Bird’s Eye View”. The Bird’s Eye aerial photos provide a different perspective and higher resolution than conventional satellite images, and may have potential to meet the requirement of vegetation blockage identification for this task. A simple table, as shown in Table 4, compares the different features of Google Earth and Bing Maps. Both packages provide image resolution in the range of 15 meters per pixel but may be up to 0.15 M/Pixel, which is sufficient to identify vegetation blockage when available. Google Earth provides the historical cross-sections of the same location at various times and makes the date of images available while Bing Maps does not provide the date of the images. Google Earth promises that the images are no more than three years old while the ages of Bing Maps images may vary a great deal. Neither provides update inquiry services but both provide “street view” images.

Table 4 - Comparative features

Features		Google Earth	Bing Maps
Ortho-photography	Resolution	15m/pixel on average, up to 0.15m/pixel	Up to 0.15m/pixel
	Image taken date	Available	Not Available
	Age of images	1-3 Years	Vary greatly
	Update by inquiry	Not Available	Not Available
Street View		Yes	Yes
Bird's Eye View		No	Yes
GIS data Support		Yes (Google Earth Pro)	Yes (third party software, such as ArcGIS)

After comparing the images accessible from various packages and the need for vegetation blockage identification, the research team has evaluated various data sources, compared the strengths and weaknesses of each, and derived a potential approach to use internet images in identifying vegetation blockage to the sight distance in railroad and highway crossing locations based on a few selected criteria documented in the following section.

6.2.1 Adequate Resolutions

In order to select a potential resource to be used to identify vegetation blockage at railroad and highway crossings, the research team concluded that one of the basic requirements is the image resolution, which should provide clear delineation of railroad and highway infrastructure, vegetation, and other blockages at crossing locations. Ground Sample Distance (GSD), defined as the distance on the ground represented by each pixel in the x and y components, measures the image resolution in remote sensing. Images in Figure 35 demonstrate different resolutions at the same location, which are reflected by different GSD levels.

The diversity of data and vendor sources for Google Earth is that certain supplemental sources, such as orthophotographs, may be used to obtain several high resolution images. As shown in Figure 36B, the resolution of this original orthophotograph obtained from Google Earth is 0.25 M/Pixel, but the highest resolution for this area from Pictometry library is 0.15M/Pixel, demonstrated in Figure 36C. If there is no additional cost, the higher resolution may serve better for many other improvements at these crossing locations while 0.15 M/Pixel resolution meets the basic requirement of vegetation blockage at crossing locations in urban areas.

The research team has selected a railroad crossing located in Cedarville, NJ as an example to illustrate the photogrammetric solution as shown in Figure 36. In order to delineate the sight distance triangle at the crossing locations, the research team has imported a GIS layer as shown in red ink in Figure 38. Consequently, the vegetation blockage inside of the safety sight distance triangles are marked by yellow and red striped areas. Due to the angle of the image, it is impossible to decide whether the bushes, in yellow, will block a driver’s view and thus need to be removed. In this case, the bird view or oblique aerial images may be useful, which will be described in detail in the following sections.

A: 1m/pixel

B: 0.25m/pixel

C: 0.15 m/pixel

Figure 35. Railroad crossing images in different resolutions

After comparing the image quality and verifying the features via field reconnaissance photos, the research team concluded that, for urban areas in New Jersey, the current images provided by Google Earth, Bing Maps, and Pictometry at 0.15 M/Pixel are sufficient to recognize the key facilities at railroad and highway crossings. A lightly lower resolution of 0.5M/Pixel is adequate for rural areas as those shown in Figure 36. However, since the majority of the images from these packages are originating from satellite or aerial photos from high in the sky, another key feature of the imaging package concerns the visual angle, which is described in the following section.

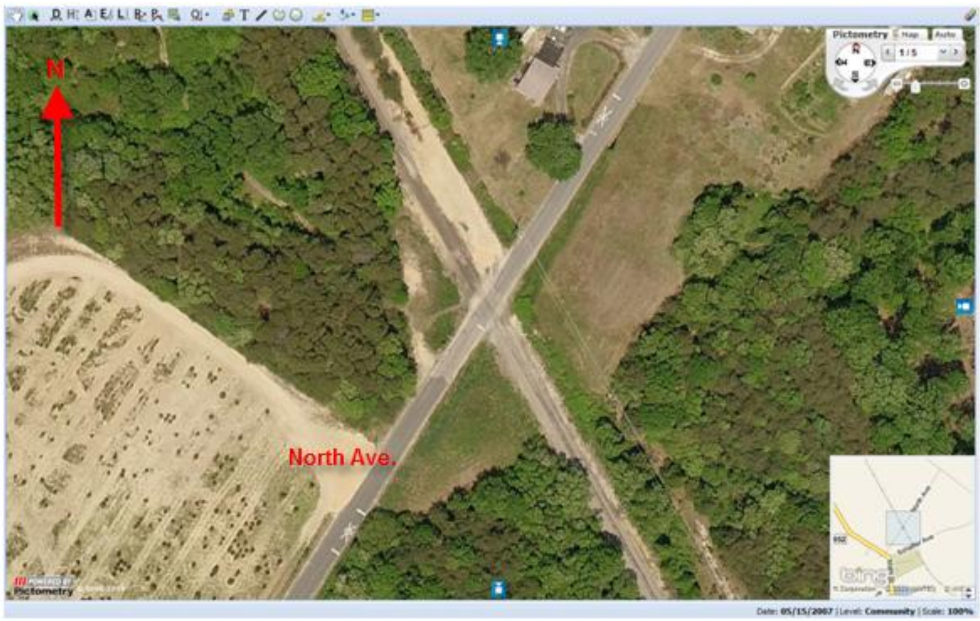


Figure 36. Original orthophoto of a passive control railroad crossing (Community level, 0.5 m/pixel)

6.2.2 <u>Proper Visual Planes</u>

As demonstrated in Figures 37 and 38, the vegetation coverage and other objectives around the railroad crossing are clearly displayed. However, it is impossible to confirm if the vegetation coverage actually blocks the safe sight distance as the images show the treetops taken from the overhead view. When identifying the safety sight distance blockage, railroad engineers use the visual plane at the eye level of the drivers, about 3 – 3.5 feet from the ground.

