U.S. Department
of Transportation

Federal Railroad
Administration

Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service

Office of Safety
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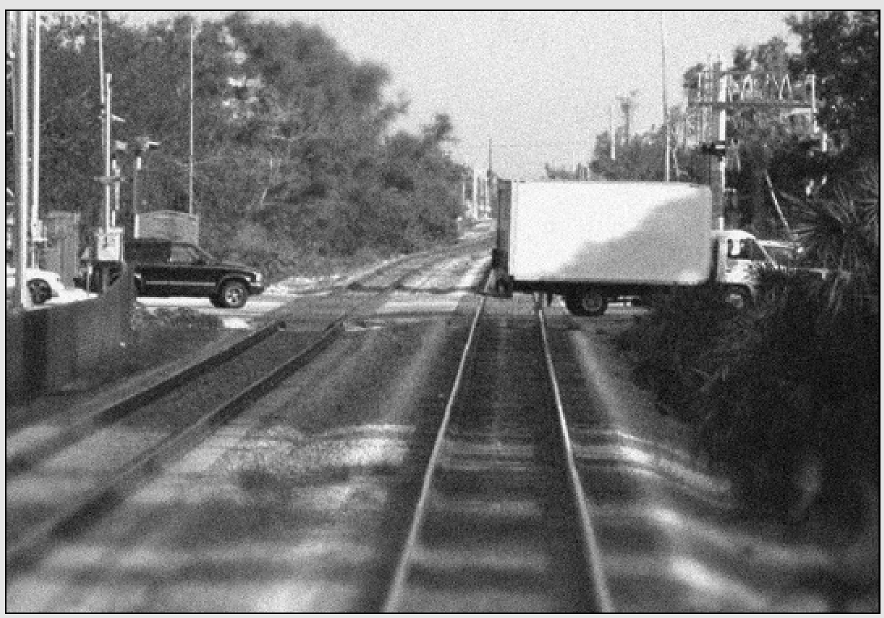

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Executive Summary

The FRA develops programs that identify, monitor, and address safety issues on passenger and freight railroads. Over the past ten years, there have been a number of collisions resulting in serious or fatal injuries to passengers and crew. To better understand the risks associated with these events, FRA requests that passenger rail operators conduct a collision hazard analysis that identifies potential hazards and hazard mitigation strategies.

The Collision Hazard Analysis Guide supports the American Public Transportation Association (APTA) Commuter Rail System Safety Program Plan initiative by providing a step-by-step procedure on how to perform a hazard analysis and how to develop effective mitigation strategies that will improve passenger rail safety. Where applicable, this analysis should be conducted in conjunction with the hazard analysis element under the passenger railroad's System Safety Program Plan (SSPP). The techniques described in this guide are focused on passenger rail collisions but are also valid for evaluating other hazards or safety issues related to any type of operating system.

Although this guide focuses on primary and secondary collision scenarios, it is also important for the rail system to identify other conditions that affect the safety of passengers. It is necessary to adequately evaluate secondary collision potential within the scope of this guide to ensure that all credible sources for collision, such as factors creating derailments and subsequent secondary collisions, are properly analyzed.

The hazard analysis guidelines presented here are based on the U.S. Department of Defense document "System Safety Program Plan Requirements" (MIL-STD-882) and the hazard identification/resolution processes described in APTA publication "Manual for the Development of System Safety Program Plans for Commuter Railroads." The disciplined, structured approach presented in this document allows hazards to be systematically identified, analyzed, and addressed. The process provides a permanent record of hazard analysis and serves as a reference document to review and analyze future incidents, accidents, or changes in system operations.

FRA would like to acknowledge the contributions of the John A. Volpe National Transportation Systems Center and the American Public Transportation Association for partnering with FRA to produce this guide and to conduct the pilot projects used to validate the collision hazard analysis process. FRA would also like to thank South Florida Regional Transit Authority (SFRTA), operator of the Tri-Rail Commuter service, and the Virginia Railway Express. These two railroads volunteered to conduct collision hazard analysis pilot programs and shared their experience and materials with the FRA and the passenger rail community.

Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service

1. Introduction:

The Federal Railroad Administration (FRA) is responsible for promoting the safety of the nation's passenger and freight railroads. To address this responsibility, FRA develops programs that identify, monitor, and address railroad safety issues.

FRA is concerned about the risk of injury to occupants of passenger trains. Over the past ten years, there have been a number of collisions resulting in serious or fatal injuries to passengers and crew. To better understand these risks, FRA requests that passenger rail operators conduct a collision hazard analysis that identifies potential hazards and hazard mitigation strategies. The mitigation strategies should use a hazard precedence approach and be designed to eliminate, control, or mitigate all identified collision hazards, where feasible. The hazard analysis should include mitigation strategies that are currently in place or newly proposed.

Some risk is inherent to all transportation activities. However, risk can be progressively reduced through sound operational planning, training, technology deployment, and modifications to vehicles, facilities, and infrastructure. Hazard analysis provides a foundation for progressive risk reduction by ensuring that hazards are not overlooked and that areas of risk are evaluated and addressed.

It is recognized at the outset that passenger rail service is provided within a larger environment where many hazards to passenger train safety are introduced by third parties such as highway users, abutting property owners, non-railroad contractors working in proximity to the railroad, and persons committing criminal acts. While passenger railroads should attempt to address these hazards, in many cases remediation may not be within the railroad's control. Remediation may be partially or wholly the responsibility of the persons or organizations introducing the hazards or other parties with control or authority for the subject matter (e.g., host railroads, motor vehicle licensing authorities, roadway authorities, police departments, local governments). Accordingly, where the passenger railroad is unable to adequately address the hazard(s) through early detection or mitigation of consequences, the passenger railroad should reach out to other organizations to address common safety issues. FRA or other Federal authorities may be able to assist in this process.

Where applicable, this analysis should be done in conjunction with a broader hazard analysis element under the rail system's System Safety Program Plan (SSPP). Although this guide focuses on primary and secondary collision scenarios, it is also important for the rail system to identify other conditions that affect the safety of passengers. It is necessary to adequately evaluate secondary collision potential within the scope of this guide to ensure that all credible sources for collision, such as factors creating derailments and subsequent secondary collisions, are properly analyzed. The results from previously conducted hazard analysis efforts should be reviewed and incorporated.

FRA understands that many collision hazards are common to all passenger rail operations. However, a single common collision hazard analysis will not provide the detail needed to assess the risk or the effectiveness of the mitigation strategies. FRA cannot define specific hazards for a passenger railroad as accurately as those who actually operate the passenger trains and best understand the operating environment. Therefore, FRA requests that each collision hazard analysis be tailored to the specific environment present on each passenger railroad. The results of the collision hazard analysis, including the mitigation strategies, should be fully documented, maintained by the passenger railroad, and available for review by the FRA.

The Collision Hazard Analysis Guide supports the American Public Transportation Association (APTA) Commuter Rail System Safety Program Plan initiative by providing a step-by-step procedure on how to perform a collision hazard analysis and how to develop effective mitigation strategies that will improve passenger rail safety. The techniques described in this guide are focused on passenger rail collisions but are also valid for evaluating other hazards or safety issues related to any type of operating system.

2. Structured Hazard Analysis:

The hazard analysis guidelines presented here are based on the United States Department of Defense document "System Safety Program Requirements," MIL-STD-882 and the hazard identification/resolution processes described in APTA publication "Manual for the Development of System Safety Program Plans for Commuter Railroads." MIL-STD-882 is an excellent method for conducting hazard analyses. The disciplined, structured approach outlined in MIL-STD-882 allows hazards to be systematically identified, analyzed, and addressed. The MIL-STD-882 methodology also ensures that all hazards and mitigation strategies are adequately reviewed. The process provides a permanent record of the hazard analysis and serves as a reference document to review and analyze future incidents, accidents, or changes in system operations.