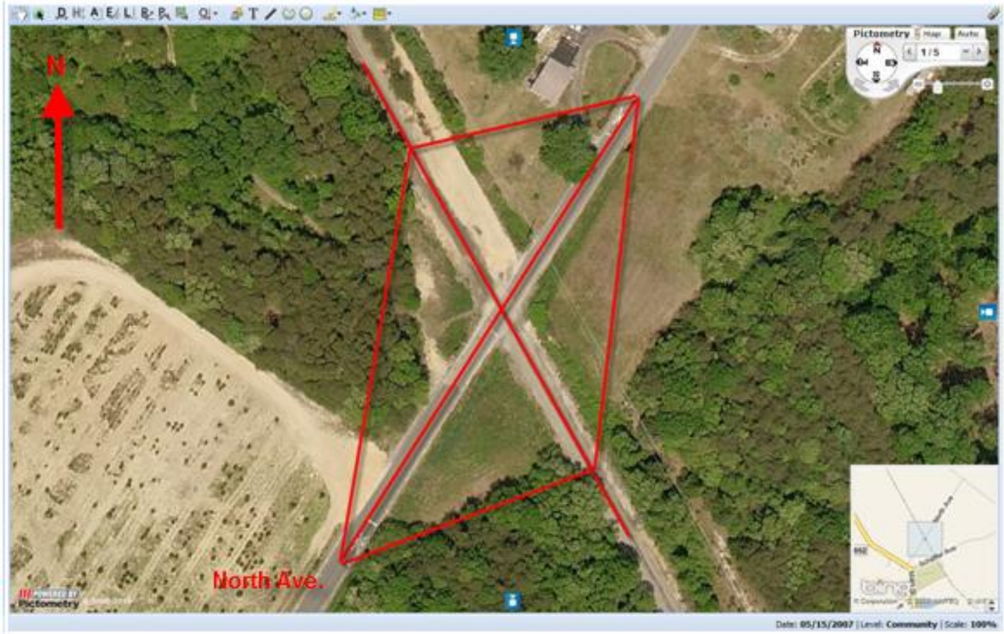


Figure 37. Orthophoto overlaid by GIS layer

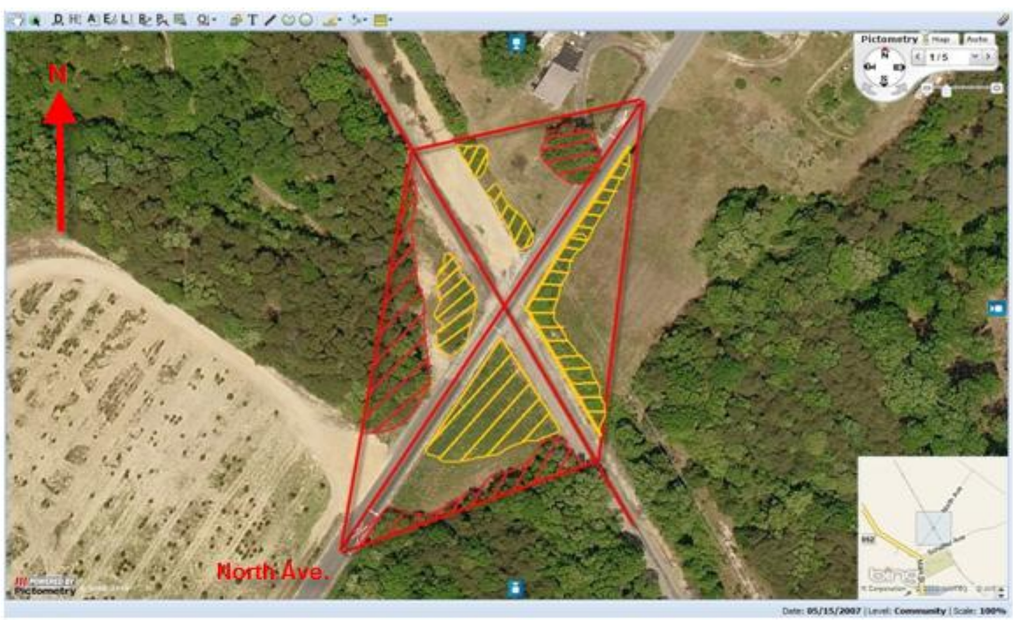


Figure 38. Orthophoto overlaid by GIS layer with shadowed blockages

With a high resolution of 0.15-0.5 M/Pixel, the Bird View images taken from angles may reveal the front, back, and sides of these blockages in order to verify the true extent of its coverage or blockage to the drivers. Figure 39 includes a series of oblique images in different directions of the same railroad crossing. It was noted that, from Figure 39A, though those bushes mentioned previously might be deemed not high enough to block drivers' sight currently, they may become blockages in the near future.

After importing the GIS layer, Figure 39D revealed those vegetation blockages, the red shadows, on each sides. It is noted that we when using orthophotos or oblique images to examine the railroad crossings, the tree top shown in these images may or may not necessarily block the driver's sight at the eye level.

6.2.3 <u>Cost Comparison</u>

In order to obtain more detailed information, the research team has communicated with Keyhole, Inc., the original creator of Google Earth, and other vendors such as Digital Globe. Digital Globe provides high resolution images with the resolution up to 0.3 M/Pixel in some cities and 0.5-0.6 M/Pixel in average. The dates of the images in their library vary in years and an up-to-date image may be requested by tasking the satellite for images up to 0.5 M/Pixel.

All Bird's View images of the Bing Maps are from Pictometry. Pictometry International Corp. is a leading provider of oblique, geo-referenced aerial imagery. After purchasing a license of the Pictometry Web Solution, users may access the Pictometry image library and navigate through terabytes of information. If needed, users may also import GIS data from Pictometry On-Line (POL), one of the Pictometry Web solutions. Our examples are mainly based on Pictometry's images because its libraries include both the straight down (nadir) images like ordinary aerial imaging and oblique images with superior resolutions of 0.15-0.3 M/Pixel. The research team has tested all these features via a trial package provided by POL. Table 5 provides some basic cost comparisons between different vendors on various features needed in the proposed approach.

A. View from east

C. View from north

B. View from south

D. Vegetation blockage identified

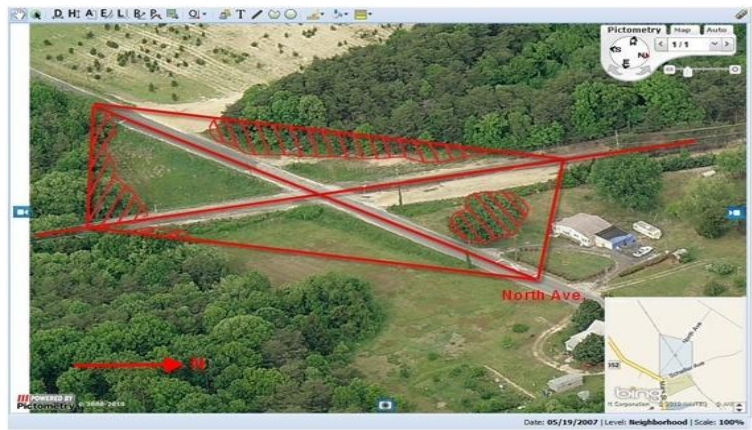


Figure 39. Oblique image overlaid by GIS layer with shadowed blockages

Table 5 - Cost comparison among various vendors

Vendors	Google earth	Bing Map	Pictometry	Digital Globe
Features	*Orthophotography *Street View *Integrate GPS data *Import and overlay images	*Orthophotography *Bird's Eye View *Import GIS data by third-party software, such as ArcGIS	*Bird’s Eye View with date of taken *Online access to measuring tools, annotations *Share access to information, annotation and shape layers with colleagues *Import GIS data	Commercial vendor of space imagery and geospatial content
Cost	Free/ A=$400/yr/B=$85,000/yr	Free	$400/SqMile	$600/Band
Note A	Google Earth Pro, $400/yr. Besides the above features plus: *Gain email support *Create premium movies *Import and overlay images *Perform batch geocoding *Measure area *Import GIS data		Images taken by airplanes: $400/square-mile each time (up to 0.15m/pixel)	Images taken by tasking a satellite. From $600 each time (up to 0.5m/pixel)
Note B	Google Earth Enterprise, from $85,000/yr. All the above features, plus: *Create a Map with custom imagery *Synthesize terabytes of imagery, terrain and vector data			

6.3 Survey and Laser Technology

Surveying is a well established science and technology for locating features on the surface of the earth. Features such as trees, buildings, roads and railroads can be located or mapped in a relative mode, location relative to each other, or in an absolute mode, geographic or state plane coordinate systems. Surveying techniques include measurements of distances, angles, and positions that are measured in the coordinates of features. Distances and angles can be determined from measurements utilizing Total Stations or Laser based technology, which include hand -held devices or 3-D Laser Scanners.

Generally survey devices locate features in a relative mode. Unless connected to known control points, the coordinates of the features are in an assumed coordinate system. The features are mapped to scale but with no connections to other features, which were not located in the current survey. Positions of features in terms of worldwide or state plane coordinate systems can be determined by precise GPS observations or by using aerial and satellite imagery. The selection of a particular surveying technology depends on several factors, including the objective of the survey, required/expected location accuracy of feature, and the environmental constraints of the surveyed area.

Under ideal circumstances where there are no obstructions of the line of sight, all the above techniques could be employed with efficient and accurate results. An example for such a circumstance is shown in Figure 40. It depicts a roadway and railroad intersection in a relatively open area. Under such circumstances the measurements and determination of safe crossing distances is relatively simple and any surveying technique would yield good results.

The selection of a particular surveying technique becomes more challenging when the area to be surveyed is densely populated with trees and other tall manmade features or when the local topography is rather complex. An example of such environment is shown in Figure 41. As the vehicle travels from right to left towards the railroad and highway crossing, the field of view is obstructed not only by trees but also by a tall mound on the right hand side which makes it impossible to see the railroad until the vehicle practically reaches the railroad tracks. Thus, more convoluted circumstances require more close range, hands-on techniques, while more simple circumstances can be surveyed with less hands-on techniques such as aerial and satellite imagery.

Figure 40. Railroad crossing in Oceano, CA with clear field of view

Figure 41. Railroad crossing with obstructed field of view in Washington Twp., NJ

Referring to the conceptual framework presented earlier, the approach used to delineate the visibility triangle in a survey field may be very different from that of photogrammetric techniques. Instead of permanently marking points A, B, D, E and F in the field, an alternative solution is to develop a process for establishing these points in the field at the time of the railroad crossing inspection without physically entering the railroad right-of-way. The proposed solution has two stages. The first is to locate points A, C, D and F. The second is to locate points B and E.

6.3.1 Stage 1: Locate Points A, C, D, and F

Applying survey techniques, there are a few ways to establish the location of these points. The first is to measure a distance from the railroad to a point on the side of the road. The distance can be measured using various distance measuring devices from total stations to a wheel-based odometer. The second method for determining the position of points A, C, D and F is using GPS technology to compute the locations of these points in terms of geographic or state plane coordinates. Depending on the required accuracy this can be done in one of the following options:

Option 1:

The first option measures a distance from railroad to points A, C, D and F along the road side. Then, the coordinates of these points in geographic or state plane coordinate systems may be determined by using GPS receivers to determine them. This has to be done only once. Subsequent surveys for determining the locations of these points would require only uploading these coordinates into a GPS receiver and navigate to their location based on the stored coordinates. The relocation of these points does have to be done with survey grade GPS receivers. A code based GPS receiver with differential correction would be acceptable for this task.

Option 2:

The second option uses an accurate GIS, which may be available from the GIS section of NJ-DOT, and measures the offset distances from the railroad tracks using GIS tools. Once the location of points A, C, D and F are marked in the GIS, their state plane coordinates can be extracted from the GIS. This is obviously a less accurate method and it is up to the NJDOT staff to determine whether the accuracy of the coordinates derived by this method is sufficient for the application.

Similar to Option 1, this has to be done only once. Subsequent surveys for determining the locations of these points would require only uploading these coordinates into a GPS receiver and navigate to their location based on the stored coordinates. Also, a code based GPS receiver with differential correction would be acceptable for this task.

Option 3:

The last option measures a distance from railroad to points A, C, D and F along the roadside using a total station or other distance measuring devices without determining their geographic or state plane coordinates.

There are some disadvantages for this option. The first is that distances have to be measured every time a site is being inspected. The second disadvantage is that it requires approaching the railroad tracks every time an inspection is conducted. Another disadvantage is that it is the most time consuming option for subsequent inspections.

6.3.2 Stage 2: Locate Points B and E

After determining the location of points A, C, D and F, the surveyors need to establish the lines of sight AB and EF and perhaps CB and EF; these lines of sight can be established by computing and measuring the deflection angle away from the road. This method would not require physically marking points B and E. The deflection angle can be measured by a total station or by a compass. Using a total station may be more accurate but also too time consuming. Total station accuracy is probably not needed for this application. Using a compass would be just the opposite. Deflection angles measured with a compass are less time consuming but could be too inaccurate. Certain proficiency is also required in properly operating the compass and knowledge of the variations in magnetic deflections.

If during the inspection it is found that there are obstacles that block the line of sight at the railroad crossings, it becomes necessary to record this finding for further action. It is recommended to photograph the view from the inspection point and to mark on the photograph the line of sight. One possible process for this task can be illustrated as follows:, for example, if, on the left side along the line of sight AB in Figure 42, there are obstacles that have to be cleared, one would take a picture at point A facing the intersected railroad. A special marker on the ground, such as a red-white range pole, could be placed along the line AB and appear in the picture. This will enable the identification and removal of obstacles that are present on the left of the line AB.

Figure 42. Computed deflection angle based on safe distances standards (red) vs. actual visibility deflection angle (blue)

The survey and laser technology may require a GIS-based database with sight distances along the roadways and railroad tracks at all railroad crossings in New Jersey that need to be inspected. The database will provide a standard sight distance triangle for each approach, which would be the base for field inspection and decision making. The deflection angles of the actual field of view and the computed field of view may also be included in the database. Photos may be incorporated into the database to monitor the historical changes and for record keeping.

The means for measuring these distances and angles at a given site should be quick, easy and accurate. Using traditional surveying equipment will enable us to obtain accurate measurements, but it will be time-consuming and not necessarily straightforward. Therefore, a good alternative would be to use some special measuring tools such as a Laser Measuring and Mapping System. An example of a hand held laser measuring and mapping system is shown in Figure 43. This portable device is capable of measuring distances that are accurate within a couple of inches and an angle within 0.1˚. These accuracies should be adequate for the task at hand.

Figure 43. A laser based system to measure distances and angles

6.4 Demonstration

In order to verify the validity of the proposed approaches, the research team has selected a few crossing locations to test and demonstrate the process for delineating the visibility triangle and identifying vegetation blockage.

6.4.1 <u>Simplified Measures</u>

In order to translate the conceptual framework and theoretical dimensions into executable field measures, the research team first converted the visibility triangle into discrete lines and angles, which are the foundation for further information assembling and vegetation blockage identification.

As shown in Figure 44, the total crossing distance, D_T, may be reflected by O1B and D_H, OA. In theory, point O should be located in the center of the lane. However, to avoid the traffic on the road, an alternative point O_2 needs to be introduced, which shifts point O_1 to O_2, as shown in Figure 45. Then, the field needing to be determined becomes $\Delta O_1A_1B_1$. The first step in the field testing is to place a range pole at point O_1.

Since $\angle OAB = \alpha$, which has been determined in the lab calculations, the distance for AO_3 is also calculated before leaving for the field. Using a roller, the surveyor can measure from point O_1 to point A_1 to a distance equal to the calculated distance of A_1O_1, and can then put the laser scanner at point $A_{1.}$ Using the laser system to measure the distance between A_1 and $O_{1,}$ adjust the laser system position along the street to meet the calculated distance of A_1O_1. Now point A_1 is found.

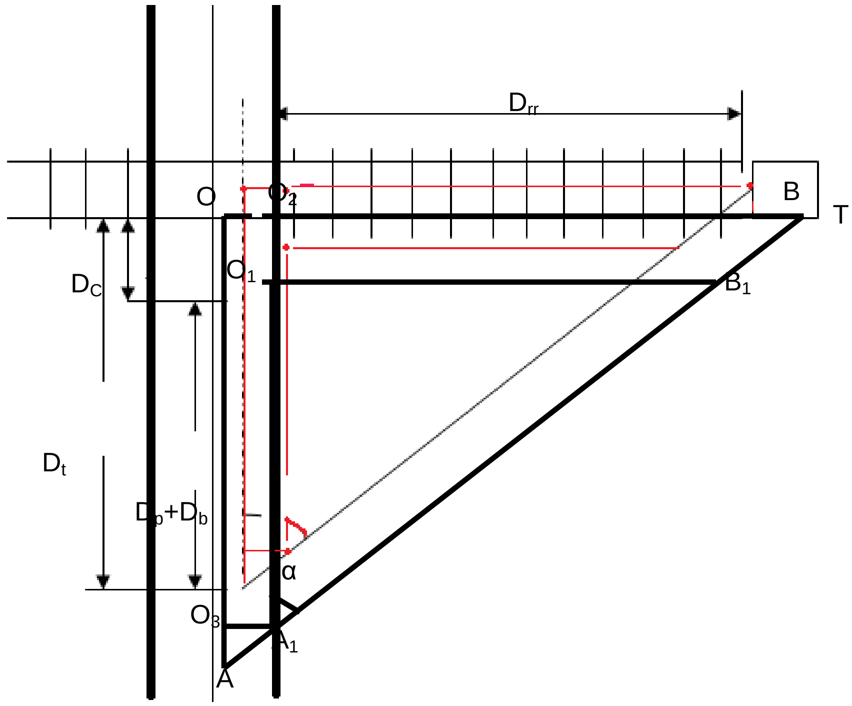


Figure 44. Diagram of the railroad intersection

Make the laser system at point A_1 face A_1O_1 direction, and then adjust the laser system to reach the angle α which has been determined previously. Now the direction that the instrument faces is direction A_1B_1.

There are two potential outcomes in the testing or application process: first, there is no obstacle that blocks the sight along the direction A_1B_1. In this case, just place a range pole to mark point B_1. The second scenario deals with the obstacle found with the field $A_1O_1B_1$. In that case, a special marker "⊥" could be made by spray paint to indicate the direction of A_1B_1 and the obstacles that need to be removed. The following section documents concrete steps in implementing the survey techniques in the field.

6.4.2 Onsite Demonstration

As shown in Figure 45, the selected highway-railroad crossing is located in Stewartsville, New Jersey (266932H). It was a public crossing, where Norfolk Southern Railroad and an urban collector intersect. The highway traffic volume was in the 5000 Average Annual Daily Traffic (AADT) in the late 1980 and should be much higher now. The railroad traffic has ceased operation since the late 1990s, which provides a safe and liability-free location of the field test of approaches.

Figure 45. Crossing location

As stated in the field plan, the first step is to locate the railroad and highway crossing points O, O_2 and O_1. As demonstrated in Figure 46, after locating Point O at the center of the highway lane and closer side of railroad tracks, the surveyor shifted a distance of OO_2 and installed a pole at point O_2. Similarly, Point O_1 provides a safety alternative that is away from upcoming railroad trains.

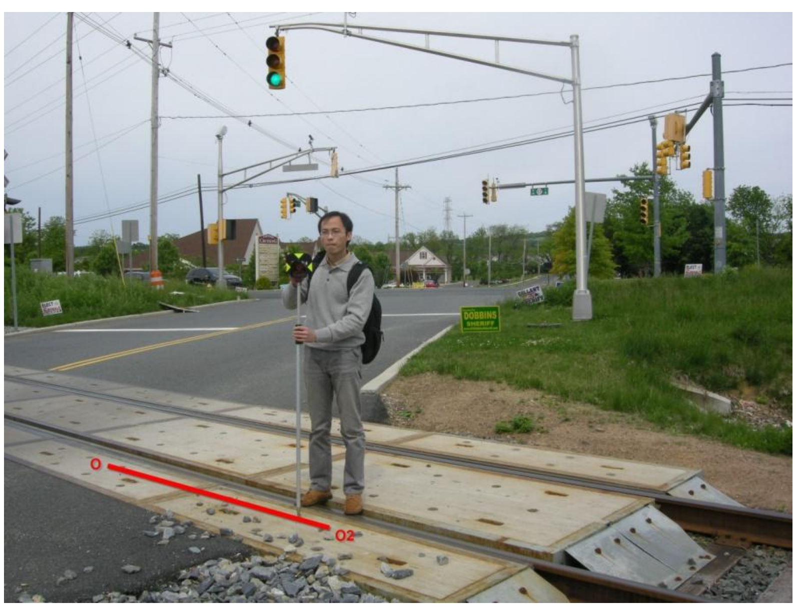


Figure 46. Point O_2 determination

Figure 47. Point O_1 determination

Once point O_1 is determined, the field staff used the laser scanner to measure a distance of A_1O_1 to locate point A_1 as depicted in Figures 48 and 49. Moving the laser scanner to point A_1, the field staff pointed the scanner to the A_1B_1 direction according to the angle α, which was calculated in the laboratory also. As exhibited in Figure 50, after traversing a distance of A_1B_1 along the direction of angle α, the laser scanner beam located point B1, which should be the alternative point of B in the original visibility triangle.