MIL-STD-882 has been used as a model to create Rail System Safety Programs, has been successfully applied to railroad transportation systems, and is an appropriate and useful tool to analyze passenger rail safety issues. For example, the System Safety Plan for Amtrak's Acela High Speed Rail service included a detailed MIL-STD-882 hazard analysis for the Acela railcars and engines. Additionally, the System Safety Plan included a MIL-STD-882 Operational Hazard Analysis (OHA) for the start-up and integration of the new service. The OHA was conducted using teams consisting of Amtrak operating managers, labor representatives, and FRA staff. These teams reviewed proposed operating plans, including yard operations, over-the-road operations, servicing, and dispatching.

The Metropolitan Transportation Authority of New York developed a System Safety Plan and used MIL-STD-882 to conduct hazard analyses for the planning, design, construction and implementation of the tunneling project to connect the Long Island Railroad to Grand Central Station. Teams consisting of operating managers, contractors, and FRA staff participated in hazard identification and resolution activities. MIL-STD-882 analysis techniques were also used for the design and construction of a new fleet of M-7, multiple unit railcars.

3. Performing the Hazard Analysis:

A hazard analysis is performed to identify hazardous conditions for the purpose of their elimination or control. A hazard analysis for a complete system may include several analysis techniques applied throughout the life cycle of the product – from initial concept and design through to the final disposal of the system. A full hazard analysis can consist of various analysis documents including a Preliminary Hazard Analysis (PHA), Failure Modes and Effects Analysis (FMEA), Operating Hazard Analysis (OHA), and others. New start properties should initiate their hazard analysis processes early and apply appropriate analysis techniques during the project planning and design phase. Existing operations already designed, built, and operating may not require all the analysis tools described above.

FRA requests that the passenger railroads perform a hazard analysis that identifies primary and secondary collision hazards and appropriate collision hazard resolutions. The analysis should consider derailment potential as a precursor to secondary collisions.

3.1 Hazard Model:

To initiate a hazard analysis, the passenger railroad should first establish the hazard model used to analyze hazards identified in the process. The hazard management team should develop and agree to a specific process used to determine how hazards will be rated for severity and frequency. It is important that the severity and frequency definitions developed be meaningful to the railroad and the hazard management team so that they can be consistently applied. Examples of severity and frequency definitions used in the military standard may not be appropriate for a railroad safety analysis. If this is found to be the case, it is perfectly acceptable to revise these definitions so that they are meaningful to the hazard management team and easy to apply.

3.2 Severity Definitions:

Severity definitions are applied to hazards and used to rate hazard consequences. The objective of establishing severity definitions is to provide a method to prioritize hazards so the hazard management team can concentrate on the most severe hazards first. Severity definitions usually consist of four categories; Catastrophic, Critical, Marginal, and Negligible. The definitions for each category are included in MIL-STD-882. However, the definitions are very broad and sometimes not directly applicable to the passenger rail operation. For example, MIL-STD-882 defines a catastrophic hazard as "Death, system loss, or severe environmental damage." On a railroad, even a minor accident or a low-speed collision can lead to the death of an individual. Therefore, it becomes difficult to prioritize a hazard because they all have the potential to become critical and unacceptable.

The passenger railroad should look for other elements that may be more meaningful and include them in the severity definition. Examples of some elements that may affect the severity of a hazard are listed in Table 1. The passenger railroad may have other elements that are specific to its operation. For example, the loss of a specific station or a bridge may have a catastrophic impact on the safety and the operation of the railroad.

In the railroad industry, it is sometimes necessary to consider the level of system loss when assessing the severity of a hazard. Considering system loss is not meant to downplay the occurrence of a serious or fatal injury; but the level of system loss provides an additional tool to determine the relative severity of a hazard. For example, an accident that destroys a bridge or tunnel could shut down passenger rail service for an extended period of time. Therefore, a hazard that causes this level of disruption should probably be considered critical or catastrophic – even if the hazard does not generate personal injuries.

FRA recommends that the passenger railroads define hazard severity in a way that is meaningful and useful for the railroads. Examples of how Virginia Railway Express (VRE) and South Florida Regional Transportation Authority (SFRTA) define severity appear in Appendix A.

POTENTIAL SEVERITY DEFINITION ELEMENTS				
ELEMENT	**Catastrophic**	**Critical**	**Marginal**	**Negligible**
Train Speed	50 to 79 mph	30 to 49 mph	10 to 29 mph	Less than 10 mph
Intrusion in Passenger Occupied Vehicle (POV)	Severe deformation of POV with crushing and tearing of structure	Loss of passenger volume with rents in structure	Minor loss of passenger volume, no rents in structure	No intrusion into POV
Impact with Object	Collision with another train or a fixed immoveable object (e.g. bridge abutment)	Collision with railroad rolling stock, MOW vehicle, or a commercial vehicle at a GC	Collision with a pedestrian or an automobile at a GC	Collision with a fixed moveable object (e.g. signal tower, GC mast)
Fire	Extensive fire in a passenger occupied area that requires intervention by trained fire fighters to control	Isolated or localized fire outside a passenger occupied area	Fuel or other combustible material spilled without ignition	No fire and no combustible products spilled
Fall from Height	Occupied equipment falls from a bridge or overpass	Occupied equipment falls or rolls down an embankment or rolls on its side	Equipment derailed but stays on track structure with minor tilting a jackknifing	Equipment stays upright and in line
Explosion	Serious explosion due to collision with flammable material, commercial carrier, or business	Less than serious explosion due to collision with explosive material/fuel tank	Potential explosion due to damage or leakage (e.g. gasoline leakage from automobile)	No explosion or leakage of explosive fluids, gases, or materials
Fatalities or injuries	More than 3 fatalities and multiple serious injuries to passengers and crew	Up to 3 fatalities or multiple serious injuries to passengers and crew	No fatalities but non life threatening injuries to passengers or crew	No injuries or minor injuries to passengers and crew
Hazardous Materials	Train strikes hazardous material carrier or commercial business, causing explosion and fire	Train collision causes life threatening hazardous material spill	Significant non life-threatening hazardous spill (.g. locomotive fuel tank rupture	Minor or no appreciable hazardous material spill
Water Hazard	Passenger occupied vehicle partially or wholly submerged	Passenger occupied vehicle comes to rest in water over 5 feet deep	Minor water hazard	No water hazard
System Disruption	System shut down for more than 24 hours	System shut down from 2 to 24 hours	System shut down from 30 minutes to 2 hours	System shut down of less than 30 minutes

Table 1. Examples of Elements that May Be Used to Define Hazard Severity

3.3 Frequency Definitions:

Frequency definitions are used to establish how often identified hazards emerge. Hazard frequency and hazard severity are combined and used to determine risk. The frequency of the hazard can be determined quantitatively (using failure rates or accident/incident statistical data) or qualitatively based on the relative frequency of expected occurrence. An estimate of how often a hazard may occur during the life of the fleet may be helpful in establishing frequency. The hazard management team should establish a meaningful definition for their operation.

What is meant by frequent? Once a day? Once a week? Several times per day? Guidance on hazard frequency from MIL-STD-882 and other properties is shown in Table 2 and Table 3.

Level	Description	Quantitative Definition (Frequency x)	Qualitative Definition
A	Frequent	$x > 1x10^{-1}$	Likely to occur frequently, continuously experienced in the fleet.
B	Probable	$1x10^{-1} > x > 1x10^{-2}$	Will occur several times in the life of an item, will occur frequently in the fleet.
C	Occasional	$1x10^{-2} > x > 1x10^{-3}$	Likely to occur sometime in the life of an item, will occur several times in the fleet.
D	Remote	$1x10^{-3} > x > 1x10^{-6}$	Unlikely but possible to occur in the life of an item, unlikely but can reasonably be expected to occur in the fleet.
E	Improbable	$1x10^{-6} > x$	So unlikely that it can be assumed occurrence may not be experienced, unlikely to occur but possible.