Figure 48. Point A_0 determination

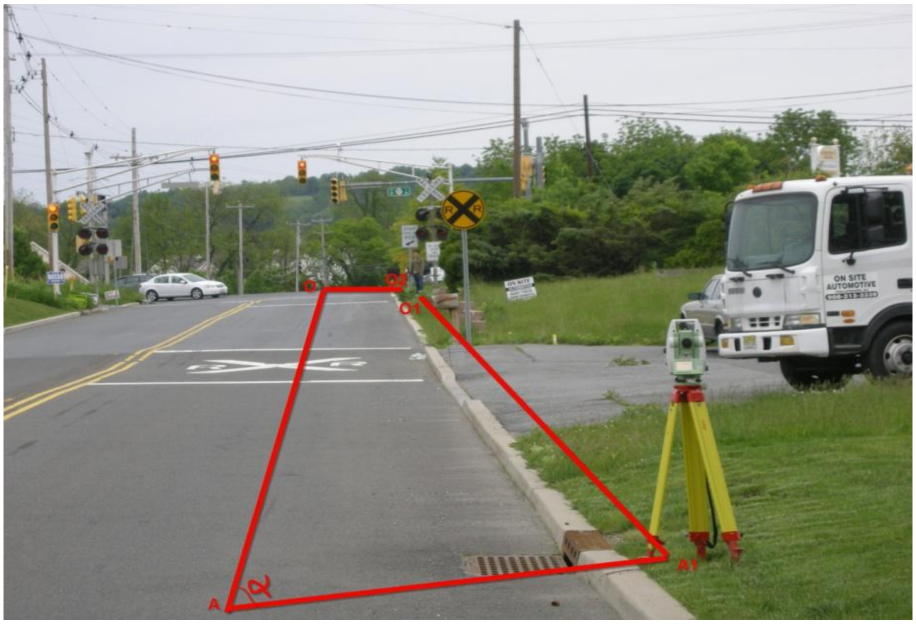


Figure 49. Determined points O_1, O_2, and A_0

Figure 50. Use the laser system to find the predetermined sight angle α

In this particular location, there is vegetation blockage, an overhanging tree that blocked the field vision of the drivers at the time. As planned, the field staff has painted a “⊥” mark using yellow spray paint. As shown in Figure 51, the vertical line of the “⊥” mark pinpoints to the cutting direction of tree trimming when applicable. To make it more visible, the field crew also painted NJDOT signs so it is recognizable when the trimming crew are on site or it will not be eliminated by others.

Figure 51. Sight angle and markers

It is noted that this is the first field testing conducted along the survey approach. Further follow-up may be conducted to evaluate how long the paint will last and/or if the trimming crew will be able to follow the directions of “⊥” mark. This approach addresses the physical delineation of visibility triangle at railroad and highway crossing locations and identifies vegetation blockage when present. However, the scope does not include jurisdictional and financial responsibility of maintaining the clearance triangle at crossing locations.

7. SUMMARY

In our effort to assist NJDOT find an optimal approach to identify vegetation blockage of the sight distances at the highway-railroad crossings, the research team has conducted a survey among state DOTs, benchmarked the current status of railroad crossing inspection among peer state DOTs, evaluated current operations, and developed a two-stage process to effectively identify vegetation blockage at crossing locations.

Based on the survey results and benchmarks for New Jersey in the areas of railroad crossing safety, a comparison among current railroad and highway crossing inspection practices in New Jersey and peer states was performed, which provided a reference for the research team to explore cost effective and efficient approach. After considering all of these modern technologies and conventional survey techniques in identifying vegetation blockage, the research team found that there isn't any consensus or commonly accepted practice existing. Finally, a two-state process, which is a combination of photogrammetric and survey approaches, was proposed.

The proposed approach combines both the web mapping applications and the conventional survey approach. The procedures accomplished via Google Earth /Bing Map help inspectors eliminate a large number of crossings from the vegetation blocakge concerns so higher priority may be placed on these locations that need immediate attention. The conventional survey steps may be executed on site to confirm if vegetation blocks the visiilbyt triangle. If yes, how much and where the trimming or clearnce should occur.

Given the budget constraints and inspector shortage existing in most of state agencies and the urgent need to meet the mandate for updating railroad crossing inventory by the recently enacted Railroad Safety Improvement Act (RSIA, 2008), the proposed approach may help priotizing railroad crossing tasks and improve the efficiency of the inspection proces, which is an important step to maintain and improve the overall railroad crossing safety.

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APPENDIX 1. VEGETATION CLEARANCE

CHAPTER OVERVIEW

This chapter is intended to present an overview of laws and regulations covering responsibility for the removal of brush, shrubbery, and trees from the railroad right-of-way within a reasonable distance from the crossing.
If the relevant statute prescribes a penalty, it is listed here. As in other chapters, the relevant citations are listed in the narrative.

STATE LAWS, REGULATIONS AND PENALTIES

ALABAMA
Alabama has no such regulation.

ALASKA
Alaska has no such regulation.

ARIZONA
Arizona has no such regulation.

ARKANSAS
Arkansas law requires all railroads operating within the state to maintain their right-of-way at or around any railroad crossing of a public road or highway free from grass, trees, bushes, shrubs, or other growing vegetation which may obstruct the view of pedestrians and vehicle operators using the public highway.
The maintenance of the right-of-way must be for a distance of fifty feet on each side of the centerline between the rails for the maintenance width and for a distance of one hundred yards on each side of the centerline from the public road or highway for the maintenance length.

Penalty

Any railroad corporation failing or refusing to comply shall be subject to a fine of not less than one hundred dollars or more than five hundred dollars for each violation. Ark. Code Ann. §23-12-201 (1999).

CALIFORNIA
California has no applicable statute.

COLORADO
Colorado law requires railroads to pay all expenses of keeping public and private crossings planked and in good repair. Colo. Rev. Stat. §40-24-104 (1999).

CONNECTICUT
If the view of that portion of the tracks of any railroad, crossing a highway at grade, which adjoins such crossing, is obstructed by trees, shrubbery, embankments of earth or structures of any kind, the Commissioner of Transportation may, after proper notice to the railroad company and to the selectmen of the town, mayor of the city or warden of the borough wherein such crossing is located and to the owners of the land adjoining the crossing, conduct a hearing and make such orders for or concerning the removal of any such obstruction as will afford an unobstructed view of the railroad tracks and highway for a distance of at least one hundred and fifty feet in each direction from the crossing. The entire expense occasioned by any order of the Commissioner is to be paid for by the owner of the land upon which the obstruction is located. Conn. Gen. Stat. §13b-281(Supp. 2002).

DELAWARE
Delaware has no applicable statute.

DISTRICT OF COLUMBIA
District of Columbia has no applicable statute.

FLORIDA
Florida law prohibits the removal, cutting, marring, defacing, or destruction of any trees or other vegetation, either by direct personal action or by causing any other person to take such action, within the rights-of-way of roads located on the State Highway System or within publicly owned rail corridors unless prior written permission has been granted by the Department of Transportation, except where normal tree trimming is required to ensure the safe operation of utility facilities, and such tree trimming is performed in accordance with the provisions of its utility accommodations guide. The Department is required to adopt rules for the implementation of this section to achieve protection of vegetation while at the same time assuring safe utility operations.
Any person who violates the provisions of this section is guilty of a misdemeanor of the second degree. Fla. Stat. §337.405 (Supp.1999). See also, Sections 775.082 and 775.083, concerning punishment.

GEORGIA
Georgia has no applicable statute.

HAWAII
Hawaii has no applicable statute.

IDAHO
Idaho law requires that the owner of real property be responsible for the removal from his property of any hedge, shrubbery, fence, wall or other sight obstructions of any nature, except public traffic or highway signs, buildings and trees, where these sight obstructions constitute a potential traffic hazard. A sight obstruction shall not extend more than three feet, or less than ten feet, in height above the existing center line highway elevation within the vision triangle of vehicle operators. The boundaries of the vision triangles are defined by measuring from the intersection of the edges of two adjacent highways forty feet along each highway and connecting the two points with a straight line. The sight distance obstruction restriction is also applicable to railroad-highway grade crossings with vision triangle defined by measuring forty feet along the railroad property line when intersecting with a highway.
The failure of the owner to remove the traffic hazard after being notified, within a specified period of time as determined by the Department of Transportation shall constitute a misdemeanor and every day the owner fails to remove the obstruction may be considered a separate and distinct offense. Civil action may be initiated by state or local officials to enforce vision triangle restrictions. Idaho Code §49-221(2)(3) (Lexis Supp.1999).

ILLINOIS
Every rail carrier operating within the State of Illinois is required to remove from its tight of way at all grade crossings within the State, all brush, shrubbery, and trees as is reasonably practical for a distance of not less than five hundred feet in either direction from each grade crossing. 625 ILCS 5/18c7401 (1999).

INDIANA
Indiana Law requires that all railroad corporations doing business in Indiana must, between July 1 and August 20 in each year, destroy detrimental plants (see Section 15-3-4-1, for definition of detrimental plants), noxious weeds, and rank vegetation growing on lands occupied by the railroad. Ind. Code Ann. §8-3-7-1 (LexisNexis Supp.2002).
Penalty
Any railroad failing to comply with these requirements will be liable for a penalty of twenty-five dollars. Ind. Code Ann. §8-3-7-2 (1999).

Each railroad in Indiana shall maintain each public crossing under its control in such a manner that the operator of any licensed motor vehicle has an unobstructed view for fifteen hundred feet in both directions along the railroad right-of-way subject only to terrain elevations or depressions, track curvature, or permanent improvements. However, the Indiana Department of Transportation may adopt rules to adjust the distance of the unobstructed view requirement based on variances in train speeds, number of tracks, angles of highway and rail crossing intersections, elevations, and other factors consistent with accepted engineering practices.
A public crossing equipped with a train-activated crossing gate is exempt from these requirements (a), if the railroad maintains an unobstructed view for at least two hundred fifty feet in both directions along the railroad right-of-way. Ind. Code Ann. § 8-6-7.6-1 (2001)

Penalty

A railroad that violates the provisions of this chapter shall be held liable to the State of Indiana in a penalty of one hundred dollars a day for each day the violation continues subject to a maximum fine of five thousand dollars to be recovered in a civil action at the suit of said state, in the circuit or superior court of any county wherein such crossing may be located. Ind. Code Ann. § 8-6-7.6-2 (2001)

IOWA

Iowa law requires every railroad operating in the state to insure that vegetation on their property which is on or immediately adjacent to the roadbed be controlled so that it does not:
(1) Become a fire hazard to track-carrying structures.
(2) Obstruct visibility of railroad signs and signals.
(3) Interfere with railroad employees performing normal trackside duties.
(4) Prevent proper functioning of signal and communication lines
(5) Prevent railroad employees from visually inspecting moving equipment from their normal duty stations. Iowa Code § 327F.27 (1999).

KANSAS

The Board of County Commissioners of each county are authorized to cut all hedge fences, trees and shrubs growing upon the highway right-of-way boundary, within three hundred fifty feet of a highway-rail crossing and thereafter keep the same trimmed. Kan Stat. Ann. § 19-2612 (1999).

KENTUCKY

Kentucky has no applicable code section.

LOUISIANA

All railroads in Louisiana are required to maintain their rights-of-way for a length of three hundred feet on each side of the centerline of public road or highway, and for a distance of fifty feet on each side of the centerline between the rails or the width of the operating right-of-way, whichever is shorter. The measurement for grade crossings with multiple tracks shall be from the centerlines of the outside tracks.

All railroad companies in Louisiana shall maintain their rights-of-way at any public road or highway railroad grade crossing that is not protected by an active warning device that includes lights and cross-arms, in such a manner that the vegetation and structures and others obstructions do not obstruct the view of motorists approaching the crossing.

Railroad companies shall cut vegetation and remove structures and other obstructions that obstruct the view of the operator of any motor vehicle approaching any public road or highway railroad grade crossing that is not protected by an active warning devices that includes lights and cross-arms, from either direction, and that are located within the maintenance width (fifty feet),

and maintenance length (three hundred feet) of the crossing.

The Department of Transportation and Development may periodically inspect and evaluate all state highway-rail grade crossings on state highways to determine whether such crossings are maintained in compliance with the provisions of this section. If the Department determines that a particular grade crossing is not in compliance with the requirements, the Department shall inform the parish or municipal governing authority in whose jurisdiction the crossing is located, and the respective governing authority shall notify the railroad.

Each parish or municipal governing authority may periodically inspect and evaluate all non-state public road or highway-rail grade crossings located within its jurisdiction to determine whether such grade crossings are maintained in compliance. If a parish or municipal governing authority determines that a particular grade crossing is not in compliance, the governing authority shall notify the respective railroad company.

Notification to a railroad company must be in writing transmitted by certified mail, return receipt requested, to the person listed as the registered agent of the railroad for service of process.

Penalty

Every railroad that fails or refuses to maintain, or to cause a grade crossing to be in compliance with the provisions of this section within fifteen working days after receipt of notification shall be subject to a civil fines of not less than one hundred dollars for each day of the violation after receipt of the notification subject to a maximum fine not to exceed five thousand dollars, payable to the appropriate parish or municipal governing authority. La. Rev. Stat. Ann. §386.1 (West 2002)

MAINE
The Maine Department of Transportation has the authority to designate the highway-rail crossings in the state at which, from all points on the highway within three hundred feet of these crossing, a traveler can have a "fair view" (emphasis author's) of an approaching train continuously from the time the train is three hundred feet from the crossing until it has passed over the crossing, either under existing conditions or by bushes, trees, fences, signboards or encroachments being trimmed, cut down or removed. Me. Rev. Stat. Ann. tit. 23, §7222 (West 1999).
When the Department of Transportation deems that trees, bushes or other encroachments are obstructing the view at highway-rail crossings and such a condition is dangerous to travelers, it may order the removal of any such obstacles. Me. Rev. Stat. Ann. tit. 23, §7234 (West 1999).

Title 23 of the Maine Revised Statute, at section 7222, allows the Department of Transportation to designate by general orders, which can be issued without formal notice or hearing, crossings in which the railroads must, through trimming brush and trees or by removing fences and signboards on their right-of-way, ensure that the motorist or traveler through the crossing has a clear view of an approaching train three hundred feet from the crossing. Me. Rev. Stat. Ann. tit. 23, §7222 (1999).

MARYLAND
Maryland has no applicable statute.

MASSACHUSETTS
If the view of a railroad crossing or highway at-grade is obstructed by standing wood in woodlands, the railroad corporation or ten citizens of a town may petition the county commissioners for the county where such crossing is situated for the removal of such standing wood; and the commissioners, after proper notice and hearing, may make orders as to such removal as the public safety demands. They shall also prescribe the limits within which such standing wood shall be taken, and shall determine the damage sustained. Any damage and expense incident thereto may be recovered from the railroad corporation. Mass. Gen. Laws Ann. ch. 160, §150 (1999).

MICHIGAN
Michigan law allows the road authority and the railroad to agree in writing for clear vision areas on crossings in high speed rail corridors. The portions of the right-of-way and property owned and controlled by the respective parties within an area to be provided for clear vision shall be considered as dedicated to the joint usage of both the railroad and the road authority. The acquisition of right-of-way, purchase, and removal of obstructions within a clear vision area, including buildings and other artificial construction, trees, brush, and other growths,

and grading or earthwork, and including the maintenance of such conditions, shall be at the equal cost and expense of the railroad and the road authority. Mich. Comp. Laws §462.317 (1999).

MINNESOTA

If a railroad, road authority, or abutting property owner fails to control the growth of trees or vegetation or the placement of structures or other obstructions on its right-of-way or property as to interfere with the safety of the public traveling on a public or private grade crossing, the local governing body of the town or municipality where the grade crossing is located may, by notice, require the obstruction to be removed as necessary to provide an adequate view of oncoming rains as the crossings. The Commissioner is required to adopt rules establishing minimum standards for visibility at public and private grade crossings.

Penalty

A railroad company, road authority, or property owner failing to comply within 30 days after being notified in writing is subject to a fine of fifty dollars for each day that the condition is not corrected. Minn. Stat. §219-384(l)(2) (1998).

MISSISSIPPI

Mississippi has no applicable code section.

MISSOURI

All railroads operating in Missouri are responsible for the maintenance of their right-of-way at highway-rail crossings. The crossing must be kept clear of vegetation, undergrowth or other debris for a distance of two hundred and fifty feet each way from the near edge of the crossing. Mo. Rev. Stat. §389.665 (1993).

MONTANA

Montana has no applicable code section.

NEBRASKA

Nebraska has no applicable code section.

NEVADA

Nevada has no applicable code section.

NEW HAMPSHIRE

Whenever, after a hearing upon petition or upon its own motion, the Department of Transportation shall be of the opinion that the protection required by its order demands that the land adjacent to any crossing shall be kept clear of buildings, trees, brush, or other obstructions, it may order the railroad corporation to clear the land of such obstruction. N.H. Rev. Stat. Ann. §373:18 (1998).

NEW JERSEY

New Jersey has no applicable code section.

NEW MEXICO

New Mexico has no applicable code section.

NEW YORK

New York has no applicable code section.