Table 2. Hazard Frequency Definitions from MIL-STD-882

Military Standard 882 establishes five frequency categories – Frequent, Probable, Occasional, Remote, and Improbable. A passenger railroad is free to modify the categories to better suit its requirements. South Florida Regional Transportation Authority, who runs the Tri- Rail commuter service, uses seven frequency categories as described in Table 3.

Frequency	Definition
Certain Event	An event has occurred. The event will re-occur or has re-occurred at a singular location or may occur at other/multiple locations.
Likely Event	An event has occurred, based on a condition that exists and/or based on the number of persons or equipment exposed to an identified hazard. Reports, observations or near-miss data indicate an event may occur.
Probable Event	An event may occur at a singular location or at multiple locations based on an identified hazard.
Unlikely Event	An event arising from an unidentified condition(s) where sufficient analytical data does not exist to identify the condition(s).
Rare Event	An event has occurred on another commuter rail system with a similar operating environment and conditions exist that may lead to a similar event.
Improbable Event	Sufficient analytical data does not exist to indicate an event will occur. However, a series of identifiable conditions could occur, leading to an event
Incredible Event	Conditions may not exist leading to an incredible event. However, unforeseen conditions outside the system could occur, leading to an event on the system.

Table 3. Table of Frequency Definitions Used by South Florida Regional Transportation Authority (Tri-Rail)

As with the severity definitions, FRA believes that the passenger railroads should define the hazard frequency in a way that is meaningful and useful for the railroads. A comparison of how other passenger railroads have defined hazard frequency appears in Appendix B.

4. Step-by-Step Process for Collision Hazard Analysis:

With definitions for hazard severity and hazard frequency established, passenger railroads are ready to begin the collision hazard analysis process. There are five main steps in performing a hazard identification and resolution hazard analysis. They are:

- System Definition
- Hazard Identification
- Hazard Assessment
- Hazard Resolution
- Follow-Up

Figure 1 contains a flowchart that describes the hazard analysis and resolution process.

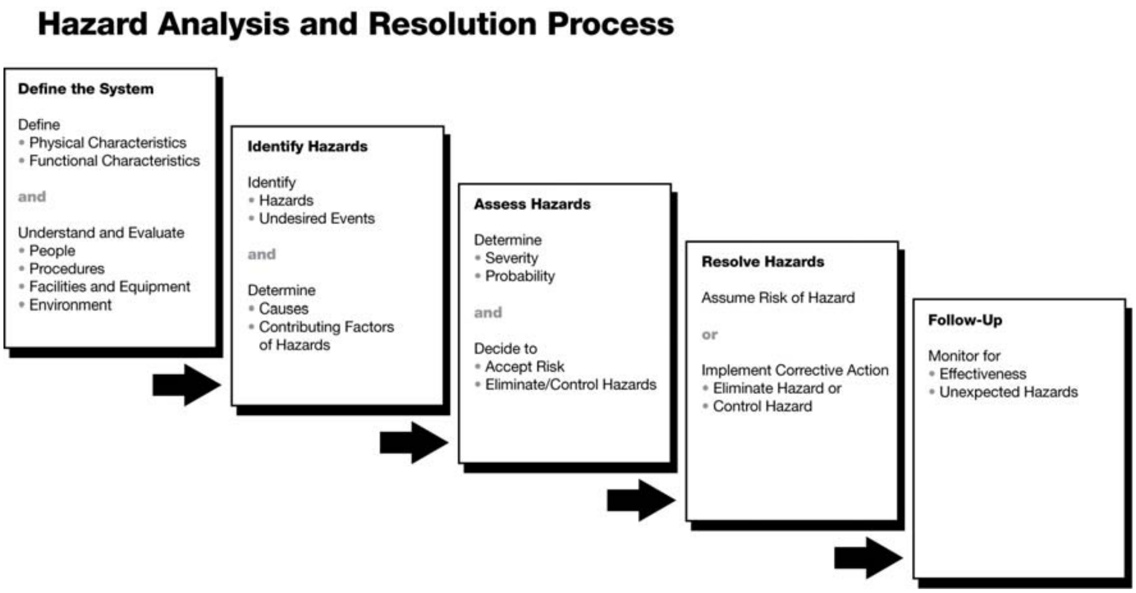

Figure 1. Schematic Diagram of the Hazard Analysis and Resolution Process

The following sections of this document provide step-by-step instructions on how to apply the hazard management process to passenger rail issues.

4.1 System Definition:

The first step of the hazard identification and resolution process is to define the system under consideration. A good system definition is important to understand the environment and interfaces that occur during operation of passenger trains – especially those elements that may positively or negatively affect safety. The system definition is best accomplished by individuals who are intimately familiar with the passenger rail operation.

The system definition should be a narrative statement that fully describes, at a minimum, train operations, rolling stock, track configuration, signal systems, infrastructure, and environment. The system definition should match or complement the system definition included in the railroad's existing system safety program plan. An example of appropriate information to include in the system definition follows:

Train Operations

- Number of trains per day
- Frequency of trains or train schedule
- Train headway
- Method of operation, including train control, train stop and civil speed enforcement systems

Rolling Stock

- Age and type(s) of equipment used
- Configuration (push-pull, MU)
- Manufacturer
- Passenger occupied areas
- Safety standards applied
- Crashworthiness standards applied

Track Configuration

- Types and location of special track work
- Grade crossings
- Civil speed restrictions
- Location and configuration of train yards
- Track maintenance program

Signal System

- Type and description of system
- Dragging equipment detectors
- Automatic train stops
- Flat wheel detectors

Infrastructure

- Bridges
- Tunnels
- Stations
- Industrial sidings or sites
- Other fixed objects or facilities along right-of-way

Environment

- Operating conditions
- Traction power source (diesel/electric)
- Freight or other rail traffic on adjacent or common lines
- Amount and type of highway grade crossing traffic
- Hazardous material
- Heavy truck traffic at industrial crossings

The system definition list presented above is not intended to be a complete list but a sample of the types of information that should be collected on the passenger rail property. The system definition list will vary depending on the specific conditions and circumstances that exist on a particular passenger railroad.

The system definition is best developed by a group of individuals with expertise in appropriate disciplines. Many organizations form a hazard management team to develop the definition, develop the hazard model, identify the hazards related to the operation, and identify appropriate mitigation strategies. The hazard management team consists of individuals who have detailed knowledge of the system. As a minimum, a passenger rail hazard management team should include representatives from the system safety, operations, mechanical, and track and signals departments. It is important that the hazard management team include all elements in the definition that could potentially affect safety. Therefore, the system definition should be prepared by someone very familiar with the passenger rail operation and reviewed by the hazard management team for completeness.

4.2 Hazard Identification:

The second step in the hazard analysis process is hazard identification. Hazard identification is looking for potential hazards or undesired events that may exist on the passenger railroad property. Use the hazard management team to identify the hazards. In this case, the area of interest is collisions so hazard identification should be restricted to those hazards related to primary or secondary collisions.

Hazard identification is a “What if?” activity that looks for potential causes and results of accidents. The hazard management team “brainstorms” to come up with as many credible hazards as possible for use in the hazard analysis.

Some hazards, such as primary collisions, may seem obvious. Primary collisions generally represent an extreme event for any passenger or freight train. Other types of accidents such as derailments and secondary collisions with fixed objects (such as bridge abutments), may not be as obvious but should be considered – especially on passenger railroads that have tunnels, bridges, grade crossings, or other fixed objects on or close to the right-of-way. Accident histories from other railroads are full of examples of crash dynamics (sometimes unexpected) during a derailment or collision. Use prior accidents as examples of what might happen and determine if the same scenario is possible on the railroad being analyzed.

Some of the hazards that should be considered in the hazard analysis are listed below. "Cab car" as used in this list indicates a passenger occupied rail vehicle that includes an operator cab with controls used to operate the train.

Train to train collisions

- Locomotive to passenger or freight locomotive(s)
- Cab car (or EMU/DMU) to cab car
- Cab car to passenger or freight locomotive(s)
- Cab car to freight car
- Cab car to passenger car
- Sideswipe collisions

Train to highway vehicle collisions

- Locomotive to automobile
- Cab car to automobile
- Locomotive to commercial/industrial vehicle
- Cab car to commercial/industrial vehicle
- Locomotive to wayside maintenance vehicle
- Cab car to wayside maintenance vehicle

Train to fixed object collisions (after derailment)

- Locomotive to tunnel portals
- Cab car to tunnel portals
- Locomotive to bridge abutments
- Cab car to bridge abutments
- Locomotive to fixed wayside objects
- Cab car to fixed wayside objects

Derailments

- Derailments at special track work
- Derailments that escalate due to track work
- Derailments that cause a train to leave the clearance envelope

As with the system definition list, the above list is not intended to be a complete list of all the hazards that should be considered. The hazard management team is in the best position to identify potential accidents on the specific passenger railroad.

The hazard management team should consider the physical characteristics of the passenger railroad when identifying the hazards. For example, the hazard management team should consider if special track work located in a specific area can initiate or escalate a derailment and result in a secondary collision with a fixed object.

An effective method for identifying hazards is to tour the system and take photographs of situations that may illustrate safety issues. Include photographs of grade crossings, special track work, station platforms, emergency walkways, industrial sidings, or any unusual conditions or events encountered during the tour. Use the photographs to generate discussions among the hazard management team on what types of hazards may exist at each location.

The following photographs contain examples of hazards that may be present on a passenger railroad. The photographs also illustrate how the passenger railroad can review their property to identify potential hazards. Some sample checklists that are used for assessing grade crossings and stations appear in Appendix C.

1. Crossovers can cause or escalate derailments and result in secondary collisions.

2. Highway overpass is potential source of vehicles or other objects falling on track.

3. Freight cars indicate siding where equipment can roll out and foul main line.

4 Unprotected bridge support could be damaged in a derailment and cause a collapse.

4.3 Hazard Assessment:

The hazard assessment approach involves assessing each hazard for severity and frequency to determine the relative risk of different types of occurrences. The assessment can be based on statistics or accident records (quantitative) or the collective opinions of a hazard management team (qualitative). Since quantitative data are often not available for accident severity or frequency or are not directly applicable to a specific passenger rail operation, a qualitative analysis, properly executed, is an acceptable method to perform hazard assessment.

The hazard assessment should use the passenger railroad's definitions for severity and frequency discussed in Sections 3.2 and 3.3. The severity and frequency rankings will lead to the hazard resolution procedures defined in the passenger railroad's system safety program plan or established by the hazard management team. The hazard resolution procedure should be established before beginning the hazard assessment process to prevent unnecessary disagreements on hazard assessment.

A risk matrix should be developed to provide a framework to categorize hazard severity and frequency and allow the hazards to be prioritized so that the most important hazards are addressed first. A passenger railroad may already have developed a standard risk matrix approach for hazard resolution and included the risk matrix in their system safety program plan. If an existing risk matrix for hazard resolution is not available, then develop an approach using the hazard management team.

The risk matrix also serves to establish the overall relative risk for each hazard. Risk is defined as a combination of the severity and frequency of a hazard. Table 4 contains a risk matrix for hazard resolution that considers the severity and frequency for each hazard.

	Hazard Categories			
Frequency of Occurrence	**I Catastrophic**	**II Critical**	**III Marginal**	**IV Negligible**
A – Frequent	1A	2A	3A	4A
B – Probable	1B	2B	3B	4B
C – Occasional	1C	2C	3C	4C
D – Remote	1D	2D	3D	4D
E – Improbable	1E	2E	3E	4E

Table 4. Risk Matrix Hazard Categories from MIL-STD-882

Associated with each level of risk are recommended actions that provide guidance on how to respond to each identified hazard. A list of recommended responses appears in Table 5.

Risk Matrix Hazard Category	**Suggested Action**
1A, 1B, 1C, 2A, 2B, 3A	Unacceptable, eliminate hazard.
1D, 2C, 2D, 3B, 3C, 4A, 4B	Undesirable, upper management decision to accept or reject risk.
1E, 2E, 3D, 3E	Acceptable with management review.
4C, 4D, 4E	Acceptable without review.

Table 5. Suggested Responses to Risk Matrix Hazard Categories

If the passenger railroad has used a different number of Severity or Frequency elements then the hazard matrix must be expanded or contracted accordingly.

For example, South Florida Regional Transit Authority uses nine severity definitions in their hazard management process. SFRTA labels their severity definitions “consequences.” The full list of SFRTA’s consequence classes and descriptions appears in Table 6.

SFRTA also uses expanded frequency categories. Rather than using the four frequency definitions listed in MIL-STD-882, SFRTA uses seven frequency definitions. The full list of the seven frequencies and the corresponding definitions is shown in Table 7.

Consequence Class	• Description
R	**Service Related –** • Delay in Revenue services, no direct effect on safety.
C1	**Negligible –** • Any hazard that can lead to superficial injuries, and may require first-aid treatment only. • Superficial system / equipment damage under $1000.
C2	**Minor –** • Any hazard that can lead to system / equipment damage, from $1000 – to the current reporting threshold amount. • Release of hazardous material into environment less than EPA reportable amount.
C3	**Minor with Medical Attention –** • Any hazard that can lead to a recoverable injuries that require admittance to an emergency room for testing and/or hospital for observation. • Exposure to hazardous material requiring medical treatment or observation.
C4	**Serious with Hospitalization –** • Any hazard that can lead to injuries which result in admittance to a hospital. • Could lead to fatality
C5	**Serious –** • Any hazard that can lead to non-recoverable injuries or may lead to a fatality. • Occupational disease or illness. • Hazards that could lead to multiple minor injuries. • System loss between current reporting threshold amount and $50,000. • Release of hazardous material into environment that is EPA reportable.
C6	**Serious with Multiple Injuries –** • Any hazard that can lead to more than 10 injuries in a single incident or more than 10 injuries in multiple incidents. • Could lead to a fatality. • Release of hazardous material into the environment that requires evacuation.
C7	**Critical –** • Any hazard that can lead to one or more fatalities, multiple serious injuries in one incident. • System / equipment loss in excess of $50,000. • Release of hazardous material into environment that will result in injury or death.
C8	**Disastrous –** • Any hazard that can lead to multiple fatalities or numerous serious injuries in a singular incident. • Hazards associated with Chemical, Biological, Radiological, Nuclear and Explosions.

Table 6. Table of South Florida Regional Transportation Authority (Tri-Rail) Consequence Definitions

Frequency	Definition
Certain Event	An event has occurred. The event will re-occur or has re-occurred at a singular location or may occur at other/multiple locations.
Likely Event	An event has occurred, based on a condition that exists and/or, based on the number of persons or equipment exposed to an identified hazard. Reports, observations or near miss data indicate an event may occur.
Probable Event	An event may occur at a singular, or at multiple locations based on an identified hazard.
Unlikely Event	An event arising from an unidentified condition(s) where sufficient analytical data does not exist to identify the condition(s).
Rare Event	An event has occurred on another commuter rail system with a similar operating environment and conditions exist that may lead to a similar event.
Improbable Event	Sufficient analytical data does not exist to indicate an event will occur. However, a series of identifiable conditions could occur, leading to an event.
Incredible Event	Conditions may not exist leading to an incredible event. However, unforeseen conditions outside of the system could occur, leading to an event on the system.

Table 7. Table of South Florida Regional Transportation Authority (Tri-Rail) Frequency Definitions

SFRTA's frequency and consequence definitions are used to create a 7 by 9 risk matrix to conduct hazard management on their property. Table 8 shows the complete SFRTA hazard risk matrix and corresponding disposition categories.