NORTH CAROLINA

North Carolina has no applicable code section.

NORTH DAKOTA

North Dakota has no applicable code section.

OHIO

Every railroad company is required to destroy or remove plants, trees, brush, or other destructive vegetation upon its right-of-way at each intersection with a public road or highway, for a distance of six hundred feet, or a reasonably safe distance from the roadway of the public road as shall be determined by the Public Utilities Commission.

Whenever any railroad fails to destroy or remove such vegetation after ten-day written notice served on its local agent, the Commission, Board of County Commissioners, Board of Township Trustees, or legislative authority of a municipal corporation, in which the intersection is located, having the care of such road or highway, shall remove such plants, trees, brush, or other obstructive vegetation and shall recover the cost of removal from the responsible railroad company.

Penalty

If the railroad company fails to pay the amount demanded within thirty days after notification by certified mail, the Commission, Board of County Commissioners, Board of Township Trustees, or legislative authority of a municipal corporation shall certify the amount demanded to the county auditor to be collected as other taxes and assessments and upon collection shall be credited to the general fund of the public body causing the work to be performed. Ohio Rev. Code Ann. §4955.36 (1999).

OKLAHOMA

Oklahoma has no applicable code section.

OREGON

Oregon has no applicable code section.

PENNSYLVANIA

Pennsylvania has no applicable code section.

RHODE ISLAND

Rhode Island has no applicable code section.

SOUTH CAROLINA

South Carolina law requires that all railroad crossings on public highways must be inspected for conditions which unsafely obstruct a motorist's view of approaching trains, for the presence of crossbucks, and for the presence of STOP signs. The Department of Transportation is responsible for inspecting crossings on state maintained highways, the governing body of each county is responsible where railroads cross county maintained highways, and the governing body of each municipality are responsible for inspecting railroad crossings on road and street right-of-way maintained by municipalities. The Department is required to inform the counties and municipalities of the railroad crossings they are responsible for inspecting. By January 1, 1989, the governing body of each county and municipality must notify the Department of the office and public official to whom the governing body has assigned responsibility for performing the inspections.

If the person inspecting a railroad crossing finds that a motorist's view of approaching trains is unsafely obstructed by vegetation, growth, or objects not permanently affixed to realty which are within the right-of-way of the railroad, the inspector must immediately notify the Deputy Director of Engineering within the Department of Transportation of the hazard. Notice from the Department shall direct the railroad to cut or remove the vegetation, growth, and objects that are obstructing a motorist's view.

Penalty

The railroad is then required to cut or remove the vegetation, growth, and objects within sixty days' of receipt of the notice. If the railroad company fails to do what is required within the specified period of time will result in a civil penalty of not less than one hundred or more than five hundred dollars. The railroad company is subject to an additional civil penalty of one hundred dollars a day for each day obstructions remain after the specified period of time.

If the inspector finds that a motorist's view of approaching trains is obstructed by vegetation, growth, or objects not permanently affixed to realty that lie outside the right-of-way of the railroad but within right-of-way of highways and roads maintained by the state, county, or municipality, the inspector shall give written notice to the appropriate department of the state, county, or municipality. The Department, counties, and municipalities have sixty days to eliminate the hazard. If counties and municipalities fail to remove the obstruction, the Department of Transportation must do so. Counties and cities will then be required to reimburse the Department.

If the inspector finds that motorist's view is obstructed by vegetation, growth, or objects no permanently affixed to realty that lie on private property outside the right-of-way of both the railroad and the highway or a right-of-way of the state, county or municipality, he or she must give appropriate notice. The owner of the property shall then have sixty days to remove the obstruction.

By January 1 of each year, counties and municipalities are required to report all railroad crossings that were inspected during the preceding year and at which no obstructions were found. The Department of Transportation must also make a similar annual report and provide the report to the Senate Transportation Committee and Education and Public Works Committee of the House of Representatives of the South Carolina Legislature. S.C. Code Ann. §58-17-1450 (1999).

SOUTH DAKOTA

South Dakota has no applicable code section.

TENNESSEE

Tennessee has no applicable code section.

TEXAS

Texas has no applicable code section.

UTAH

Utah has no applicable code section.

VERMONT

Vermont has no applicable code section.

VIRGINIA

Every railroad operating in Virginia is required to clear from its right-of-way trees and brush for one hundred feet on each side of public road crossing at grade when such trees or brush would otherwise obstruct the view of approaching trains.

Penalty

A violation by a railroad brings a fine of not more than five hundred dollars for each offense, to be imposed by the State Corporation Commission after due notice and hearing. Va. Code Ann. §56-411 (1999).

WASHINGTON

Every railroad operating within the State of Washington is required to keep its right-of-way clear of all brush and timber in the vicinity of a railroad grade crossing with a county road for a distance of one hundred feet from the crossing so as to allow a person an unobstructed view in both directions of an approaching train. Likewise, the county legislative authority shall keep their right-of-way clear for one hundred feet in both directions. Wash. Rev. Code §36.86.100 (1999).

Every railroad is required to keep its right-of-way clear of all brush and timber in the vicinity of a railroad grade crossing with a state highway for a distance of one hundred feet from the crossing so as to allow a person an unobstructed view in both directions of an approaching train. Likewise, the Washington Transportation Department is responsible to clear their right-of-way in the same manner and for the same distance. Wash. Rev. Code § 47.32.140 (1999).

WEST VIRGINIA

West Virginia has no applicable code section.

WISCONSIN

Every railroad operating in Wisconsin must keep its right-of-way clear of brush or trees for a distance of at least three hundred thirty feet in each direction from the center of its intersection with any public highway, and for such further distance as is necessary to provide an adequate view of approaching trains. Wis. Stat. §195.29(6) (1999).

WYOMING

Wyoming has no applicable code section.

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APPENDIX 3. RAILROAD GRADE CROSSING SAFETY SURVEY

ID. ________________________ Surveyor __________________________

Name of the Agency: ____

Jurisdictions of your agency _____________________________________

1. How many railroad crossings under the jurisdictions of your agency?

Total: _________

Private: _______%,

Public: ________%.

2. Would you please tell us the number or percentage of each type of crossings?

Grade separated ________

At Grade ______________

Gated ________________

Passive Controlled ______

3. What are the passive control devices you are using at grade crossings, check all that apply.

☐ Flashing Lights

☐ Cross bucks

☐ Stop signs

☐ Other, Please specify: ______________________________________

4. What is the effectiveness of these control devices? Please mark 1 through 5 for each control device (1 being least effective and 5 most effective).

Flashing Lights _______

Cross bucks _________

Stop signs __________

Other ______________

5. How many field inspectors does your agency have for Railroad Crossing?

☐ 1-5

☐ 6-10

☐ 11-20

☐ 21-30

☐ 30 or more, please specify ________________________________.

6. How long does it take for the inspection cycle to complete?

☐ Within one year
☐ 1- 2 years
☐ 3-4 years
☐ 5 years or more

7. Do you have a typical check list used by the field inspectors?

☐ Yes, would you please send (rliu@njit.edu) or upload a copy? Then proceed Question No. 15.
☐ No, please continue to the next question.

8. What types of railroad services intersect with the roads in your jurisdiction, please mark all that apply.

☐ AMTRAK
☐ Passenger Transit Services
☐ Class I Railroad
☐ Regional Railroad
☐ Local/Short line Railroad

9. What aspects of the grade crossing were examined by field inspectors? Please mark all that apply.

☐ GPS location with Latitude and Longitude
☐ Types and Status of control devices
☐ Status of pavement markings
☐ Crossing angels
☐ Width of the road and railroad ROW
☐ Speed limits for both train and automobiles
☐ Crossing surface grade and texture
☐ Vegetation blockage
☐ Other, Please elaborate ________________________________.

10. Is there an overall rating system for a grade crossing?

☐ No.
☐ Yes, please elaborate: _________________________________.

11. How is the stopping sight distance or clearance triangle measured at grade crossing?

☐ Given as a fixed number, which is ______________ feet.
☐ Estimated using operating speed and geometry of the crossing.
☐ Other, please explain:

____

____

12. What is your practice in maintaining vegetation clearance within the sight distance triangle?

- ☐ Estimate in the field inspection
- ☐ Measure the distance using rollers
- ☐ Outline the triangle area using conventional survey methods
- ☐ Use Google maps to estimate the vegetation coverage
- ☐ Other, please elaborate:____

13. How effective are these practices? Please mark 1 through 5 for each that you had experience with (1 being the least effective and 5 the most effective).

Estimate in the field inspection ________
Measure the distance using rollers ________
Outline the triangle area using conventional survey methods ________
Use Google maps to estimate the vegetation coverage ________
Other, please elaborate: ______________________________________

14. Who is responsible to eliminate the encroachment of vegetations in the safety triangle?

- ☐ Department of Transportation
- ☐ Railroad
- ☐ Local Jurisdiction
- ☐ Other, please specify: ____

15. Does your agency participate in the "operation lifesaver" program?

☐ No,

☐ Yes, please rate the effectiveness of the program (1 being the least effective and 5 the most effective) in terms of

- ☐ Educate drivers ________________________
- ☐ Reduce number of the accidents ___________
- ☐ Identify problem locations _________________
- ☐ Other, please specify and rate ______________

16. Please provide us your contact information if you are interested in receiving a summary of the survey results.

____

____

Thank you very much.