Frequency	Consequence								
	R	C1	C2	C3	C4	C5	C6	C7	C8
	Service Related	Negligible	Minor	Minor with Medical Care	Serious Admitted to Hospital	Serious	Serious with Multiple Injuries	Critical	Disastrous
Certain	R	B	B	B	A	A	A	A	A
Likely	R	C	B	B	B	B	A	A	A
Probable	R	C	C	B	B	B	B	A	A
Unlikely	R	C	C	C	C	C	B	B	A
Rare	R	D	C	C	C	C	C	B	B
Improbable	R	D	D	D	D	C	C	B	B
Incredible	R	D	D	D	D	D	D	C	C

Table 8. South Florida Regional Transportation Authority (Tri-Rail) Expanded Risk Matrix

The recommended hazard category dispositions based on the SFRTA Risk Matrix are listed in Table 9.

Risk Class	Description
A	**High Risk** - Short term mitigation actions must be taken immediately. Appropriate risk control measures will be implemented to reduce or eliminate the risk. Medium / Long term mitigation plans must be developed. Close observation and frequent review of mitigation plans must be evaluated for effectiveness.
B	**Medium Risk** - Short term mitigation actions must be taken as soon as practicable. Appropriate risk control measures will be implemented, if necessary, to reduce the risk. Medium / Long term mitigation plans must be developed and evaluated periodically for effectiveness.
C	**Low Risk** - Appropriate risk control measures may be implemented to reduce the risk. Medium / Long term mitigation plans may be developed to reduce or eliminate the risk and be periodically evaluated for effectiveness.
D	**Negligible Ris**k – Risk may be considered acceptable; no additional risk control action may be required. Appropriate risk control measures may be implemented to further reduce or eliminate the risk. Risk should be tracked in the hazard consequence log.
E	**Hazard Eliminated** - Hazard has been eliminated and/or condition(s) no longer exists.
R	**Service-Related** - No direct safety risk; no safety action is necessary. Not to be registered in the Hazard Log.

Table 9. South Florida Regional Transit Authority (Tri-Rail) Risk Matrix Disposition Categories

4.4 Hazard Resolution:

The results of the hazard identification and hazard assessment steps should be captured on a hazard analysis worksheet. The hazard analysis worksheet contains all of the information collected on each hazard and serves as the record of how hazards are to be controlled or mitigated. Use the worksheet for hazard management – to ensure that all identified hazards are systematically addressed. A sample worksheet including sample hazards appears in Table 10.

4.4.1 Hazard Analysis Worksheet

The left side of the hazard analysis worksheet contains information on each identified hazard. The hazard description and the cause and effects are included in this section along with an estimate of the severity and the frequency or probability of the hazard. It is important for the hazard to be adequately defined within the environment and operating parameters of the passenger railroad. A collision, for example, can include a variety of scenarios. Collisions can occur with a locomotive or cab car in either the lead or trail position. Collisions can occur between a passenger train and a highway vehicle (automobile, truck, commercial vehicle, or maintenance vehicle), another train (freight or passenger), miscellaneous rolling stock (freight cars, passenger equipment) or with other passenger trains in various configurations. It is important that these combinations be considered when analyzing collisions because the crash dynamics and results of each type of collision may be quite different.

The hazard process should also consider different locations and configurations on the system that may be critical in escalating an accident. The worst high speed rail accident in history was the derailment of a German ICE train near Eschede, Germany. The accident occurred in 1998 and resulted in 101 passenger and crew fatalities and more than 200 injuries. The derailment was initiated by a broken wheel. The broken wheel, however, did not immediately cause a general derailment. The general derailment occurred two miles later when the train encountered a turnout and bridge supports. The turnout and its close location to the bridge support escalated the derailment and caused all of the fatalities and injuries. The accident dynamics would have been quite different if the turnout and bridge supports were not in close proximity. The hazard management team should identify all locations along the passenger rail right-of-way that could potentially cause or escalate an accident.

4.4.2 Developing Mitigation Approach

The right side of the worksheet includes information on the mitigation approach – the strategy adopted to reduce the severity or the frequency of the hazard. Once a mitigation approach is determined, the effect of the mitigation strategy on the severity and the probability or frequency of the hazard is estimated and the revised risk matrix figure is recorded on the worksheet. Make sure that a mitigation strategy does not have an adverse effect on another part of the operation and cause an unintended safety issue. In this manner, hazards that require mitigation can be moved to a lower risk matrix category where the risk may be more acceptable to the passenger railroad operator. As mitigation actions are implemented, the status of the hazard will change from open to closed. The last column should include references to the dates and documents that establish the closure action.

SAMPLE HAZARD ANALYSIS WORKSHEET									
HAZARD IDENTIFICATION					**MITIGATION APPROACH**				
Hazard Number	Hazard Description	Cause	Effects	S P	Mitigation Strategy	Rev. S Rev. P	Status	Responsibility	Comments
1.1	Cab Car Grade Crossing Collision with Industrial Vehicle	Collision at Industrial Grade Crossing located at Milepost 234.5.	Cab car penetrated and derailed. Severe/Fatal Injuries to crew and passengers.	2C	SHORT TERM: Reduce train speed from 50 mph to 30 mph to reduce severity and increase effective sight distance. Remove brush in the area of the grade crossing to increase visibility.	3D	Closed	Operations Department Track & Signals Dept.	See Revised Time Table dated 11-01-2005.
				2C	MEDIUM TERM: Petition state to add crossing gates to crossing.	3E	Open	Admin. Government Affairs	Include in the FY 2007 Request
				2C	LONG TERM: Work with industry to Eliminate Grade Crossing	4E	Open	Grade Crossing Safety Committee	Meet with ACME Steel to negotiate construction of an overpass to increase safety and reduce delivery delays.
1.2	Cab Car Collision with Freight rolling stock	Vandals release hand brakes on cut of cars located on industry siding.	Cab car strikes freight cars. Cab car penetrated. Severe/Fatal Injuries to crew and passengers.	2B	SHORT TERM: Increase local police patrols in the areas of greatest risk. Add lighting in the area of the siding.	2E	Open	Security RR Police Dept. Facilities	Develop MOU with local police department to patrol area. Include improved lighting enhancements in the annual budget.
				2B	MEDIUM TERM: Install automatic derail to prevent freight cars from fouling main.	3E	Open	Track & Signals Dept...	Include automatic derail in the track capital budget.

EXAMPLE

Table 10. Hazard Analysis Worksheet (Illustrative Only)

Some hazards will require more than one mitigation strategy. For example, a passenger railroad may decide to limit passengers in the forward end of the train as a way of reducing the risk of passenger injury. This would be a valid short term strategy but may not be appropriate in the long term. A longer term strategy, however, may be to provide a positive train control system or to require energy absorbing crush zones or additional crashworthiness features on new rolling stock. Improvements in rolling stock crashworthiness may represent a valid method to better protect passengers but is one that cannot usually be achieved immediately. Therefore, the mitigation strategies or actions are sometimes categorized as short term, medium term, or long term actions.

4.4.3 Hazard Precedence

The hazard precedence approach is a technique for controlling hazards during different phases of the system life cycle. Keep the hazard precedence approach to hazard mitigation in mind when developing mitigation strategies. The approach is most often used on new systems because many hazards can be eliminated during the design stage – before the system is initiated and put in service. The hazard precedence approach, however, is also useful when assessing existing systems, although changes to the design become retrofits and are generally far more expensive.

The hazard precedence approach encompasses the following philosophy to eliminate or control hazards:

- Design to eliminate hazards
  - Design to control hazards
    - Provide safety devices
      - Provide warning devices
        - Provide special procedures or training
          - Accept hazard or dispose of system

A flowchart and decision matrix for applying the hazard precedence model is shown in Figure 2.

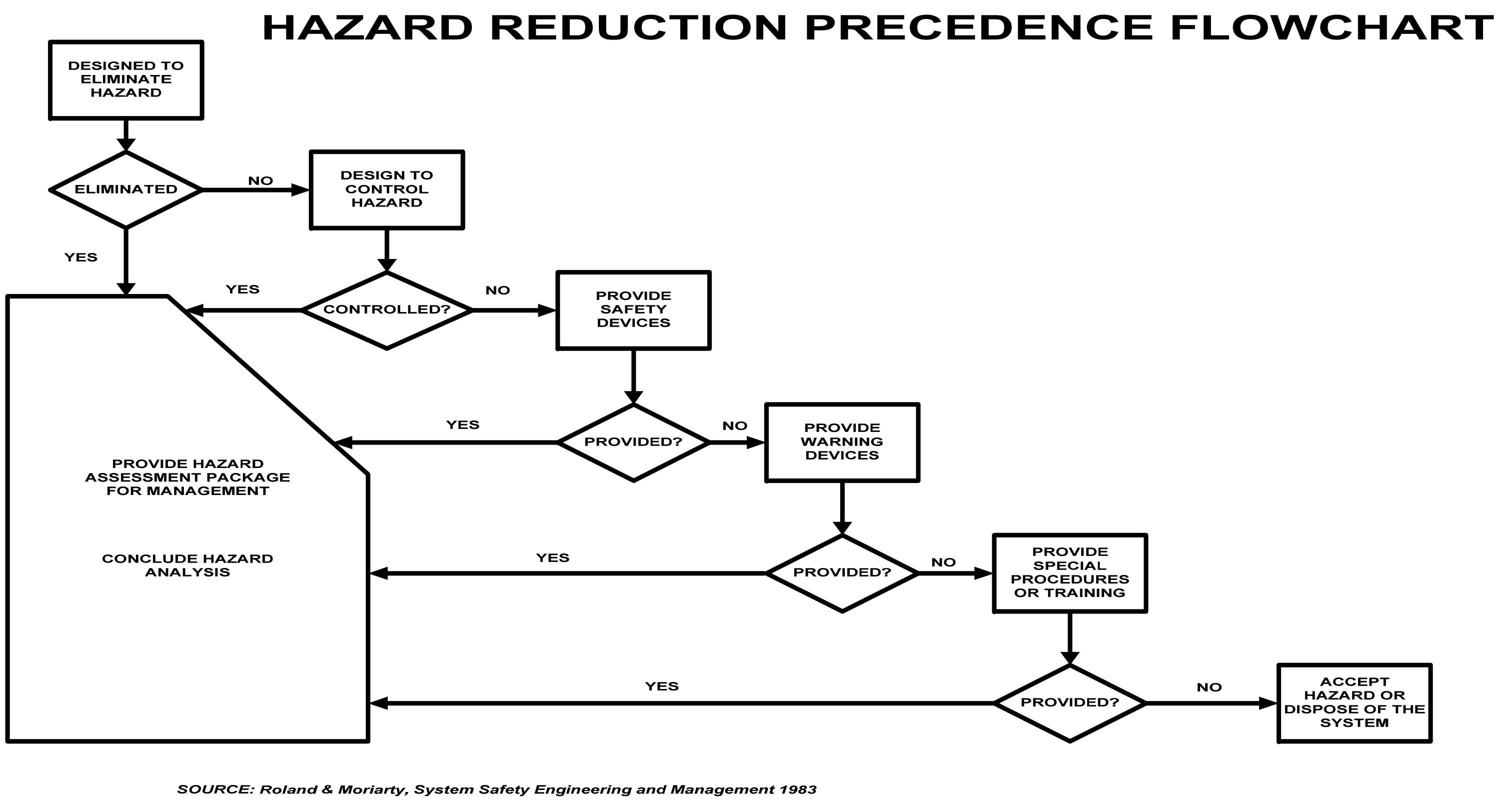

Figure 2. Hazard Reduction Precedence Flowchart

Follow-Up

The hazard management team should conduct regular reviews of the hazard analysis worksheet to ensure that mitigation strategies are fully implemented and all hazards are satisfactorily closed out. Medium term and long term actions should be tracked to completion. The hazard analysis can also be used to justify capital dependent mitigation strategies and help maintain visibility during budget requests.

Hazard analysis is not a one-time activity. The techniques described in this document should regularly be applied to the passenger rail system as changes occur in the configuration or the operation of the system and as the external environment changes. The hazard analysis worksheets should be revisited and updated whenever changes occur. Changes that can affect the hazard analysis include:

- New or expanded passenger service
- Revised operations procedures
- Procurement of new or modified equipment
- Changes to grade crossing traffic mix or protection equipment

It is important to make the hazard analysis a living process that can be modified and updated as new information is collected about the passenger rail operation. The hazard analysis worksheets should also be reviewed after each incident or accident to determine if the hazard analysis is valid or needs to be updated. The analysis is reviewed to determine if all hazards were identified and if frequency and severity information remains well-founded. The hazard analysis should be updated with new information as it becomes available.

Some passenger railroads hire consultants to conduct hazard analysis. Consultants often have extensive experience in conducting hazard analysis; however, hazard analysis is an ongoing process that requires full participation by the passenger railroad. The railroad must manage and update the hazard analysis over the long term. A short term consulting contract will make these goals difficult.

If a passenger railroad needs to use a consultant to conduct a hazard analysis, make sure that the consultant is part of a hazard management team that includes appropriate railroad personnel so that the hazard analysis can be taken over by the railroad when the consulting contract ends.

5. Summary:

FRA encourages passenger rail operators to evaluate the collision risk associated with passenger rail operations. There is a history of tragic accidents that resulted in serious injuries to passengers and crew. The outcome of some of these accidents may have been less tragic if mitigation strategies to better protect train occupants had been developed and implemented.

FRA requests the passenger rail operators to perform their own collision hazard analysis and identify methods that they can use to make their operation safer, especially considering the vulnerability of equipment and the potential risk to persons occupying passenger spaces. Using this hazard management approach, FRA hopes to achieve improvements in passenger rail safety and sharing of hazard management information among passenger rail operators.

The hazard management and hazard analysis approach outlined in this document represents one method to conduct a collision hazard analysis. However, there are many other methods and techniques for conducting a hazard analysis. Additional information on how to apply hazard analysis techniques to railroad operations exists in a variety of documents. The documents listed in the Bibliography represent a small sample of the type of information available.

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Acronyms

APTA	American Public Transportation Association
DMU	diesel multiple unit
EMU	electric multiple unit
FMEA	Failure Modes and Effects Analysis
FRA	Federal Railroad Administration
MIL-STD-882	Military Standard 882 (System Safety Program Requirements)
MOU	memorandum of understanding
OHA	Operating Hazard Analysis
PHA	Preliminary Hazard Analysis
SSPP	System Safety Program Plan
SFRTA	South Florida Regional Transportation Authority (Tri-Rail)
VRE	Virginia Railway Express

Appendix A. Sample Severity Definitions

Virginia Railway Express Category Definition

		MIL-STD 882	Virginia Railway Express (VRE)
Category	Description	Definition	Definition
I	Catastrophic	Death, system loss, or severe environmental damage	Operating conditions are such that human error, design deficiencies, element, subsystem or component failure or procedural deficiencies may result in collisions that result in multiple fatalities or major system loss and requires immediate termination of the unsafe activity or operation until the hazard is mitigated. For the purposes of this project, at VRE this can be defined as multiple losses of life, severe damage or total loss to multiple railcars, severe damage to rail infrastructure (rail, signals, roadbed, etc.), or other system loss that will cause all or a portion of the system to be unavailable for normal operations for an extended period of time (defined as greater than 30 calendar days). Subcategories: 1.1 Loss of life (passenger, employee, contractor or public) 1.2 Severe damage to vehicles 1.3 Severe damage to rail infrastructure 1.4 Other serious system loss (rail control, station loss, hazardous material release, sabotage/terrorism, etc.) 1.5 Two or more of the above subcategories affected
II	Critical	Severe injury, severe occupational illness, major system or environmental damage	Operating conditions are such that human error, subsystem or component failure or procedural deficiencies may result in collisions that cause severe injuries or major system damage and require immediate corrective action to mitigate the hazard. This can be defined as multiple severe injuries resulting from collisions, railcars that have major damaged but repairable, rail infrastructure that is damaged but can be repaired sufficiently within a month to allow service to operate in the area, or other significant system loss that is not severe enough to prevent some restoration of service within 30 calendar days. Subcategories: 1.1 Severe injuries to passengers, employees, contractors or public 1.2 Major damage to railcars 1.3 Major damage to rail infrastructure