APPENDIX 4. SAMPLE INSPECTION RECORDS

Crossing Inspection

AARDOT	054251U	**Seq#**	132A	**Milepost**	105.8	**Year Last Rebuilt**		**Status**	Open
NHLocality	WAKEFIELD					**# of Tracks**	1	**Direction**	North/South
Crossing Name	LONG RIDGE ROAD (Mathew's)					**District**	3	**Urban Compact**	No
Railroad	NEW HAMPSHIRE NORTHCOAST					**Hwy Designation**	TOWN		
RailroadLine	CONWAY BRANCH					**Exempt** ☐		**GPSNorthing**	
Owner	NEW HAMPSHIRE NORTHCOAST					**Preempted** ☐		**GPSEasting**	
Crossing Comments	P 6/14/89								

Inspection Results

Railroad	**RailroadLine**	**Inspection Date**
NEW HAMPSHIRE NORTHCOAST	CONWAY BRANCH	1/8/2009

Approaches

Surface	Gravel	**Condition**	Fair	**Inspector**
				J. Robinson

Crossing

Surface	Planked	**Condition**	Fair

Sight Distance *

Quad1	Sufficient	**Quad2**	Sufficient	**Quad3**	Sufficient	**Quad4**	Sufficient

Appliance Count

Traffic Light(s)	0	**Gate(s)**	0	**Bell(s)**	0	**Mast(s)**	0	**Cant(s)**	0

Roadway Signs

Type	**Location**	**Condition**	**Count**
stop here on red	West	Fair	1
stop here on red	East	Fair	1
Crossbuck	West	Fair	1
Crossbuck	East	Fair	1
AWS (Advanced Warning Sign)	West	Missing	
AWS (Advanced Warning Sign)	East	Missing	

Pavement Markings

Type	**Location**	**Condition**
Stop Bar	West	Missing
Stop Bar	East	Missing
RRxing Marking	West	Missing
RRxing Marking	East	Missing

Crossing Signals

Required Remedial Action

Install AWS East & West.

Suggested Remedial Action

Gravel road makes P'Marks unnecessary.

Inspection Comments

RAILROAD INSPECTION REPORT

RAILROAD ICRR District #5 RR MILEPOST: 150.19

COUNTY: Dewitt ROUTE: U.S.51 LOCATION: CLINTON, W. of

DOT/AAR: 313628J

☑ Tag Place ☐ Tag Miss

Device Type

- ☑ Flashing Lights
- ☑ Gates
- ☑ Cantilever
- ☑ Crossbucks
- ☑ Warning Signs
- 2 Bell Number
- ☑ Pavt Marking
- ☑ Stop Lines
- ☐ Sidelights

Type of Circuitry

- ☐ Track Circuits
  - ☐ Type C
  - ☐ AFO
- ☑ Motion Sensors
- ☐ Motion Predictors

Looking north

Date: 08/12/2009

Bulb Rating

Lamp Size:	12 IN
LED	Bulb Volts:
LED	Bulb Watts:

Voltages

AC Volt:	8.7
DC Volt:	8.6

Unit Flashes/Minute (35 Min - 60 Max)

46

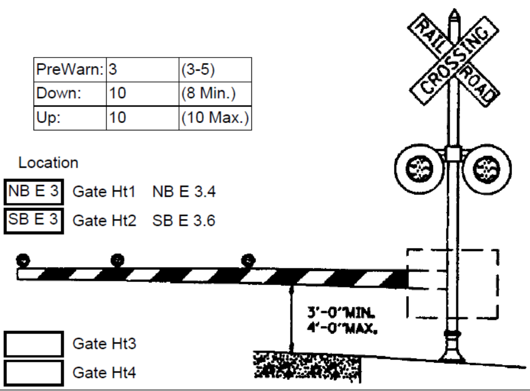
DOT Tree Trimming Needed

N/A	Quadrant
N/A	Quadrant

PreWarn:	3	(3-5)
Down:	10	(8 Min.)
Up:	10	(10 Max.)

Location

NB E 3	Gate Ht1	NB E 3.4
SB E 3	Gate Ht2	SB E 3.6
	Gate Ht3	
	Gate Ht4	



Signal Location	C/L Track	Curb/Edge
NBe	10.65	14.7
NBw	12.65	8.5
SBe	12.75	8.2
SBw	12.45	8.6

District Not Required to check electrical components, voltage readings or actual operation of the system.

Interconnect/Pre-emption Status

Is crossing interconnected with highway signals?	No
If Yes, Mininimum Time in seconds	0

Time is measured from when the signal is received by the traffic signal controller until the train arrives at the crossing.

Travel Dir.		FLASHING INDICATIONS (Effective Distances) (FEET) 14	13	12	11	10	9	8	7	6	5	4	3	2	1	Adj. Mad	Sight Obstru
NB	Stand							GM	GM	GM	GM	CANT	CANT	CANT	CAN		none
	Type							LED	LED	LED	LED	LED	LED	LED	LED		
	Dist							400	400	1000	1000	1000	1000	1000	100		
SB	Stand							GM	GM	GM	GM	CANT	CANT	CANT	CANT		none
	Type							LED	LED	LED	LED	LED	LED	LED	LED		
	Dist							1400	1400	700	700	1000	1000	1000	1000		
	Stand																
	Type																
	Dist																
	Stand																
	Type																
	Dist																

TRAIN VOLUME / **TRACK SPEED (Max.)**

6	Freight Per	Day	40
	Amtrack Per		
1	Switches Per	Day	

Veh ADT:	7300	2007
Posted Speed:	55	
Traffic Lanes:	4	

Comments: Signals appear to be in satisfactory operating condition. Wire access cover on east cantilever had been removed and was open. Appeared to have been forced open. Advised maintainer to get fixed asap.

State Inspector: Bart Sherer, Dan Magee Railroad Rep Angela Walsh Inspection Date 08/12/2009

RAILROAD CROSSING REPORT Wisconsin Department of Transportation
DT1589 4/2003 (Replaces ED705)

1. Railroad Project ID	2. Operating Railroad	
3. Companion Construction Project ID	4. Companion Hwy Constr. Letting Date	5. Engineering ID
6. Road Name	7. Official DOT/AAR Crossing Number	
8. Highway Number/Town Road/Street Name	9. Railroad Subdivision and Milepost	
10. County	11. Town/City/Village of	

Attach sketch of crossing including track centers, approach grades and obstructions to view of approaching trains.

EXISTING DEVICES AT CROSSING

Provide information for both approaches	Northbound/Eastbound		Southbound/Westbound		Comments
	YES	NO	YES	NO	
12. Stop Signs	☐	☐	☐	☐	
13. Cross Bucks	☐	☐	☐	☐	
14. Wig Wag Signals	☐	☐	☐	☐	
15. Flashing Light Signals	☐	☐	☐	☐	☐ 8" ☐ 12" ☐ INC ☐ LED
16. Cantilever Signals	☐	☐	☐	☐	☐ 8" ☐ 12" ☐ INC ☐ LED
17. Gates	☐	☐	☐	☐	
18. Crossing Illuminated	☐	☐	☐	☐	
19. Flagging	☐	☐	☐	☐	
20. Bell	☐	☐	☐	☐	☐ M ☐ E
21. Sidelights	☐	☐	☐	☐	
22. Stop Bar	☐	☐	☐	☐	Distance From Crossing
23. Public Road Intersection	☐	☐	☐	☐	
24. Humped Crossing Sign	☐	☐	☐	☐	
25. Railroad Advance Warning Signs	☐	☐	☐	☐	
26. RXR Pavement Markings	☐	☐	☐	☐	
27. Advisory Speed Signs	☐	☐	☐	☐	

OTHER CROSSING INFORMATION

28. Total No. of Tracks	29. No. of Main Line Tracks	30. No. of Other Tracks	31. Angle of Crossing ( ) LHF ( ) RHF

32. Total No. of Lanes	33. No. of Through Lanes	34. No. of Parking Lanes	35. No. Exclusive Use Lanes	36. No. Sidewalks	37. Sidewalk Width	38. Pavement Width	39. Curb ☐ Y ☐ N	40. Roadway Width

41. Crossing Surface Type	42. Length of Existing Crossing	43. Crossing Surface Condition

Average Daily	6 a.m.-6p.m. Number	6p.m.-6a.m. Number	Timetable Speed		ADT	50. Year
44. Passenger Trains			MPH	47. Highway ADT (present)		( )
45. Freight Trains			MPH	48. Highway ADT (design)		( )
46. Switching Moves			MPH	49. Posted Speed Limit		

Stopping Sight Distances

Distances at which crossing warning devices first visible (WDV) [1] and vehicle stopping distances (VSD) from crossing based on speed [2]

51. Approach	52. WDV	53. VSD

Quadrant Sight Distances

View of trains from stopping distance.

54. Quadrant	Sight Distance [3]	
	55. Actual	56. Req'd

Clearing Sight Distances

View of trains at 25 feet from nearest rail.

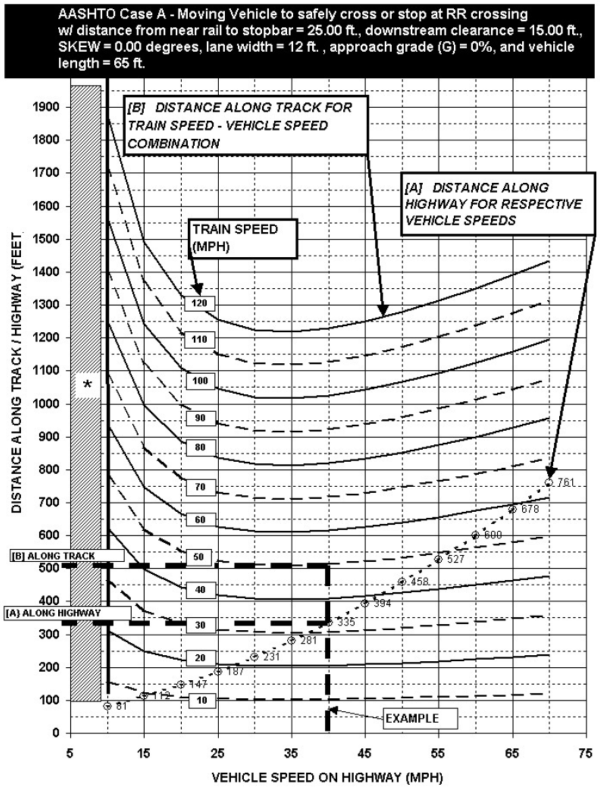
57. Quadrant	Sight Distance [4]	
	58. Actual	59. Req'd

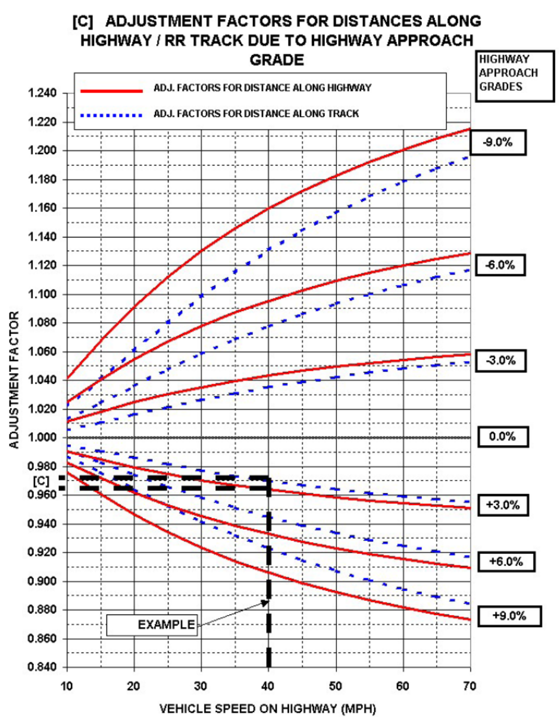
SIGHT DISTANCES

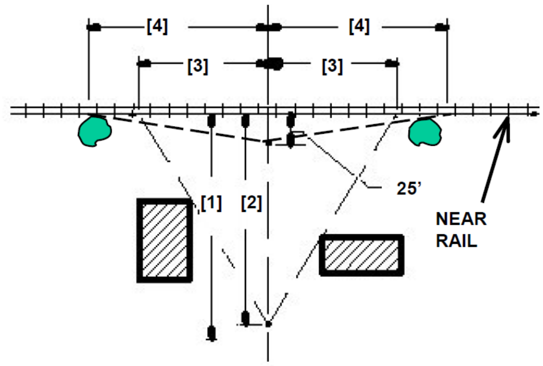
60. Obstructions, Comments

61. Diagram (Label Quadrants)

62. By	63. Title	64. Date







[1] see item 52
[2] see item 53
[3] see items 55 and 56
[4] see items 58 and 59

ILLUSTRATION FOR ONE APPROACH

Applies to right-angle single track crossings with vehicle speeds between 10 and 70 mph and train speeds between 10 and 120 mph. **Crossings that do not meet these criteria require special consideration.**

See:

•AASHTO (2001). A Policy On Geometric Design Of Highways And Streets. 4th edition. Pages 735-743. Washington, DC.

•FHWA publication "Guidance on Traffic Control Devices at Highway-Rail Grade Crossings" for guidance on calculating clearing sight distance.

** **Crossings with a stop condition or where vehicle speeds are less than 10 mph are to be reviewed with the Grade Crossing Safety Engineer.***

EXAMPLE

To evaluate an existing condition to determine if visual contact with a train is adequate to safely decide whether to STOP or PROCEED.

Given a 40 mph Posted Highway Speed on a 3% upgrade with an approaching 50 mph Train requires:

[A] 335' Distance Along The Highway

[B] 513' Distance Along The Track

[C] Apply Grade Adjustment Factors to both distances:

•Adjusted Distance Along The Highway = 335 x 0.965 = 323' (required [2] – see item 53)

•Adjusted Distance Along The Track = 513 x 0.97 = 498' (required [3] – see item 56)

INSTRUCTIONS

5. Enter the ID number the government agencies (DOT, local) are using for surveys, plans, etc. (preliminary engineering).

12. – 20. Under each of the two approaches, indicate if the item exists. Under the "Comment" column, enter any pertinent information such as "too low," "poor condition," etc.

13. Also include reflectorization information.

15. – 16. Also check off the lamp size and whether the lamps are incandescent (INC) or light emitting diodes (LED).

18. Also, under the "Comment" column, enter the distance from the crossing. NOTE: Crossing Illumination should be within 150 feet of the crossing before being included.

19. Also record "yes" in the approach where the flagger is normally located. Flaggers may select a favored approach due to geometrics or obstructions.

20. Also record whether bell is mechanical (M) or electronic (E).

21. – 27. Under each of the approaches, indicate if the item exists and at what distance it is located from the crossing. Measure the distance along the roadway from the near side of the near rail to the closest point of the item to the crossing.

22. NOTE: Record intersection(s) entering within the vehicle safe stopping distance (as shown on FDM 17-25-1, Attachment 1 of the nomograph), and describe the intersection traffic control under 63.

27. Also enter the posted advisory speed.

28. Enter the total number of tracks located between the Railroad Crossing Warning Devices.

31. Enter the most severe track angle in the crossing and check the appropriate box for left-hand-forward (LHF) or right-hand-forward (RHF). "Angle" is measured between the roadway centerline and the track centerline in the quadrant common to both. Boxes would be blank for a 90-degree crossing angle.

32. Enter the total number of paved lanes (driving, parking, bypass, etc.) through the crossing.

33. Enter the number of "through" driving lanes.

34. Enter the number of lanes available for parking (either marked or unmarked) through the crossing.

35. Enter the number of "exclusive use" lanes pullout (bypass, stopping, etc.) through the crossing.

36. Enter the number of sidewalks.

37. Enter the width and location of sidewalk(s) - distance from edge of pavement or face of curb to the inside edge of each sidewalk.

38. Enter the total pavement width between edges of pavement or between faces of curbs. Measure perpendicular to the roadway centerline.

39. Indicate if curb and gutter are constructed on the crossing approaches by checking the (Y) box "yes" or the (N) box "no."

40. Enter the total roadway width, between outside shoulder points, backs of curbs, or outside edges of sidewalks. Measure perpendicular to the roadway centerline.

41. Enter crossing surface type (rubber, concrete, flange and guard timber, etc.).

42. Enter the total length of crossing (width of roadway as defined in 38 as measured along the track centerline).

43. Record the assessment of the crossing surface condition (material not covering total roadway, timbers failing, etc.).

44. – 46. Record the number of scheduled trains between the indicated hours, and record the timetable speed for each type or train. Obtain the information from the operating railroad.

51. Enter the crossing approach.

52. Enter the actual distance from the crossing at which the crossing warning devices are first visible.

53. Enter the required vehicle safe stopping distance, refer to discussion in FDM 17-25-1, Attachment 1.

54. Enter the quadrant.

55. Enter the actual sight distance available at the vehicle safe stopping distance. Record obstructions in 60.

56. Enter the required sight distance, refer to discussion in FDM 17-25-1, Attachment 1.

57. Enter the quadrant at a distance 25 feet from the crossing.

58. Enter the actual sight distance at a distance of 25 feet from the crossing.

59. To be calculated after review with Grade Crossing Safety Engineer, only if necessary to evaluate required clearing sight distance [4].

60. Indicate obstructions and any comments for each quadrant.

61. Show the roadway centerline, and label the crossing angle, the quadrants, and the north arrow.

62. Identify the person to be contacted for additional information or clarification.

63. Record the contact person's title.

64. Enter the date the information was obtained.

NOTE: Train information must be secured from the operating railroad.