Virginia Railway Express Category Definition

		MIL-STD 882	**Virginia Railway Express (VRE)**
Category	Description	Definition	Definition
			1.4 Other major system loss 1.5 Two or more of the above subcategories affected
III	Marginal	Minor injury, minor occupational illness, or minor system or environmental damage	Operating conditions are such that they may result in collisions with minor injuries or system damage and are such that human error, subsystem or component failures can be counteracted or controlled. These collisions are of the type that does not interrupt regular service for more than one to two days. Subcategories: 1.1 Moderate injuries to passengers, employees, contractors or public 1.2 Moderate damage to railcars 1.3 Moderate damage to rail infrastructure 1.4 Other moderate system loss 1.5 Two or more of the above subcategories affected
IV	Negligible	Less than minor injury, occupational illness, or less than minor system or environmental damage	Operating conditions are such that human error, subsystem or component failure or procedural deficiencies will result in collisions with no significant effect on the system. Service is interrupted for very few passengers for less than one day. The categorization of hazards is consistent with risk-based criteria for severity; it reflects the principle that not all hazards pose an equal amount of risk. No subcategories are required for negligible effects of a collision.

South Florida Regional Transportation Authority (SFRTD) (Tri-Rail) Consequence Class Description

Consequence Class	Description
R	**Service Related –** • Delay in Revenue services, no direct effect on safety.
C1	**Negligible –** • Any hazard that can lead to superficial injuries, and may require first-aid treatment only. • Superficial system/equipment damage under $1000.
C2	**Minor –** • Any hazard that can lead to system/equipment damage, from $1000 – to the current reporting threshold amount. • Release of hazardous material into environment less than EPA reportable amount.
C3	**Minor with Medical Attention –** • Any hazard that can lead to a recoverable injuries that require admittance to an emergency room for testing and/or hospital for observation. • Exposure to hazardous material requiring medical treatment or observation.
C4	**Serious with Hospitalization –** • Any hazard that can lead to injuries which result in admittance to a hospital. • Could lead to fatality.
C5	**Serious –** • Any hazard that can lead to non-recoverable injuries or may lead to a fatality. • Occupational disease or illness. • Hazards that could lead to multiple minor injuries. • System loss between current reporting threshold amount and $50,000. • Release of hazardous material into environment that is EPA reportable.
C6	**Serious with Multiple Injuries –** • Any hazard that can lead to more than 10 injuries in a single incident or more than 10 injuries in multiple incidents. • Could lead to a fatality. • Release of hazardous material into the environment that requires evacuation.
C7	**Critical –** • Any hazard that can lead to one or more fatalities, multiple serious injuries in one incident. • System/equipment loss in excess of $50,000. • Release of hazardous material into environment that will result in injury or death.
C8	**Disastrous –** • Any hazard that can lead to multiple fatalities or numerous serious injuries in a singular incident. • Hazards associated with Chemical, Biological, Radiological, Nuclear and Explosions.

Appendix B. Sample Frequency Definitions

Hazard Frequency Categories

		MIL-STD-882	**MIL-STD-882**	**Tri-Rail**	**VRE**
Level	Description	Quantitative Definition (Frequency x)	Qualitative Definition	Qualitative Definition	Qualitative Definition
A	Frequent	$x > 1x10^{-1}$	Likely to occur frequently, continuously experienced in the fleet.	**Certain Event** An event has occurred. The event will recur or has recurred at a single location or may occur at other/multiple locations. **Likely Event** An event has occurred, based on a condition that exists and/or based on the number of persons or equipment exposed to an identified hazard. Reports, observations or near-miss data indicate an event may occur.	The probability of a particular event or a specific hazard occurring may be defined as a nondimensional ratio of the number of times that a specific event occurs to the total number of trials in which this event will occur during the planned life expectancy of a system. Generally, hazard probability is described qualitatively in potential occurrences per units of time, miles, trips/runs or passengers carried. A hazard probability may be derived from the analysis of transit system operating experience, evaluation of VRE safety data or from historical safety data from other passenger rail systems. Likely to occur frequently to an individual item or continuously experienced in the system. Examples in the case of collisions include unprotected grade crossings or rail operators not being efficiency tested.
B	Probable	$1x10^{-1} > x > 1x10^{-2}$	Will occur several times in the life of an item; will occur frequently in the fleet.	**Probable Event** An event may occur at a singular, or at multiple locations based on an identified hazard.	Will occur several times in the life of an item or will occur frequently in the system. Examples include trespassers on the right-of-way and suicides.

Hazard Frequency Categories

		MIL-STD-882	MIL-STD-882	Tri-Rail	VRE
Level	Description	Quantitative Definition (Frequency x)	Qualitative Definition	Qualitative Definition	Qualitative Definition
C	Occasional	$1x10^{-2} > x > 1x10^{-3}$	Likely to occur sometime in the life of an item; will occur several times in the fleet.	**Unlikely Event** An event arising from an unidentified condition(s) where sufficient analytical data does not exist to identify the condition(s).	Likely to occur sometime in the life of an item or will occur several times in the system. Examples include rules or signal violations by qualified employees, and undetected or uncorrected mechanical or infrastructure defects.
D	Remote	$1x10^{-3} > x > 1x10^{-6}$	Unlikely but possible to occur in the life of an item, unlikely but can reasonably be expected to occur in the fleet.	**Rare Event** An event has occurred on another transit system with a similar operating environment and conditions exist that may lead to a similar event.	Unlikely, but possible to occur in the lifetime of an item. Unlikely, but can be expected to occur in the system. Examples include impairment or fatigue of qualified operators, operator illness or incapacitation or major infrastructure or software failure.
E	Improbable	$1x10^{-6} > x$	So unlikely that it can be assumed occurrence may not be experienced, unlikely to occur but possible.	**Improbable Event** Sufficient analytical data does not exist to indicate an event will occur. A series of identifiable conditions could occur, however, leading to an event. **Incredible Event** Conditions may not exist leading to an incredible event. Unforeseen conditions outside the system could occur, however, leading to an event on the system.	So unlikely to occur, it can be assumed possible that occurrence may not be experienced. These types of collisions are most unlikely, but possible to occur in system. Examples include acts of sabotage or terrorism.

Appendix C. Sample Hazard Analysis Forms

The following six checklists offer examples of measuring risk and probability.

Grade Crossing Assessment

Highway Grade Crossing Name**:**	Location:	Mile Post:
Crossing Jurisdiction	DOT No:	
Type of Crossing Warning (Check all that apply): ☐Gates ☐Cantilever FLS ☐Standard FLS ☐Wig Wags ☐Hwy. Traffic Signals ☐Bells ☐Cross bucks ☐Stop signs ☐Key down feature ☐Do not stop on tracks FLS ☐Gate arm lights ☐ Other		4 quadrant gates ☐Yes ☐No 9 inch curbs ☐Yes ☐No
Vehicle View of track obstructed by: ☐Permanent Structure ☐Standing RR Equipment (Distance:) ☐Standing Train (Distance:) ☐Topography ☐Vegetation ☐Wayside Structure ☐Not Obstructed ☐Other:		Whistle Ban ☐Yes ☐No Whistle Ban Signs Posted ☐Yes ☐No
Train View of crossing obstructed by: ☐Permanent Structure ☐Standing RR Equipment (Distance:) ☐Standing Train (Distance:) ☐Topography ☐Vegetation ☐Wayside Structure ☐Not Obstructed ☐Other		
Track Speed Thru Crossing Frt: Psgr: Commuter: Typical Speed Thru Crossing Frt: Psgr: Commuter:	Location of warning: ☐Both Sides ☐Side of Vehicle Approach ☐Opposite Side of Vehicle Approach	Crossing illuminated by street or special lights ☐Yes ☐No
Adjacent Intersection Description		

Grade Crossing Assessment

Adjacent Intersection Description
Distance in feet to adjacent road: Parallel connecting road:
At grade ☐Yes ☐No Grade Separated ☐Yes ☐No

Train Detection: ☐Constant Warning Time ☐Motion Detectors	Traffic Light Interconnection / Preemption ☐Not interconnected ☐Simultaneous Preemption ☐Advance Preemption	Type of development ☐Open Space ☐Residential ☐Commercial ☐Industrial

Number of Traffic Lanes crossing tracks East: West:	Truck Pull out lanes Highway On / Off Ramps: (Distance:) ☐Yes ☐No	Posted highway speed	Does traffic queue across tracks ☐Yes ☐No Time:

Nearby intersection is it signalized ☐ Yes ☐Less than 75 feet ☐75 to 200 feet ☐200 to 500 feet ☐N/A ☐ No	Are there sidewalks on the approaches of the crossing ☐Yes ☐No
Crossing surface ☐Timber ☐Asphalt ☐Asphalt & Flange ☐Concrete ☐Concrete & Rubber ☐Rubber ☐Metal ☐Other	Do sidewalks go through the crossing ☐Yes ☐No Pedestrian crossing gates ☐Yes ☐No

Pavement markings ☐Stop lines ☐RR Xing Symbols ☐None

Grade Crossing Assessment

Is the crossing near a station ☐Yes ☐No Distance:	Is the crossing near an interlocking ☐Yes ☐No Distance:	Is the crossing affected by switching operation in the area ☐Yes ☐No Location:
Avg. Vehicular traffic	Avg. Bus traffic	Avg. Pedestrian traffic
Avg. Truck traffic	Hazardous Material route	Event Recorder ☐Yes ☐No
Is the crossing in close proximity to: ☐Schools ☐Bus Stops ☐Parks ☐Other (explain) ☐Playgrounds		
Other: Other:		

Access Database Consequence

ID #: 1
DATE: 1/29/2006

CONSEQUENCE CATAGORY: COLLISION
CONSEQUENCE: Train with motor vehicle at highway rail grade crossing

POTENTIAL CAUSE: Train crew visibility is obscured by light posts, signal masts & boxes, fencing, vegetation and fixed structure

EFFECTS: Loss of life, serious injury, damage to equipment, service disruption

CONSEQUENCE CLASS: C5
FREQUENCY CLASS: PROBABLE
RISK CLASS: B

MITIGATION: Assess crossing with obstructions (see notes)

POST CONSEQUENCE CLAS: C5
POST FREQUENCY CLASS: UNLIKELY
POST RISK CLASS: C

OPEN: ☑
CLOSED: ☐
NOTES: Assesments of all crossings are being conducted to identify crossings with this condition. As of 04/04/06 vegetation has been cut back at some locations. OL safety blitzes are being conducted. Identification of signal masts and signal boxes that may need to be relocated is

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ID #: 2
DATE: 1/29/2006

CONSEQUENCE CATAGORY: COLLISION
CONSEQUENCE: Train with motor vehicle or pedestrian

POTENTIAL CAUSE: Missing or misplaced wayside whistle post signs. Engineers may not give sufficient audible warning before entering

EFFECTS: Loss of life, serions injury, damage to equipment, service disruption

CONSEQUENCE CLASS: C5
FREQUENCY CLASS: PROBABLE
RISK CLASS: B

MITIGATION: Assess whistle post for location (See Notes)

POST CONSEQUENCE CLAS: C5
POST FREQUENCY CLASS: UNLIKELY
POST RISK CLASS: E

OPEN: ☐
CLOSED: ☑
NOTES: CSXT & TCRC completed an assesment of whistle post locations and replaced missing whistle post.

SFRTA CONSEQUENCE LOG

ID #	DATE	CONSEQUENCE CATAGORY	CONSEQUENCE	CONSEQUENCE CLASS	FREQUENCY CLASS	RISK CLASS
1	1/29/2006	COLLISION	Train with motor vehicle at highway rail grade crossing	C5	PROBABLE	B

POTENTIAL CAUSE

Train crew visibility is obscured by light posts, signal masts & boxes, fencing, vegetation and fixed structure

POST CONSEQUENCE CLASS	POST FREQUENCY CLASS	POST RISK CLASS
C5	UNLIKELY	C

OPEN	CLOSED
☑	☐

EFFECTS

Loss of life, serious injury, damage to equipment, service disruption

MITIGATION

Assess crossing with obstructions (se

NOTES

Assesments of all crossings are being conducted to identify crossings with this condition. As of 04/04/06 vegetation has been cut back at some locations. OL safety blitzes are being conducted. Identification of signal masts and signal boxes that may need to be relocated is being completed. Use of a mirror may mitigate the condition at some locations, feasiblity is being determined.

ID #	DATE	CONSEQUENCE CATAGORY	CONSEQUENCE	CONSEQUENCE CLASS	FREQUENCY CLASS	RISK CLASS
2	1/29/2006	COLLISION	Train with motor vehicle or pedestrian	C5	PROBABLE	B

POTENTIAL CAUSE

Missing or misplaced wayside whistle post signs. Engineers may not give sufficient audible warning before entering a gr

POST CONSEQUENCE CLASS	POST FREQUENCY CLASS	POST RISK CLASS
C5	UNLIKELY	E

OPEN	CLOSED
☐	☑

EFFECTS

Loss of life, serions injury, damage to equipment, service disruption

MITIGATION

Assess whistle post for location (See

NOTES

CSXT & TCRC completed an assesment of whistle post locations and replaced missing whistle post.

Monday, May 01, 2006

Page 1 of 1

Consequence Log

VRA Safety/Security Report

VRE SAFETY/SECURITY REPORT #

DATE REPORTED:
TIME REPORTED:

REPORTED TO:
LINE/TRAIN:
(Identify Dispatch Center if Applicable)

LOCATION:
HOW IDENTIFIED:

BY WHOM:

DESCRIPTION OF INCIDENT OR CONDITION (Attach Extra Sheets as Necessary):

HAZARD ASSESSMENT:

FOLLOW-UP HAZARD ASSESSMENT NEEDED?
IF YES, BY WHOM?

VRA Safety/Security Report

SKETCH OF THE INCIDENT:

RESOLUTION:
DATE OF RESOLUTION:

ACTIONS TAKEN

RESOLUTION HAZARD ASSESSMENT:

FURTHER ACTION NEEDED:

ACTION(S) REQUIRED:

PERSON(S) RESPONSIBLE FOR FOLLOW-UP AND CLOSURE:

1/25/03

VRE Grade Crossing Inspection Form

Crossing Location Inspected and Railroad Ownership:			**Date Inspected:**			
Inspected By:			**Time:**			
Components Inspected	**(A)cceptable, (U)nacceptable** or **(N/A)** not applicable	**Exceptions Reported To** (Railroad or Agency**)**	**Person Receiving Report**	**Date And Time Reported**	**Follow-up Date**	**Date Corrected**
Crossing Approach Warning Signs						
Humpback Crossing Warning Signs						
Warning Signs on Crossing						
Pavement Approach Warning Markings						
Multiple Track Signs						
Pavement Approach Conditions						
Crossing Pavement or Timber Conditions						
Track Sight Distance, Obstructions, Brush, Foliage, Etc.						
Warning Lights at Crossing						
Protective Gates at Crossing						
Other, not listed						

Remarks: