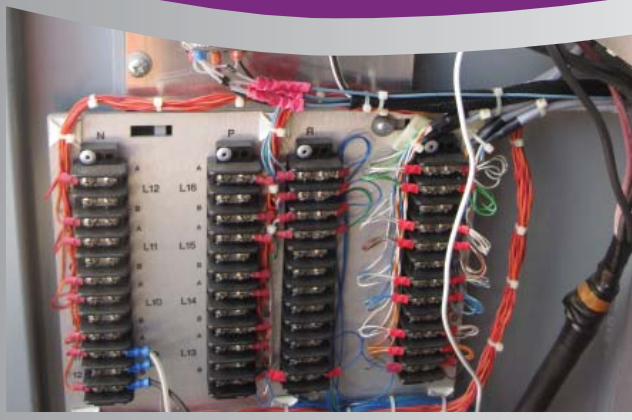
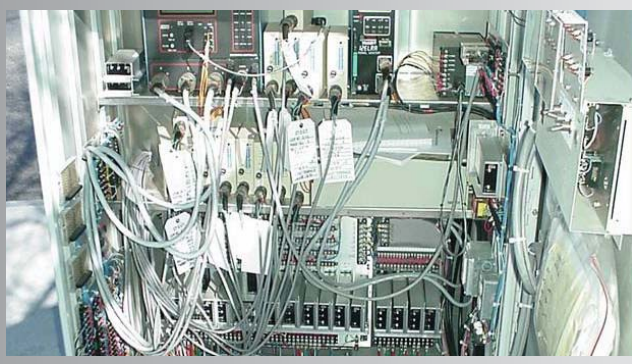
Recording Devices for Interconnected Grade Crossing and Intersection Signal Systems: An Informational Report





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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-SA-12-020		

4. Title and Subtitle	5. Report Date
Recording Devices for Interconnected Grade Crossing and Intersection Signal Systems: An Informational Report	October 2012
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
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9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
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	11. Contract or Grant No. DTF61-05-D-00024

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Federal Highway Administration *Office of Safety* *1200 New Jersey Ave., SE* *Washington, DC 20590*	Final Report September 2010-September 2012
	14. Sponsoring Agency Code

15. Supplementary Notes

This report was produced under the FHWA contract DTF61-10-D-00022-T-11003. The Contracting Officer's Technical Manager (COTM) was Guan Xu, FHWA Office of Safety. The USDOT Technical Panel members were Brian Gilleran, Joe Glinski, Jeff Shaw, Chris Webster, and Wei Zhang.

16. Abstract

Over 15 years ago, the National Transportation Safety Board (NTSB) issued 29 recommendations to improve safety at active controlled highway-rail grade crossings following the school bus-commuter train collision in Fox River Grove, Illinois. The objective of this task order was to develop technical information to assist highway agencies and railroads with integrating effective event recording devices within interconnected/preempted highway-rail grade crossing signal systems. This information is intended to be applicable to the installation of new systems as well as to retrofitting existing systems. The objective also included developing technical information that could be used to establish periodic inspection of traffic signals by State and local highway agencies as well as detailed joint annual inspections of interconnected highway-rail grade crossing signal systems. Specific emphasis was placed on highway agencies, as there are currently no national regulations to counterpart 49 CFR 234 and AREMA mandates for railroad agencies. The outcomes of this effort are focused to help the Federal Highway Administration (FHWA) and the Federal Railroad Administration (FRA) implement the two NTSB recommendations, supporting Safety Advisory 2010-02.

17. Key Words	18. Distribution Statement
Railroad, Highway, Grade Crossing, Intersection, Event Recording, Signal Systems, Preemption	No restrictions.

19. Security Clasif. (of this report)	20. Security Clasif. (of this page)	21. No. of Pages	21. Price
Unclassified	Unclassified	131	

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LIST OF ABBREVIATIONS

AHWS	Automatic Highway Warning System
AREMA	American Railway Engineering and Maintenance-of-Way Association
ATC	Advanced Transportation Controller
CFR	Code of Federal Regulations
DIR	Direction of Train
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
HRI	Highway Railroad Intersection
ICO	Island Circuit Occupied
IEEE	Institute of Electrical and Electronics Engineers
IMSA	International Municipal Signal Association
LTI	Long Term Obstacle Indicator
MUTCD	Manual on Uniform Traffic Control Devices
NEMA	National Electrical Manufacturers Association
NGD	Entrance Gate Down
NGP	Entrance Gate Present
NGU	Entrance Gate Up
NTSB	National Transportation Safety Board
PEA	Preemption Warning Active
PER	Preemption Relay
PSP	Product Safety Plan
RSO	Roadway System Operational
RSPP	Railroad Safety Program Plan
SO	System Operational (railroad)
TPD	Train Presence Detection
USDOT	United States Department of Transportation
VAS	Vehicle Arrestor Barrier Status
VP	Vehicle Presence
WSA	Warning System Active
XGD	Exit Gate Down
XGP	Exit Gate Present
XGU	Exit Gate Up
XR	Grade Crossing Relay

CHAPTER 1. INTRODUCTION

In 1996, the National Transportation Safety Board (NTSB) issued a final investigative report on the school bus-commuter train collision that occurred at a highway-rail grade crossing in Fox River Grove, Illinois (1). In the report, 29 recommendations were made to improve safety at active controlled highway-rail grade crossings that are interconnected with adjacent signalized intersections. Two recommendations were classified as "Open – Unacceptable Response" by NTSB for a number of years:

1. *NTSB Recommendation I-96-010. NTSB recommends that DOT require the use and maintenance of railroad and highway/traffic signal recording devices on all new and improved installations at railroad/highway grade crossings that have active warning train detection systems and are interconnected/preempted to highway signal systems. These devices record sufficient parameters to allow railroad and highway personnel to readily determine that the highway signals and railroad-activated warning devices are coordinated and operating properly. NTSB recommends that DOT require that the information from these devices be used during comprehensive and periodic joint inspections.*

2. *NTSB Recommendation I-96-011. NTSB recommends that DOT requires that existing recording devices for railroad and highway signals systems at interconnected/preempted grade crossings be retained or upgraded as necessary; requires that these recording devices be maintained and that the information from these devices be used during the comprehensive and periodic joint inspections.*

In September 2010, the Federal Railroad Administration (FRA) issued Safety Advisory 2010-02 to address these two recommendations (2). The advisory recommended that four actions be taken by highway agencies and railroads:

1. *Each State and local highway authority and railroad should conduct comprehensive joint inspections of highway traffic signal pre-emption interconnections when the highway-rail grade crossing active warning system is placed in service, whenever any portion of the system which may affect the proper function of the interconnection is modified or disarranged, and at least once every 12 months, during which observation of the actual pre-emption function and its effect on the highway traffic signal system can be made;*

2. *Each State and local highway authority and railroad should install railroad and highway traffic signal recording devices at all new and improved highway-rail grade crossings that have active warning systems which are interconnected with highway traffic signal systems;*

3. *Each State and local highway authority and railroad should maintain and upgrade existing railroad and highway traffic signal recording devices at highway-rail grade crossings that have active warning systems which are interconnected with highway traffic signal systems; and*

4. *Each State and local highway authority and railroad should use the data provided by railroad and highway traffic signal recording devices during their comprehensive periodic joint inspections of interconnected highway-rail grade crossing active warning systems and highway traffic signal systems to determine whether further investigation of any recorded operational anomalies may be warranted.*

Following the issuance of the Safety Advisory, NTSB changed their classification of the two recommendations to "Closed – Acceptable Alternate Action".

The objective of this task order was to develop technical information that would assist highway agencies and railroads with integrating effective event recording devices within interconnected/ preempted highway-rail grade crossing signal systems. This technical information is intended to be applicable to the installation of new systems as well as to retrofitting existing systems. The objective also included developing technical information that could be used by State and local highway agencies as they perform periodic inspection of traffic signals as well as detailed joint annual inspections of interconnected highway-rail grade crossing signal systems. The outcomes of this effort are focused to help the Federal Highway Administration (FHWA) and the FRA implement the two NTSB recommendations, supporting Safety Advisory 2010-02.

The tasks completed to achieve the objective were as follows:

- Collect, Review, and Evaluate Available Technologies and Current State-of-Practice.
- Develop a Technical and Policy Information Document.
- Develop a Model Strategy for States to Establish Regular Joint Inspections of Interconnected Systems.

This report documents the findings and outcomes of these individual tasks.

CHAPTER 2. EXISTING EVENT RECORDING TECHNOLOGY AND CURRENT PRACTICE

Currently, the technology being installed in highway traffic signal controller cabinets and railroad grade crossing equipment bungalows includes some ability to record event data. The data recorded, however, are not always either easily retrieved or of much use for effective analysis. Additionally, communication and data transmission between the highway and railroad systems is relatively limited.

This chapter summarizes the collection and analysis of information related to existing recording capabilities of devices installed within highway traffic signal controller cabinets and/or railroad grade crossing equipment bungalows. A brief description of a "market–available" event recording device is provided; no product endorsement is made or implied by its inclusion in this document. This chapter also documents current highway agency and railroad testing, inspection, and regulation practices pertaining to interconnected signal systems.

2.1 Event Recording Technology

2.1.1 HIGHWAY

There are many different types of devices used in highway traffic signal controller cabinets that can record various types of events or information. These devices are manufactured according to several national standards for signal control assemblies, including NEMA TS-1, NEMA TS-2 Type 1, NEMA TS-2 Type 2, Type 170, Type 179, Type 2070, and ATC. Some agencies use a hybrid approach to highway traffic signal cabinet architecture and customize these standards to meet their unique individual requirements. Field examples of highway traffic signal control assemblies and data transfer set-ups are shown in Figure 1.

Table 1 summarizes the various highway traffic signal control device manufacturers, listed by device type. Based on the manufacturer listing, a sampling of events (or alarms) that can be recorded and stored as data in each highway traffic signal control cabinet device is presented in Table 2. Please note that the information presented in Table 1 and Table 2 is for highway traffic signal controller applications only. Additionally, the listing in Table 2 contains events (or alarms) related to highway traffic signal control that may be relevant in maintaining highway-rail grade crossing operation; not every event (or alarm) would be recorded, but could be investigated as second- or third-tier information if an incident did occur. Most in-cabinet event recording systems are focused on system malfunction monitoring of such anomalies as signal conflicts, field circuit failures, short interval occurrences, internal electrical levels out of range, and electrical noise. Traffic flow information can also be logged, as well as a variety of user-defined functions such as cabinet door open, keyboard data change, and system coordination status. The event recording capability varies depending on cabinet architecture. The exact number and type of events (or alarms) recorded also vary greatly depending on the type, model, and manufacturer of the device. Additionally, each device typically requires manufacturer-specific software to record and/or access the desired information.

A. Type 170 Cabinet Assembly
B. Type 2070 Cabinet Assembly
C. NEMA TS-1 12-Channel Conflict Monitor
D. NEMA TS-1 Cabinet Assembly
E. NEMA TS-2 Type 2 Cabinet with Field Master
F. Field Laptop Data Transfer to Traffic Signal Cabinet
G. NEMA TS-2 Type 1 Cabinet with Field Master

Figure 1: Field Examples of Highway Traffic Signal Controller Assemblies and Data Transfer Set-ups

Table 1: Highway Signal Control Manufacturers Reviewed by Device Type

DEVICE	MANUFACTURERS	
Conflict Monitors / Malfunction Management Units	Econolite Eberle Design Inc. (EDI) Naztec	Peek Reno A & E
Controllers	Eagle-Siemens Econolite McCain	Naztec Northwest Signal Peek
Pre-emption Devices	EMTRAC Systems Global Traffic Technologies (GTT)	Tomar
Vehicle Detection	Inductive Loops: Eberle Design Inc. (EDI) Global Traffic Technologies (GTT) Reno A & E	Video: Econolite Iteris Naztec Peek Traficon

Highway traffic signal control assemblies, when located in the vicinity of a highway-rail grade crossing, typically have a single point connection from the railroad grade detection/control system – one per approach. Upon receipt of a valid preempt call from the rail system, the highway traffic signal assembly will revert to a preempt state at the intersection. While standard highway traffic signal control assemblies have various levels of event/data recording capability, only those cabinets containing specialized recording units designed for such an application have the capability to log more detail than a preempt call being activated, the time the call was received, and the time the signal reverted back to normal operation. Events/data such as time of event signal display status, vehicle/pedestrian call status, preempt call reports, and sequence time duration is available from various devices; however, recording capabilities are typically contained in manufacturer-specific devices and not consolidated in a single device within a highway traffic signal control cabinet that is readily available for field review purposes. Information that is being recorded can be accessed on a device-by-device basis either through a front panel display on the device itself or via connection to a laptop computer containing the appropriate firmware designed to interrogate the device and retrieve such data. Typically, the laptop firmware required for data retrieval is manufacturer-specific to the device being interrogated.

Table 2: Sampling of Highway Signal Events (or Alarms) Recorded by Device Type

DEVICE	EVENT (OR ALARM) RECORDED	
Conflict Monitors / Malfunction Management Units	+24 VDC latch status	Field check / dual indication switch status
	AC line – brownout	Field signal voltages
	AC line – power down	Flash delay time
	AC line – short interrupt	Graphical display of channel voltage levels
	AC line – voltage value	Log clear
	Cabinet temperature	Minimum yellow change channel disable jumper status
	Configuration change – jumper selection	Per channel voltage levels
	Configuration change – program card	Permissive channel jumper status
	Configuration change – switches	Port 1 fail
	Control signal voltages	Signal sequence history (30 seconds prior to event)
	CVM latch status	Time line sequence log
	CVM status	Voltage limit faults
	Dual indication enable status	Voltage dropout
	Entry to flash	Voltage surge
	Event monitoring trigger	
	Exit from flash	
Controllers	Alarm log fault	MMU conflict
	BIU frame error	MMU field check fault
	Cabinet door open	MMU minimum clear fault
	Checksum failure	MMU Port 1 failure
	Communication log fault	MMU red failure
	Conflict flash on/off	No coordination – command free
	Controller power on/off	No system command – back up operation
	Coordination / free switch active	Preempt on / off
	Coordination active	Priority on / off
	Coordination fault / cycle problem	SDLC failure
	Coordination fault / program problem	Software clock adjust
	Cycle zero phase fault	System active
	Data change – keypad	System communications status
	Data change – remote	System off line – remote flash
	I/O failure	System off line – voltage monitor
	Local flash on / off	Time change – keypad
	Low battery	Watchdog failure
	Manual control enable active	Watchdog time-out
Pre-emption Devices	Active channel call	Preempt call placed to controller
	Duration of event	Priority (high / low)
	End of event	Start time of event
	Event green time	Vehicle class
	Final green phase	Vehicle speed
Vehicle Detection	Loop status	

2.1.2 RAILROAD

In general, event/data recording capability within a railroad grade crossing equipment bungalow in the vicinity of a highway-rail grade crossing is dependent on a standalone unit rather than as an integral part of another installed device. The use of standalone event recorders allows railroads to deploy the same technology at different types of signal locations and in conjunction with equipment of varying age and manufacturer. It assists in the isolation of non-vital functions – such as event recording – from vital functions, allowing the railroads to have significant discretion as to what events/data are recorded. Many devices can be expanded, daisy chained, or networked to increase the number of inputs that railroad event recorders can monitor. Some newer systems incorporate elements that were formerly distinct units (e.g., grade crossing predictor, grade crossing controller, and event recorder); however, among existing crossing systems, these are the exception rather than the rule.

Table 3 summarizes by manufacturer the various railroad event recorders reviewed for this task. Table 4 presents a sampling of events (or alarms) that can be recorded. All of the devices listed Table 3 can record the identified events if the proper inputs are provided. Other events (e.g., temperature, train speed, gate up/down, etc.) require additional modules/sensors to provide the necessary inputs to the event recorder. The number and types of events actually recorded vary with each railroad's standard practice; however, most railroads do not record as many events as shown in the table. Please note that the information presented in Table 3 is for railroad event recording applications only.

Table 3: Railroad Event Recorder Manufacturers Reviewed by Device Type

DEVICE	MANUFACTURER
CWR-24E CWR-72E CWR-96E CWR-264E CWR-272E CWR-264XC • CWR-264P • CWR-264S VDL Microlok II (Data Logger) VDL S7-300 (Data Logger)	MICRO-AIDE
Micro Data Analyzer I Micro Data Analyzer II Universal Data Analyzer Universal Recorder Module	North American Signal
Event Analyzer Hawk Recorder (GETS)	Progress Rail
SEA/R SEAR II Argus GCP-4000	SAFETRAN

Some devices employ more complex event recording functions and can monitor performance of the highway-rail grade crossing warning system. For example, if programmed correctly and provided with the proper inputs, an event recording device may be able to detect unsafe conditions such as gates not down within 5 seconds of a train occupying the island circuit or warning time of less than 20 seconds. Some devices can also assist in performing and recording monthly, quarterly, and yearly tests required by the FRA.

Device memory can typically store over 100,000 events, which can be retrieved through the device's graphic interface or by downloading to a laptop in the field using standard connections such as RS232 or USB. Data formats and communications capabilities vary by manufacturer. Devices may communicate by several methods, including dial-up modem, cellular modem, Ethernet modem, Base Communications Package (BCP), Mobile Communications Package (MCP) radio, VHF, UHF, and spread spectrum radio. The communication capabilities can be used to provide alarms to railroad control centers or to maintenance personnel in real time. Some devices also include GPS capabilities for location and time stamping.

Table 4: Sampling of Railroad Events (or Alarms) Recorded by Device Type

DEVICE	EVENT (OR ALARM) RECORDED
CWR-24E CWR-72E CWR-96E CWR-264E CWR-272E CWR-264XC CWR-264P CWR-264S VDL Microlok II (Data Logger) VDL S7-300 (Data Logger)	AC and DC voltage levels AC power on / off Battery capacity Bell operation Crossing warning equipment activation / deactivation False crossing activation Flash rate Gate level Gate up / gate down
Micro Data Analyzer I Micro Data Analyzer II Universal Data Analyzer Universal Recorder Module	Ground faults Interlocking logic operation Lamp-out conditions
Event Analyzer Hawk Recorder (GETS)	Low battery voltage Preemption call
SEA/R SEAR II Argus GCP-4000	Stick circuit operation Temperature Track occupancy – approach circuits and island circuits Train speed Unauthorized facility entry Warning time

2.1.3 SUMMARY

As shown in Tables 1 through 4, there are several prominent manufacturers of highway and railroad signal control devices. Likewise, there are a number of devices that can be assembled within a cabinet or bungalow architecture, each of which has its own capability to record various events. Depending on the type, model, and manufacturer of the device or the agency's standard practice, the number and type of events being recorded vary greatly. As such, one challenge is to determine which events can be recorded across different signal control architectures that will satisfy the two NTSB recommendations. A second challenge is to determine how to easily retrieve these events from the various devices being used. To date, the amount of data exchanged between highway and railroad signal control systems is limited; many times it is a single preemption call circuit. Much more data will need to be consolidated and supplied to the recording device, whether it is located in the highway traffic signal controller cabinet or railroad grade crossing equipment bungalow. Another significant challenge will be addressing the existing electrical isolation that exists between the two systems, as any data exchanged will require a common electrical reference. A proposed single recording device will have several technical challenges. These challenges will be addressed in subsequent sections pertaining to technical guidelines.

2.1.4 MARKET PRODUCT

One currently available device that does support the recording of events in both highway traffic signal cabinets and railroad bungalows that may be of interest is "Interconnected Grade-Crossing Operations Recorder (IGOR)". This event recording device was recently developed through a partnership between Campbell Technology Corporation (CTC) and Reno A&E. IGOR units are installed in both the highway traffic signal controller cabinet and the railroad grade crossing equipment bungalow and can be integrated into various system architectures. The device records events such as traffic signal state, right-of-way transfer time, track clearance green time, and gate and flashing warning light status. The device also has the ability to record high-definition video, if desired. An informational brochure for IGOR is provided in Appendix A.

2.2 State of Practice for Inspection, Testing, and Regulation

Highway agency and railroad personnel can be important sources of information when seeking to understand the technical capabilities of currently deployed event recording devices in highway and railroad signal control systems. Using the United States Department of Transportation (USDOT) FRA National Highway-Rail Grade Crossing Inventory database (3), the number of locations per State where interconnected highway-rail recording devices are currently deployed were identified. Additionally, consideration was given to the FRA's top 10 "worst" States for highway-rail grade crossing accidents/incidents on average during the time period 2006 through 2008.

From these sources, a prioritized list of 12 States was created to contact for further information. The 12 States are listed below and highlighted in Figure 2:

- California
- Florida
- Georgia
- Illinois
- Indiana
- Louisiana
- Minnesota
- New Jersey
- North Carolina
- Ohio
- Texas
- Washington

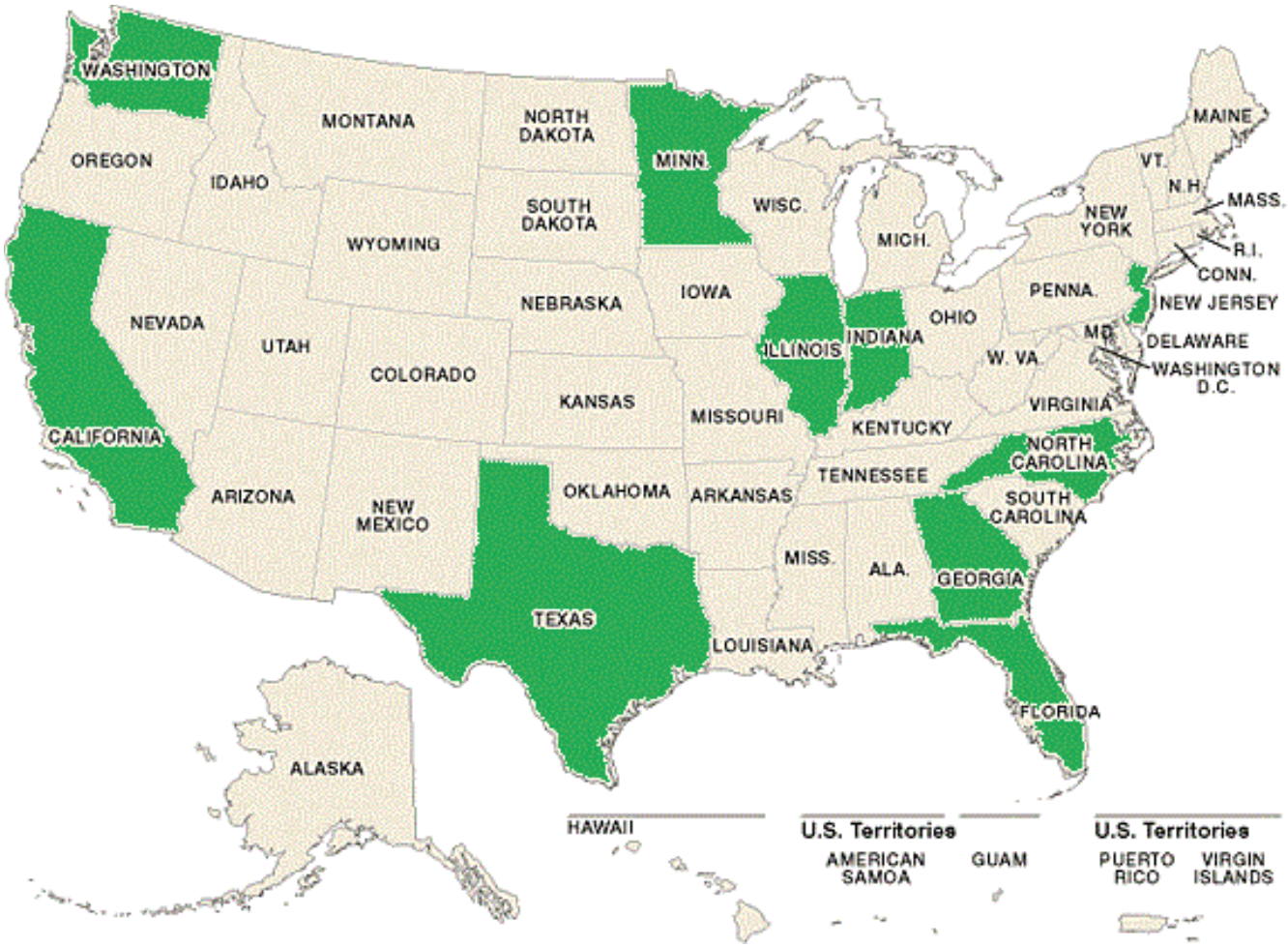

Figure 2: Priority States

State traffic engineers from each of the 12 identified States were contacted, as well as personnel at a number of Class I railroads and commuter rail/transit organizations. Table 5 summarizes the railroads contacted. The objective of these contacts was to gain further insight of the following:

- Technical capabilities and requirements of deployed recording devices to function in an interconnected system.
- Specific recording device deployment experiences.
- Current policy or practice for inspecting and maintaining signal control systems and recording devices.
- Financial perspective or installing, operating, and maintaining recording devices.

An initial email was sent to the various contacts requesting that the recipient forward contact information for personnel directly related to highway-rail grade crossing operation and maintenance; only a limited number of responses were received. From State highway agencies, direct contact information for related personnel was received from California, Georgia, Minnesota, and New Jersey. From the railroads, responses were received from three Class I railroads and one commuter railroad. As a follow up to the initial email, direct phone calls were made in an attempt to solidify further contacts for future questioning; however, these efforts did not produce additional State highway agency or railroad responses.

Table 5: Railroads Initially Contacted

RAILROAD TYPE	RAILROAD	
Class I	Burlington Northern Santa Fe Railway (BNSF)	Kansas City Southern (KCS)
	Canadian National (CN)	Norfolk Southern (NS)
	Canadian Pacific (CP)	Union Pacific (UP)
	CSX	
Commuter Rail / Transit	Amtrak	NITCD
	Capitol Metro	NJ Transit
	Dallas Area Rapid Transit (DART)	San Francisco Bay Area Rapid Transit (BART)
	Maryland Area Regional Commuter (MARC)	SCRRA – MetroLink
	MBTA	SFRTA – Tri-Rail
	Metro	Sound Transit – Seattle
	MTA – Long Island Railroad (LIRR)	Southeastern Pennsylvania Transportation Authority (SEPTA)
	MTA – Metro North	Utah Transit Authority (UTA) – Salt Lake City
		Virginia Rail Express (VRE)

A questionnaire was sent to the respondents with regard to existing recording device deployment practices as well as testing and inspection policies and practices. The questionnaire sent to the respective highway agencies and railroads is included as Appendix B. In addition to existing technical and policy information that is vital to developing practical guidelines for interconnected highway-rail recording devices, the questionnaire also sought to gain insight on the financial ramifications of such devices. This includes more than just the initial cost of the device, with consideration being given to associated costs such as installation, operation, service life, interfacing with existing infrastructure, maintenance (preventative and reactionary), and other indirect costs such as staff training relative to the device. With the limited number of responses from highway agency and railroad personnel, providing a comprehensive assessment of the financial impacts of such devices proved to be difficult.

The following summarizes the state-of-practice based on the questionnaire responses received from the various State highway agencies and railroads.

2.2.1 HIGHWAY

Event Recording

Until recently, highway traffic signal systems generally did not have recording devices that can be used to assist with preventive maintenance. The majority of States responded that, within the traffic signal controller cabinet, the controller and the malfunction management unit (MMU) can record events related to preemption calls and similar types of events. It was noted that in-cabinet devices store a predetermined amount of system activity before overwriting files. One State responded that they have event recorders at two crossings equipped with "health" monitors that report directly to the railroad. Responses also indicated that the railroads will typically install event recording devices within new bungalows. Other than the use of a supervisory circuit, no other information or data was reported as being exchanged between highway and railroad traffic signal control facilities in the field.

Preemption Design

From the responses, two different design plans were indicated: two conductor, normally closed circuit activation and four conductor. With regard to the four conductor, the pairs reported were preempt relay, supervisory relay, gate down relay, and supervisory latch relay. One State noted that, while two conductor closed loop is acceptable, four conductor is normally used. Example block diagrams/ wiring diagrams of "typical" installations depicting interconnected highway-rail signal control systems already in place are shown in Appendix C.

Battery back-up systems (BBS) are available to support critical highway traffic signal functions. One State responded that a few of their highway traffic signals are equipped with BBS, but not at all highway-rail grade crossings. Another State indicated that installing BBS is a design standard for all of their new signals with railroad preemption. Overall, the provision of BBS at new and upgraded highway traffic signal installations is becoming standard practice for several agencies. Railroad signal systems typically have their own BBS, which do not supply back up power to an adjacent highway traffic signal control system.

The majority of the responses indicated that highway-rail grade crossing facilities are not remotely monitored. One State did respond that many of their highway traffic signals at railroad crossings with preemption are structured with closed loop signal systems that have the capability of providing remote monitoring. These signals can be called up via telephone line, providing an agency with various levels of remote system monitoring and control capability. These types of systems can report back the number of railroad preemption calls and certain malfunctions.

At this time, responding highway agencies did not envision or anticipate future plans to modify how highway and railroad signal control systems are interconnected.

Testing

Highway agencies test the circuitry that interfaces the traffic and rail signal controllers. This is typically done at the initial turn-on of new highway-rail interconnected signal system installations. The majority of the responses indicated that no approved inspection or testing checklists were available. Instead, technicians use checklists developed by the local or regional highway agency. As an example, one State responded that a technician will place the highway traffic signal into flash mode by creating

an open circuit and disconnect the highway-rail interconnect wire. Upon attempting to reset, the highway traffic signal should not exit flash mode. Another State indicated that, if possible, a train will be present for testing or the team will wait for the arrival of a train to observe correct operation. Most responses noted that representatives from the responsible railroad are not required to be present at the initial testing and turn-on, but their presence is requested. Typically, personnel from both the highway agency and the railroad are present.

Preventive maintenance and testing practices varied across the responses received. Intervals range from monthly to quarterly to bi-annually to annually. One State responded that they do not engage in such practices. Similar to initial turn-on, respondents indicated that there is typically no written procedure or checklist for these activities. One State did, however, supply documentation of their preventive maintenance and testing practice protocols. Another State indicated that they are in the process of developing a standardized inspection and reporting method. Maintenance activities as well as periodic inspections and testing are often recorded and filed for several years. Local or district highway operations offices typically initiate and lead the preventive maintenance and testing activities. Railroad personnel are typically not present during these activities unless requested by the local or district highway agency or if a problem is noted with rail equipment. However, railroads may be provided a copy of the work performed for their records.

2.2.2 RAILROAD

Event Recording

Railroads generally have event recorders installed at the majority of highway-rail grade crossings. Depending on the railroad, every new or updated crossing in the last 5 to 10 years has an event recorder installed. Event recorders identified by respondents include:

- Safetran SEA/R, SEAR II and SEAR IIi
- Progress Rail Event Analyzer, Hawk, and HCA
- Micro-Aide Recorders
- IDERS
- EPC

For the most part, the recorders installed are standalone devices; however the SEAR IIi is integrated into the railroad signal controller.

Not all railroads record the exact same inputs and alarms at highway-rail grade crossings. Generally, power off, gate down, island presence, and dropping of the preemption circuit are recorded by all railroads at locations with a device installed. Some railroads record more information such as alarms when lights are not flashing; when the gate is all the way up, starting to go down, and all the way down; and when the train reaches the approach, each side of the island circuit, and when it clears the opposite approach. A railroad may choose not to record more inputs or alarms if it has older equipment installed that cannot store as much information or data as the newer equipment.

Event recorders are generally not used by railroads to conduct testing and inspection of the crossing and are not regularly downloaded as part of any inspection procedure; however, some railroads may occasionally check the log history for short warning times. Railroads typically allow event recorders to store data in memory until it begins overwriting rather than transmitting the information to a central location. If a report is needed for a claim or an incident, it is downloaded on site.

The coverage of crossings that are remotely monitored ranges from 5 to 40 percent, depending on the railroad. If an element of the crossing does not operate as it was set up or intended, an alarm is sent to a central office. This can be done a number of different ways: through radio, a cellular modem, phone line, or even a third party, which then calls the railroad.

Preemption Design

Railroads typically have their own standard drawings for preemption circuit installation. These generally follow American Railway Engineering and Maintenance-of-Way Association (AREMA) standards for preemption circuits (at least functionally), but may differ slightly depending on the location or age of the crossing. Railroad acquisitions may inherit crossings with different preemption circuit layouts. Railroads are generally aware of new signal equipment capabilities that can pass additional information (other than the preemption request) between the railroad signal controller and the highway traffic signal controller; however, they are not availing themselves of it.

Example block diagrams/wiring diagrams of "typical" installations depicting interconnected highway-rail signal control systems already in place are shown in Appendix C. Example preemption circuits are not provided due to concerns with confidentiality.

Testing

For the initial inspection of newly installed or upgraded interconnected highway-rail grade crossings, railroads typically test the entire crossing following the *Code of Federal Regulations (CFR)*, but do not have any special procedures that are required to be followed. The highway agencies are informed of the inspections by the railroads, but they often do not participate in the testing.

For the testing of highway traffic signal preemption, railroads follow the federal regulations, which require that preemption interconnections are tested once per month for proper operation. This test requires verification that the preemption circuit opens up when the crossing relay (XR) drops, but does not entail testing the actual preemption time provided at the highway traffic signal. The railroads' test procedures generally do not vary by State and do not contain any tests beyond what is required by the CFR.

Some States may require railroads to conduct a joint inspection of the highway traffic signal preemption with the highway agency. Railroads would like to verify that the highway traffic signal controller received the preemption indication as well as visually observe at what time the queue actually clears from the crossing. Typically, only the railroad is required to sign off on the inspection. If a joint inspection is conducted, railroads require that participating highway agency personnel are properly trained for safe access and working within railroad right-of-way.

Railroads have also expressed scheduling concerns, as maintainers currently have difficulty meeting the existing requirements. At present, railroads would not generally use a device that can perform a self-test of preemption to replace the required monthly inspections. The railroads generally suggested that such devices would be used daily or weekly and probably at night, but only as an additional aid to the human tests each month. Once these devices are industry- and FRA-approved, they could be a huge time saver for the railroads.

2.3 State of Knowledge for Inspection, Testing, and Regulation

This section addresses inspection and testing of highway and railroad signal systems as prescribed in various literature sources.

2.3.1 HIGHWAY

Currently, there is no national highway traffic signal inspection policy that mandates what is to be inspected, how the inspection is to be conducted, and when the inspection should take place. Highway traffic signal system testing and inspection processes are typically developed by State or local highway agencies. The 1989 edition of the *ITE Traffic Signal Installation and Maintenance Manual* (4) states, "Maintenance problems can often be traced to inadequate inspection during signal equipment installation…A major contributing factor is often the lack of comprehensive inspection guidelines, including a final acceptance "punch list" to ensure a thorough, systematic inspection by the field inspector."

The International Municipal Signal Association (IMSA) has created a Traffic Signal Inspection Certification Program to educate and certify field technicians in the inspection of highway traffic signal installations. Inspection topics include traffic signal displays and supports, underground and overhead equipment, vehicular and pedestrian detection systems, controller assemblies, safety requirements, electrical grounding and bonding, and final acceptance and turn-on. The knowledge is intended to ensure that specified construction practices are properly followed during signal installation, resulting in correct operation.

The IMSA course and the *2010 ITE Traffic Signal Maintenance Handbook* (5) provide guidance for inspection and testing of highway traffic signals through construction to acceptance; however, no guidance is provided for similar activities post-acceptance. In the 1989 edition of the *ITE Traffic Signal Installation and Maintenance Manual*, the chapter on risk management provides a section specific to periodic inspections and reviews. This section states, "Review of court cases indicates that, in general, a 6-month interval for routine inspection is considered a reasonable exercise of due care. Thus, conduct of the routine preventative maintenance program as outlined in Chapter 4 should meet the basic requirements for routine inspection." Chapter 4 states, "…preventative maintenance should be performed on detector equipment every 3 months; on signal controller cabinets, signals, and related equipment at 6- or 12-month intervals; on controller equipment generally on an annual basis." The preventative maintenance checklist with recommended intervals is included in Appendix D. Again, it is noteworthy that this information does not appear in the more recent 2010 publication.

2.3.2 RAILROAD

Title 49 Part 234 Subpart D of the *Code of Federal Regulations* (49 CFR Part 234) (6) details all of the maintenance standards and requirements for inspecting and testing highway-rail grade crossing signal systems. Each railroad must comply with maintenance and testing procedures outlined in the CFR and is required to document these tests and provide them to the FRA. In addition to the test reports, railroads are required to document all incidents that occur within the railroad right-of-way and file these reports with the FRA. Railroad organizations that do not comply with 49 CFR are subject to fines imposed by the FRA.

Inspection and testing of highway-rail grade crossings are required at monthly, quarterly, and annual intervals. Most Class I railroads, Amtrak, and major commuter railroads have developed documented procedures to satisfy these requirements, some of which go beyond the 49 CFR requirements. Appendix E presents further information regarding the monthly, quarterly, and yearly testing requirements defined under various rules of 49 CFR, particularly warning system operation, warning time, and highway signal preemption.

With regard to event recording devices, 49 CFR does not contain any laws mandating the maintenance or inspection of devices used to monitor highway-rail grade crossings. The railroads are under no regulatory requirement to install event recorders as part of their Automatic Highway Warning System (AHWS). However, for locations with an event recording device installed as part of the AHWS, the lack of maintenance and inspection regulation results in widely varying practices.

2.3.3 HIGHWAY TRAFFIC SIGNAL PREEMPTION

Currently in the United States, according to the FRA grade crossing inventory, there are a total of 215,820 at-grade railroad crossings. Of these, highway traffic signal preemption is used at 4,954 (approximately 2%). As stated in Section 8C.09 of the *Manual on Uniform Traffic Control Devices (MUTCD)* (7), "If a highway-rail grade crossing is equipped with a flashing-light signal system and is located within 200 feet of an intersection or midblock location controlled by a traffic control signal, the traffic control signal should be provided with preemption in accordance with Section 4D.27. Coordination with the flashing-light signal system, queue detection, or other alternatives should be considered for traffic control signals located farther than 200 feet from the highway-rail grade crossing. Factors to be considered should include traffic volumes, highway vehicle mix, highway vehicle and train approach speeds, frequency of trains, and queue lengths. The highway agency or authority with jurisdiction and the regulatory agency with statutory authority, if applicable, should jointly determine the preemption operation and timing of traffic control signals interconnected with highway-rail grade crossings adjacent to signalized highway intersections."

According to 49 CFR, highway-rail grade crossing warning systems must provide a minimum of 20 seconds of warning. If preemption is necessary, the preemption time is added to the minimum warning time to determine the track detection point of the approaching train. Also, under Section 8C.09 of the MUTCD, "If preemption is provided, the normal sequence of traffic control signal indications shall be preempted upon the approach of trains to avoid entrapment of highway vehicles on the highway-rail grade crossing."

At highway-rail grade crossings with preemption, the FRA regulates the railroad portion of the system; however, the FRA has no regulatory means to assure that the highway portion of the system is working as desired.

2.4 LIABILITY

The CFR regulates the railroads and requires them to conduct regular inspections of their equipment. The highway authorities are under no federal inspection regulations and are not required to inspect their equipment. The railroads generally feel that, until the highway authorities are required to regularly test their equipment, a joint inspection would be difficult to conduct.

A major concern for the railroads is liability. The highway agency does all of the traffic signal design, calculates the necessary warning time to clear the intersection, and then informs the railroad how much warning time is needed. The railroad then provides the necessary time; however, the railroad personnel are not familiar with the highway traffic signal equipment or the process of calculating the warning time. The overall opinion of the railroads is that it is not necessary or practical to have railroad personnel looking into whether or not the highway traffic signal preemption is working beyond testing that the circuit is being dropped coming out of the railroad equipment box. The railroads maintain that they should not be responsible for inspecting anything on the highway side of the preemption and are not comfortable signing off on whether or not a highway traffic signal is working properly.

CHAPTER 3. TECHNICAL AND POLICY INFORMATION

This chapter offers technical information needed to address the design, installation, operation, maintenance, and inspection of event recording devices at locations with interconnected highway-rail grade crossing signal systems.

3.1 Technical Information

This section describes the functional requirements for event recording devices to be installed at highway-rail grade crossing locations with highway traffic signal preemption. The intent of these devices is to provide operating and maintaining agencies with a tool to assist them in ensuring that interconnected signal systems are working as designed. These devices can be installed as standalone units or integrated with other devices installed in a highway traffic signal controller cabinet or railroad grade crossing equipment bungalow. The functional requirements of three different potential interconnected system configurations are discussed in this section, and are classified as "new", "hybrid", and "legacy" systems. The new configuration refers to new or future systems with interfacing capabilities between highway and railroad signal controllers using *IEEE Standard 1570* (8). A hybrid configuration refers to existing systems having some level of event recording and/or processing capabilities. The legacy configuration refers to existing systems having no event recording or processing capabilities. For the highway components of these systems, the minimum requirements should be supported by all types of highway traffic signal control architectures and assembly types.

Minimum required events and alarms are proposed for each system configuration. For each proposed event and alarm, there is a description of the event or alarm and an explanation of how it can be monitored and recorded. For new and hybrid system configurations utilizing *IEEE Standard 1570*, these explanations include how the events and alarms can be generated from the information included in the defined *IEEE Standard 1570* messages. For the hybrid and legacy systems that will not be utilizing the *IEEE Standard 1570*, the explanations include how the events and alarms can be generated from the various equipment and circuits input to the event recorder.

3.1.1 NEW SYSTEMS

"New" systems have the capability to interface between the highway traffic signal controller and railroad grade crossing controller using IEEE Standard 1570. IEEE Standard 1570 uses a serial communication interface between the highway and railroad systems to communicate vital safety-critical system information such as preemption requests and health status, as well as additional information and data used to monitor each system. IEEE Standard 1570 is explained in further detail in a subsequent section (see ***"IEEE Standard 1570"***).

There are currently only a few existing highway traffic signal controllers that provide even a limited amount of support for IEEE Standard 1570. These controllers use IEEE Standard 1570 as another means of providing the preemption input and only support the two safety-critical IEEE Standard 1570 messages, which are subsequently described in detail. At present, there are no highway traffic signal controllers capable of using the additional IEEE Standard 1570 railroad messages (other than preemption information) to modify the preemption sequence in the traffic controller. Highway agencies and/or traffic signal equipment manufacturers will need to develop this functionality in the future. The additional information provided via the IEEE Standard 1570 messages will still be a useful maintenance tool for highway agencies and railroads through monitoring and event recording.

The supervisory component of the interconnected interface should be performed using the defined IEEE Standard 1570 messages over the serial communication interface. This system should meet the Federal requirements for processor-based signal and train control systems defined in 49 CFR 236

Subpart H (see ***"49 CFR 236 Subpart H Requirements"***).

Figure 3 shows a functional block diagram of a typical new system configuration.

IEEE Standard 1570

This section provides an explanation of the IEEE Standard 1570, the IEEE standard for the interface between the rail subsystem and the highway subsystem at a Highway Railroad Intersection (HRI). The following summarizes the content of the IEEE Standard 1570, including the necessary components and the messages the standard defines in detail.

The IEEE 1570 standard defines the Advanced Transportation Controller (ATC) as the platform that provides the digital data communication link at the highway traffic signal control cabinet. The term "ATC" refers to a specific controller standard that is a product of a national standards development effort comprised of the Institute of Transportation Engineers (ITE), American Association of State Highway and Transportation Officials (AASHTO), and the National Electrical Manufacturers Association (NEMA). This standard is still being developed with the latest version 06.05, which is pending approval as of this writing. There are several other enhanced controller platforms currently available on the market that are in use by agencies and could support the IEEE 1570 standard. For this reason, the generic term "traffic controller" is being used in this report so as to not preclude the use of alternative traffic signal controller platforms that an agency may want to use to support the IEEE 1570 communications standard in a future deployment.

The primary purpose of an interconnection interface between the highway and railroad controllers at a HRI is to preempt highway traffic signal operation in order to clear traffic from the crossing as a train approaches. Existing standards define analog interfaces, generally using an electrical cable to convey voltage between the two subsystems, where the absence of voltage on the wires results in the highway traffic signal entering preemption operation. As required by Federal regulations, this existing interface is designed to meet both fail-safe and closed loop principles.

IEEE Standard 1570 specifies a digital communications interface between the highway and railroad subsystems that provides equivalent functions and maintains the safety requirements of existing systems. In addition to providing the preemption functions currently carried out by an interconnection circuit, this interface specifies digital data communications to provide for the sharing of additional information between the highway and railroad subsystems. This standard also supports future upgrades in equipment functionality on both sides of the system, but it does not mandate that functionality.

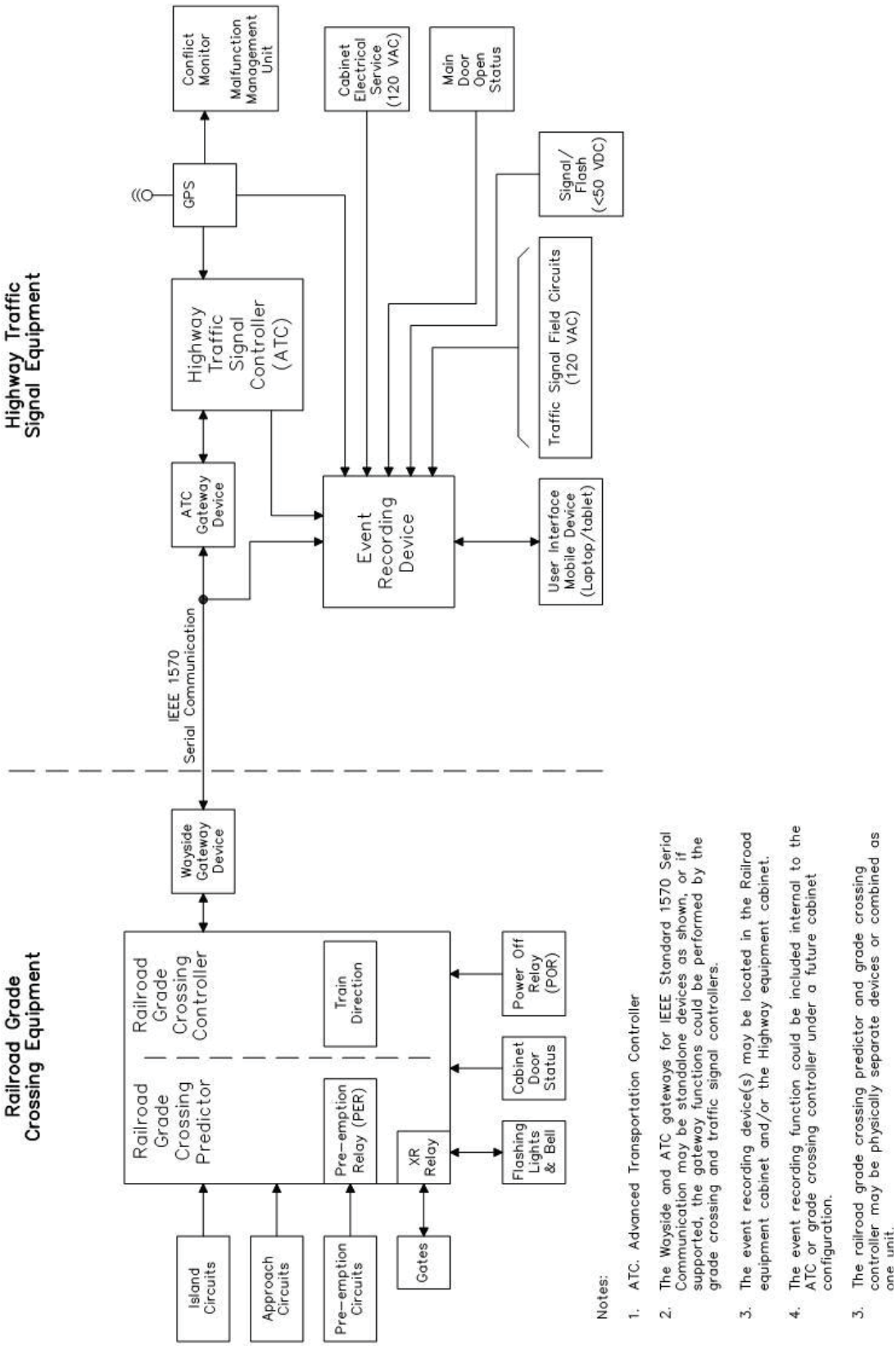

Figure 3: New System Configureation Functional Block Diagram

The IEEE Standard 1570 interface uses a digital serial connection between the highway advanced transportation controller (ATC) and the railroad wayside equipment terminator. Both the ATC and the wayside equipment terminator handle numerous control functions, which typically reside in separate physical devices and communicate via an internal communications network. IEEE Standard 1570 does not make assumptions about the technology used to implement those control functions. The standard only specifies the interface between highway and railroad subsystems and not the interfaces internal to the highway or railroad subsystems. In other words, this interface provides a means for control functions in the ATC and the wayside equipment terminator to communicate with one another without specifying the internal communication structure in either system. This allows for flexibility in the actual allocation of components and supports alternative equipment placement should it be necessary in the future.

The HRI interface consists of a virtual or logical component and a physical component. The virtual component is what provides the channel for communication between the ATCs and the wayside equipment terminator. It consists of the message formats and information content that flow between the two systems. The physical component of the interface is the physical connection that facilitates the transfer of data between the highway and railroad internal data networks, acting as a bridge between the two independent components.

The HRI interface architecture is made up of four functional components: ATC functions, ATC gateway, wayside functions, and wayside gateway. Figure 4 shows the HRI interface and the functional components of the HRI interface architecture, which are described following the figure.

The ATC functions are those functions internal to the ATC that obtain or generate the information to be transmitted to the railroad system across the HRI interface. They also process data received from the railroad system.

The ATC gateway acts as the internal router and interface bridge controller for the ATC. It is responsible for interfacing with the internal ATC functions and routing incoming or outgoing messages across the HRI interface to the wayside gateway or to the appropriate ATC function.

The wayside functions are those functions internal to the wayside equipment terminator that obtain or generate the information to be transmitted to the highway system across the HRI interface. They also process data received from the highway system.

The wayside gateway acts as the internal router and interface bridge controller; for the wayside equipment terminator. It is responsible for interfacing with the internal wayside functions and routing incoming or outgoing messages across the HRI interface to the ATC gateway or to the appropriate wayside function.

More than one type of protocol is specified for the HRI interface. This gives equipment manufacturers flexibility to implement the HRI interface to fit an installation's specific circumstances. The data link and physical layer protocols provide the physical infrastructure for the HRI physical interface. The protocols specified for these layers include Ethernet, RS232, RS422, and RS485. These protocols should support the transfer of individual message packets of up to 128 bytes in length at a minimum of 19.2 kilobytes per second, meaning the protocols should be capable of transferring a 128 byte message packet across the HRI interface in less than 250 milliseconds.

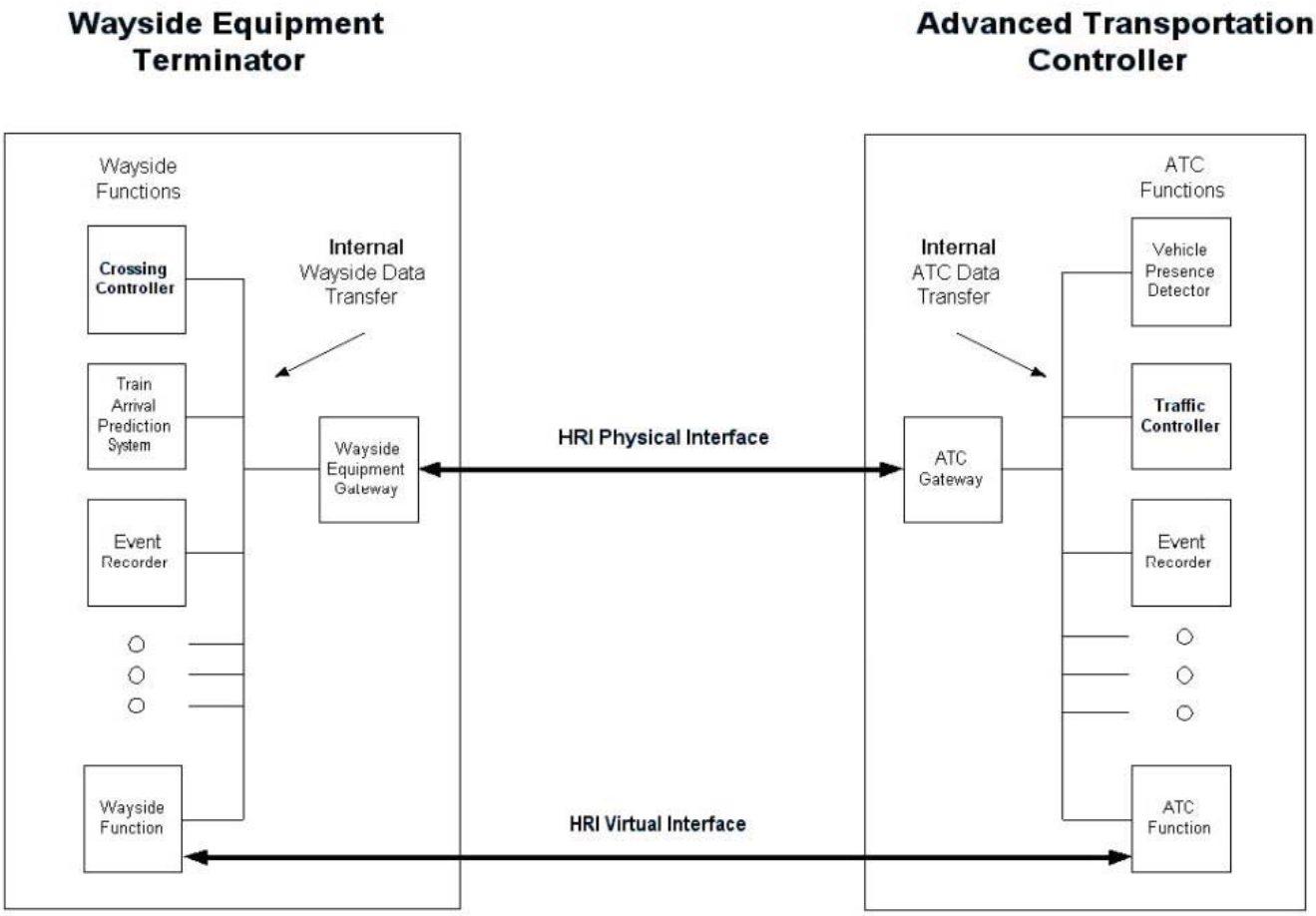

Figure 4: HRI Interface

HRI Messages

IEEE Standard 1570 defines a total of 12 messages for exchange over the HRI interfaces, which are listed in Table 6.

This section, which addresses the required minimum amount of information to be shared between the highway and railroad subsystems, describes how four of the eight defined messages should be used to transfer information to the event recorder in system configurations using the IEEE Standard 1570 protocol for communication. A description of each of the four messages recommended for use is provided with an explanation of the standard information included in each message packet.

The same standard data format is used for all defined HRI messages. The information in this standard data format includes the message length, a time stamp (date and time, from the month down to the second), a message sequence number, a message label, and a message version number. Also included is information identifying the message as vital or non-vital and the actual message data.

Table 6: HRI Messages

MESSAGE ID	MESSAGE NAME	SOURCE	DESTINATION	SAFETY-CRITICAL?
9.4.40	HRI Rail Crossing Operational State	Railroad	Highway	Yes
9.4.41	HRI Approaching Train Information	Railroad	Highway	No
9.1.41	HRI Approaching Train Information Request	Railroad	Highway	No
9.4.42*	HRI Wayside Equipment Status	Railroad	Highway	No
9.1.42*	HRI Wayside Equipment Status Request	Highway	Railroad	No
9.4.43	HRI Roadway Obstacle Detection State	Highway	Railroad	Yes
9.4.44*	HRI ATC Equipment Status	Highway	Railroad	No
9.1.44*	HRI ATC Equipment Status Request	Highway	Railroad	No
9.4.45	HRI User-Specific Wayside Message	Railroad	Highway	No
9.1.45	HRI User-Specific Wayside Message Request	Highway	Railroad	No
9.4.46	HRI User-Specific ATC Message	Highway	Railroad	No
9.1.46	HRI User-Specific ATC Message Request	Railroad	Highway	No

*Reserved for future use

HRI Rail Crossing Operational State (9.4.40)

This message is transmitted from the railroad system to the highway system and is defined as a safety-critical message. The message is sent at a frequency of once per second, and is called the vital heartbeat message from the wayside system. Byte 0 of the message data includes a field named RHBA, for receiving vital heartbeat (9.4.43) from the ATC system. The status of this field will be either '0' for "Not Receiving Message 9.4.43" or '1' for "Receiving Message 9.4.43". The definition of receiving or not receiving is determined locally and should be defined by the equipment manufacturers or the highway agency and railroad. Receipt of the vital heartbeat message from the ATC system, as well as the highway system's receipt of the wayside vital heartbeat message within the specified allowable time, represents the vitality of the HRI interface.

Also included in byte 0 of the message data is the number of crossings. The standard is defined for 1 to 8 crossings, each of which may contain from 1 to 8 tracks and up to a maximum of 8 trains associated with each crossing. The overall message length is dependent on the number of crossings and the number of trains associated with each of those crossings. Bytes 1 through 7 are repeated for each crossing, and bytes 5 through 7 are repeated for each train associated with each of the crossings. Other fields defined in this message include:

- Crossing sequence number
- Number of trains associated with this crossing
- System Operational (SO)
- Train Presence Detection (TPD)
- Warning System Active (WSA)
- Preemption Warning Active (PEA)
- Exit Gate Present (XGP)
- Exit Gate Up (XGU)

- Exit Gate Down (XGD)
- Entrance Gate Present (NGP)
- Entrance Gate Up (NGU)
- Entrance Gate Down (NGD)
- Preemption Design Time
- Train Sequence Number
- Direction (DIR) - Direction of the train
- Island Occupied (ICO)
- Warning System Activation Design Time
- Estimated Time to Warning System Activation

Note that not all of these fields are required for use as outlined in this section.

HRI Roadway Obstacle Detection State (9.4.43)

This message is transmitted from the roadway system to the railroad system and is defined as a safety-critical message. The message is sent at a frequency of once per second, and is called the vital heartbeat message from the ATC system. Byte 0 of the message data includes a field named RHBW, for receiving vital heartbeat (9.4.40) from the wayside system. The status of this field will be either '0' for "Not Receiving Message 9.4.40" or '1' for "Receiving Message 9.4.40". The definition of receiving or not receiving is determined locally and should be defined by the equipment manufacturers or the highway agency and railroad. Receipt of the vital heartbeat message from the wayside system, as well as the railroad system's receipt of the ATC vital heartbeat message within the specified allowable time, represents the vitality of the HRI interface.

This message also provides safety-critical crossing obstacle information to the railroad system. The information fields defined in the message include:

- Vehicle present with gate down (VP)
- Long term obstacle indicator (LTI)
- Vehicle arrestor barrier status (VAS)
- Roadway system operational (RSO)

It is noted that the standard is not intended to define the functionality of obstacle detection; it is only intended to provide a framework for transferring such information to the railroad system should any obstacle detection exist. The specific functionality should be agreed upon by the highway agency and railroad. Obstacle detection functionality is not required for event recording as defined in this section.

HRI User-Specific Wayside Message (9.4.45)

This message is transmitted from the railroad system to the highway system and can be defined as either an informational message or as a safety-critical message. The highway agency and railroad should jointly determine the message definition. Transmission of the message can be defined as either on request or on a periodic basis. Therefore, the message frequency should also be determined and agreed upon by the highway agency and railroad. If the message is sent upon

request, the defined HRI User-Specific Wayside Message Request (9.1.45) will be used. This is a one byte query message sent from the ATC system to the wayside system to request that the wayside system send the HRI User-Specific Wayside Message (9.4.45).

The data content and format of the user-specific message should be defined by the highway agency and railroad. Additionally, the highway agency and/or railroad should specify data fields in this message to include the following information:

- Lock out protection
- Power (On/Off)
- Entrance alarm (Open/Closed)

This message data is required in order to monitor and record several of the events described in "Events". The highway and railroad equipment used to communicate these messages, as well as the event recording devices used to monitor these messages, should be programmed to support the user-specific message settings.

HRI User-Specific ATC Message (9.4.46)

This message is transmitted from the highway system to the railroad system and can be defined as either an informational message or as a safety-critical message. The highway agency and railroad should jointly determine the message definition. Transmission of the message can be defined as either on request or on a periodic basis. Therefore, the message frequency should also be determined and agreed upon by the highway agency and railroad. If the message is sent upon request, the defined HRI User-Specific ATC Message Request (9.1.46) will be used. This is a one byte query message sent from the wayside system to the ATC system to request that the ATC system send the HRI User-Specific ATC Message (9.4.46).

The data content and format of the user-specific message should be defined by the highway agency and railroad. Additionally, the highway agency and/or railroad should specify data fields in this message to include the following information:

- Preempt in (Field termination)
- Preempt in (Traffic controller input)
- Vehicle and pedestrian signal circuits
- Signal/Flash
- Cabinet electrical service
- Main cabinet door status

This message data is required in order to monitor and record several of the events described in "Events". The highway and railroad equipment used to communicate these messages, as well as the event recording devices used to monitor these messages, should be programmed to support the user-specific message settings.

49 CFR 236 Subpart H Requirements

The primary purpose of the safety-critical interconnection interface between the highway and railroad systems of a highway-rail grade crossing is to preempt highway traffic signal operation in order to clear traffic from the crossing as a train approaches. As required by Federal regulations, this existing interface is designed to meet both fail-safe and closed loop principles. Section 8C.09

of the MUTCD specifies, "This preemption feature shall have an electrical circuit of the closed-circuit principle, or a supervised communication circuit between the control circuits of the highway-rail grade crossing warning system and the traffic control signal controller." Part 16.30.10 of the *AREMA C&S Manual* (9) states that, "The interconnection between the traffic control signal and the railroad warning system shall be a double break relay circuit or serial data circuit in accordance with IEEE Standard 1570-2002." New systems should also provide fail-safe supervision of the vital preemption functions to be carried out using the serial communication interface specified in IEEE Standard 1570. 49 CFR 234.275 states that, "Highway-rail grade crossing warning systems, subsystems, or components that are processor-based and that are first placed into service after June 6, 2005, which contain new or novel technology, or which provide safety-critical data to a railroad signal or train control system that is governed by part 236, subpart H or I, of this chapter, shall also comply with those requirements. New or novel technology refers to a technology not previously recognized for use as of March 7, 2005."

New systems using the IEEE Standard 1570 interconnection interface between the highway and railroad systems are subject to the requirements of 49 CFR 236 Subpart H. 49 CFR 236 Subpart H specifies the minimum performance standards for safety-critical products. This includes the requirements railroads are subject to for development, installation, implementation, inspection, testing, operation, maintenance, repair, and modification of safety-critical products. Additionally, 49 CFR 236 Subpart H contains a detailed explanation of the required filing and approval processes for Railroad Safety Program Plans (RSPPs) and Product Safety Plans (PSPs). It also specifies product implementation procedures, operation requirements, testing and records recording requirements for safety-critical products, and the requirements of training and qualification programs for these products. Supervisory components and acceptable message frequencies of the IEEE Standard 1570 communication interface should be specified in the RSPP and PSP.

Each railroad subject to this subpart must submit a RSPP to the FRA for approval. The RSPP is the principal safety document for all safety-critical products and it must establish the minimum PSP requirements that will govern the development and implementations of the safety-critical products. These plans must include complete descriptions of the preliminary safety analysis, including the methods used to evaluate a system's behavioral characteristics, the risk assessment procedures, the system safety precedence followed, and identification of the safety assessment process. A RSPP also requires identification of verification and validation methods, including the standards to be used in this process. Finally, the RSPP requires a description of the process used to identify human factors issues and development of design requirements to address those issues, as well as to specify requirements for product configuration management. Railroads should consult 49 CFR 236.905 for a complete description of the contents required in a RSPP.

Railroads must also submit a PSP for each new product subject to 49 CFR 236 Subpart H. The PSP must provide complete descriptions of the product and all of its components, the railroad operation(s) it is intended for, the product operational concepts, and safety requirements. The PSP also must include all safety assessment, verification and validation processes and the associated results, a hazard mitigation analysis, a risk assessment, description of the safety assurance concepts, and a human factors analysis. Complete descriptions of the specific training for railroad employees and contractors and of the specific procedures and test equipment needed to ensure safe and proper installation, implementation, operation, maintenance, repair, inspection, testing, and modification are also required to be included in a PSP. Among several other requirements, a PSP must also include, for each of the requirements of 49 CFR 234, an explanation of how the product meets the requirement, why the requirement is not applicable to the product design, or how the new product satisfies the requirement using alternative methods. Railroads should consult 49 CFR 236.907 for a complete description of the contents required in a PSP.

As stated in 49 CFR 236.909, the minimum performance standard for products covered by this subpart is that, "The safety analysis included in the railroad's PSP must establish with a high degree of confidence that introduction of the product will not result in risk that exceeds the previous condition. The railroad shall determine, prior to filing its petition for approval or informational filing, that this standard has been met and shall make available the necessary analyses and documentation as provided in this subpart." This section also explains the requirements for full and abbreviated risk assessments that must be completed to support the minimum performance standard.

Full risk assessments are required to address the safety factors associated with the introduction, modification, replacement, or enhancement of safety-critical products. This includes any risks from the previous condition that are no longer present as a result of the new product or change, new risks associated with the changed or new product, and risks that are not affected. 49 CFR 236 Appendix B contains the specific requirements of a full risk assessment. An abbreviated risk assessment may be submitted instead of a full risk assessment if there are no new hazards introduced as result of the change, and there is not an increase in hazard severity or exposure from the previous condition. Railroads should consult 49 CFR 236.909 for specific requirements of an abbreviated risk assessment to support the minimum performance standard.

Event Recording

New system configurations should include an event recording device to monitor the communication between the highway and railroad systems. The recording device(s) should be connected to the communication interface between the ATC gateway in the highway traffic signal controller cabinet and the wayside gateway in the railroad grade crossing equipment bungalow, and should monitor the messages sent between the two systems. Event recorders installed should be able to process the IEEE Standard 1570 messages in order to monitor the status of the various highway traffic signal and railroad grade crossing subsystems and record the required events, as necessary. The proposed minimum required events to record are listed below with a general description and an explanation of the associated IEEE Standard 1570 message and message field that contains the information required for a recorded event.

Highway Events

1. *Roadway System Operational*
   The health of the highway traffic signal system should be monitored using message 9.4.43. In this message, the Roadway System Operational (RSO) field represents an overall health check to show that the highway system is operational. This message should be monitored for a change in status between "System Operational" and "System Not Operational". In the occurrence that the highway system is not operational, an event record should be created and an alarm reported.

2. *Preempt In*
   This should record the change in state of preemption controller input based on the MUTCD standard hierarchy (drawbridge, railroad, emergency, transit). Specific to rail operation, there should be one input for each rail preemption circuit entering the highway traffic signal controller cabinet.

   Field Termination should record the first electrical termination in the highway traffic signal controller cabinet from the rail control circuit. A change in status at the first electrical termination in the highway traffic signal controller cabinet should be recorded as an event. This will identify if an active preemption call was received by the highway traffic signal controller cabinet assembly from the railroad control system. The status of the preemption field termination should be included in message 9.4.46 as defined by the highway agency.

Traffic Controller Input should record the electrical termination in the highway traffic signal controller cabinet as it provides the preemption input to the highway traffic signal controller. A change in status of the preemption input into the highway traffic signal controller should be recorded as an event. This will identify if an active preemption call was properly routed through interface circuitry to initiate a valid preemption sequence. The status of the preemption traffic controller input should be included in message 9.4.46 as defined by the highway agency.

3. *Vehicle/Pedestrian Signal*
   This should record phases, overlaps, and displays for vehicle and pedestrian signals. Circuit status should be provided at the termination point used for connecting the highway traffic signal control system with vehicle and pedestrian signal displays ("green", "walk", etc.). This information should be logged for a time period of at least 60 seconds, but not less than the highway traffic signal cycle length, prior to a rail preemption call and for an equal time period after the call for rail preemption is terminated. The status of the vehicle/pedestrian signals should be included in message 9.4.46 as defined by the highway agency.

4. *Right-of-Way Transfer Time*
   This should record the status of the right-of-way transfer time in the highway traffic signal preemption sequence. The right-of-way transfer time is the amount of time needed for the highway traffic signal equipment to react to a preemption call plus any green, yellow, red, pedestrian walk, and pedestrian clearance time prior to the track clearance green interval. The status of the right-of-way transfer time (when it commences and terminates) should be included in message 9.4.46 as defined by the highway agency.

5. *Track Clearance Green Interval*
   This should record the status of the track clearance green interval in the highway traffic signal preemption sequence. The track clearance green interval is the portion of the highway traffic signal sequence after completion of the right-of-way transfer time when the green signal indications are displayed to roadway users in order to vacate the highway-rail grade crossing based on the minimum track clearance distance. The status of the track clearance green interval (when it commences and terminates) should be included in message 9.4.46 as defined by the highway agency.

6. *Flash Operation*
   This should distinguish between conditions upon which an intersection operates in flash mode: conflict monitor trigger, manual switch trigger, or time of day programming trigger. In conflict monitor or manual switch mode, the highway traffic signal controller cannot initiate the preemption sequence. In time of day mode, the highway traffic signal controller can initiate the preemption sequence. The input provided from the highway traffic signal controller cabinet electrical bus connected to flash transfer relays should be monitored and a change in status should be recorded as an event. The status information for flash operation should be included in message 9.4.46 as defined by the highway agency.

7. *Cabinet Electrical Service*
   This requires monitoring for deviations in electrical service voltages that would trigger the conflict monitor/malfunction management unit. Any deviation in the electrical service triggering the conflict monitor/malfunction management unit as defined by the highway agency should be recorded as an event. This serves to identify the stability of electrical service. This information for the highway traffic signal controller cabinet electrical service should be included in message 9.4.46 as defined by the highway agency.

8. *Main Cabinet Door(Open/Closed)*
   This requires monitoring of highway traffic signal controller cabinet access, prompting further examination of the various devices and data programming to determine if changes have been made. This is particularly beneficial if the highway traffic signal controller cabinet has been accessed in between inspections. The input should be provided through an appropriate electrical switch connected to the main cabinet door that detects a change in status between when the door is opened or closed. A change in status between "Open" and "Closed" should create an event record and an alarm reported. The status information for main cabinet door should be included in message 9.4.46 as defined by the highway agency.

Railroad Events

1. *Supervisory Circuit*
   The vitality of the highway-rail grade crossing preemption circuit should be supervised by monitoring the status of the receiving vital heartbeat fields in messages 9.4.40 and 9.4.43, which are each sent once per second between the ATC and wayside systems.

   The RHBA field in the message 9.4.40 indicates if the wayside system is receiving the vital heartbeat (9.4.43) from the ATC system. This message should be monitored for a change in status between "Receiving Message 9.4.43" and "Not Receiving Message 9.4.43".

   The RHBW field in message 9.4.43 indicates if the ATC system is receiving the vital heartbeat (9.4.40) from the wayside system. This message should be monitored for a change in status between "Receiving Message 9.4.40" and "Not Receiving Message 9.4.40".

   In the occurrence that one of these messages is not received within a certain time interval as determined by the highway agency and railroad and a change in status occurs, an event record should be created and an alarm reported. This supervisory component of the system should meet the requirements of 49 CFR 236 Subpart H (see "49 CFR 236 Subpart H Requirements").

2. *Railroad System Operational*
   The health of the railroad grade crossing warning system should be monitored using message (9.4.40). In this message, the System Operational (SO) field represents an overall health check to show that the railroad system is operational. This message should be monitored for a change in status between "System Operational" and "System Not Operational". In the occurrence that the railroad system is not operational, an event record should be created and an alarm reported.

3. *Railroad Preemption Request*
   The preemption request from the wayside system to the ATC system is contained in message 9.4.40. The Preemption Warning Active (PEA) field(s) of the message should be monitored for a change in status between "Active" and "Not Active". A change in status of this field should be recorded as an event. This recorded event serves to identify when an active railroad preemption call was placed.

4. *Approach Circuits*
   Train presence detection (TPD) information for each crossing track is contained in message 9.4.40. The TPD field(s) of the message should be monitored for each track crossing included in the message. A change in status between "Train Present" and "No Train Present" should be recorded as an event. This recorded event serves to identify when a train has been detected on an approach of any of the crossing tracks.

5. *Railroad Crossing Relay*
   The railroad crossing relay (XR) controls when the active grade crossing warning systems are operational. For newer systems, the grade crossing controller processors carry out the function of the railroad crossing relay by assigning variables in a logical expression to set the status of the grade crossing warning system. The status information of the grade crossing warning system is contained in message 9.4.40. The Warning System Active (WSA) field(s) should be monitored for a change in status between "Activated" and "Not Activated". This recorded event serves to identify when the railroad grade crossing warning system is in an operational state (e.g., lights flashing, bells ringing).

6. *Entrance Gate Status*
   Entrance gate status information is contained in message 9.4.40. The Entrance Gate Present (NGP) field of the message indicates if entrance gates are present at the crossing and can either have a status of "Entrance Gate(s) Present" or "Entrance Gate(s) Not Present". In the occurrence that there is a change in status, an event record should be created and an alarm reported.

   The Entrance Gate Up (NGU) and Entrance Gate Down (NGD) fields should be monitored for a change in status. For the NGU field, a change in status between "Entrance Gate(s) Up" and "Entrance Gate(s) Not Up" should be recorded as an event. For the NGD field, a change in status between "Entrance Gate(s) Down" and "Entrance Gate(s) Not Down" should be recorded as an event.

7. *Exit Gate Status (if present)*
   Exit gate status information is contained in message 9.4.40. The Exit Gate Present (XGP) field of the message indicates if exit gates are present at the crossing and can either have a status of "Exit Gate(s) Present" or "Exit Gate(s) Not Present". In the occurrence that there is a change in status, an event record should be created and an alarm reported.

   The Exit Gate Up (XGU) and Exit Gate Down (XGD) fields should be monitored for a change in status. For the XGU field, a change in status between "Exit Gate(s) Up" and "Exit Gate(s) Not Up" should be recorded as an event. For the XGD field, a change in status between "Exit Gate(s) Down" and "Exit Gate(s) Not Down" should be recorded as an event.

8. *Island Circuit Occupancy*
   Island circuit occupancy information for each crossing track is contained in message 9.4.40. The Island Occupied (ICO) field(s) of the message should be monitored for each track crossing included in the message. A change in status between "Island Circuit Occupied" and "Island Circuit Unoccupied" should be recorded as an event.

9. *Train Direction*
   Traditionally, the direction of a train movement is determined by the status of the directional stick relays on each track. For newer systems, the railroad grade crossing controller processors carry out the function of the directional stick relays by assigning them as variables in a logical expression relating train presence detection on the approach and island circuits to the train's direction. Once a train has been detected on an approach circuit and an island circuit consecutively, the train's direction is determined and the appropriate directional stick variable is set to indicate the direction of the train's movement.

   The directional information of each train movement is contained in the Direction (DIR) field(s) of message 9.4.40. A change in status between "Unknown", "Heading East/North" and "Heading West/South" should be recorded as an event. A status of "Unknown" is the default

when there is no current train movement. The directional designations do not indicate the geographical direction of movement, but refer to the directional designation for the track as defined on the railroad's track plans.

10. *Lock Out Protection*
    Lock out protection should be provided for each train movement through a highway-rail grade crossing. After a train movement has completed, if the trailing circuit does not clear after a preset time interval, an event should be created and an alarm reported. This information should be included in message 9.4.45 defined by the operating railroad.

11. *Power(On/Off)*
    This requires the electrical power source for the railroad grade crossing equipment bungalow to be monitored. The power off relay (POR) switches the power source that feeds the bungalow. When there is a loss of power, the POR drops to switch to the battery power supply. A change in status of the power off relay (when it drops or picks up) should be recorded as an event and an alarm reported. Additionally, any changes in voltages that would result in an alarm being reported, as determined by the operating railroad, should create an event record. This information should be included in message 9.4.45 as defined by the operating railroad.

12. *Entrance Alarm (Open/Closed)*
    This requires the bungalow door switch to be monitored for a change in status between "Open" and "Closed". A change in status should create an event record and an alarm reported. This may require the installation of an electrical switch in existing railroad grade crossing equipment bungalows that changes state when the door is opened and closed. This event record would allow the railroad to determine when the bungalow has been accessed, flagging the potential necessity for further examination of various devices and programming. The status of the bungalow door should be included in message 9.4.45 as defined by the operating railroad.

Figure 5 illustrates the sequence of railroad events to be recorded for each train movement through the highway-rail grade crossing.

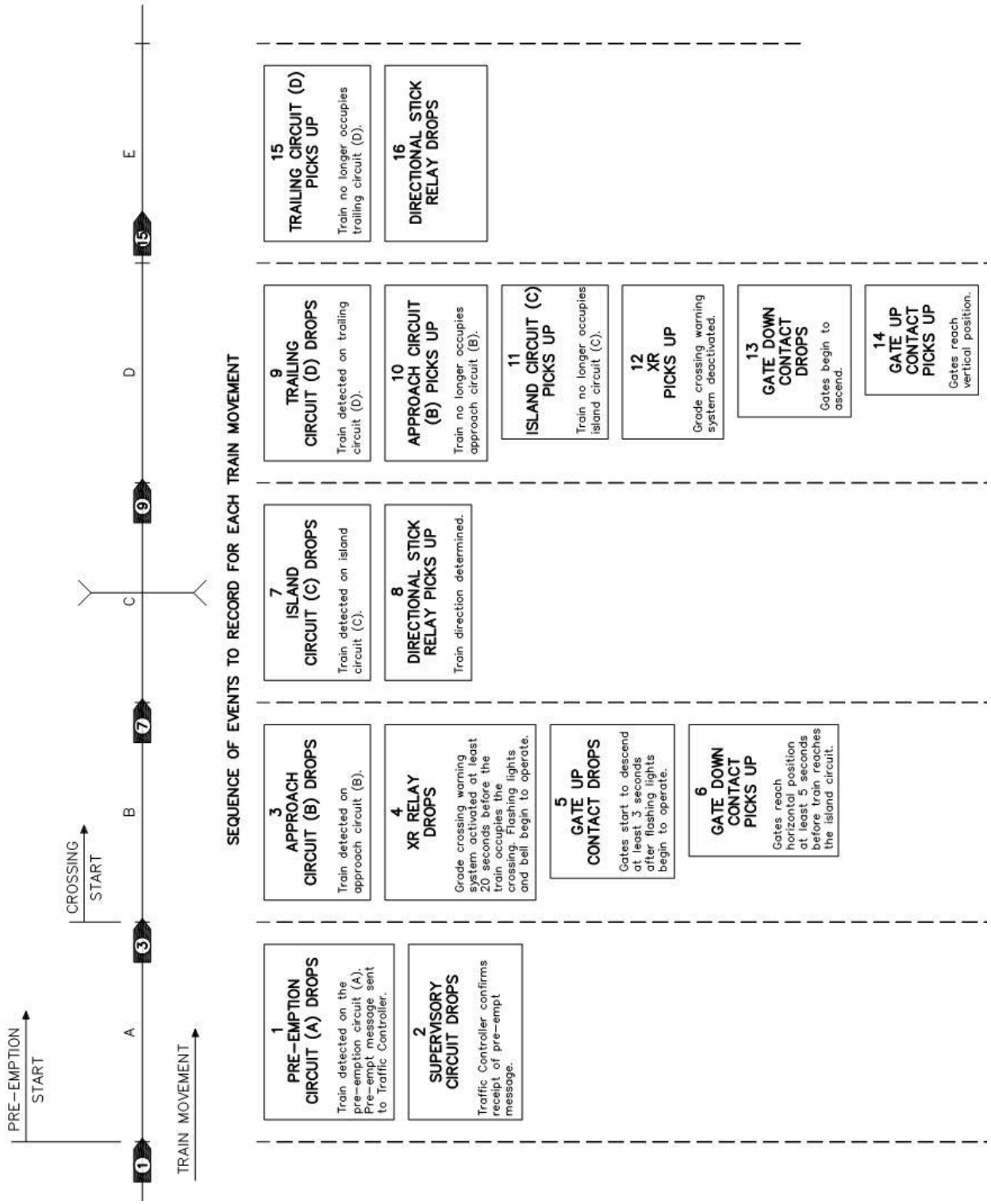

Figure 5: Railroad Events to be Recorded for each Train Movement

Alarm Reporting

In addition to monitoring the IEEE Standard 1570 messages and recording the required events, the device should be able to process this information in order to flag recorded events and/or report alarms. Event recorders should use user-specific logical expressions to relate fields of various IEEE Standard 1570 messages to determine that the highway and railroad systems are working as designed. As defined by the highway agency and/or railroad, any recorded event or logical combination of events should be flagged as an alarm. A list of situations that should result in the reporting of an alarm along with explanations of how they can be determined is provided below. At a minimum, flagging event records will allow highway agency and/or railroad personnel to determine if a problem exists at a crossing during regular maintenance or inspections.

The following is a list of proposed situations for which an alarm should be reported. These alarms should be determined by monitoring the recorded events or IEEE Standard 1570 messages previously described. Event recorders should be capable of processing and relating the fields of each recorded event or IEEE Standard 1570 message described in order to trigger the alarm(s).

1. Event records indicate that the vital heartbeat message from the ATC system is not being received by the wayside system or the vital heartbeat message from the wayside system is not being received by the ATC system. This should be determined by monitoring the RHBA field of message 9.4.40 and the RHBW field of message 9.4.43. If the status of the RHBA or RHBW fields changes from '1' to '0', indicating one of the vital heartbeat messages has not been received by the opposite system, then an alarm should be reported.

2. Event records indicate that the highway or railroad system is not operational. This should be determined by monitoring the SO field in message 9.4.40 and the RSO field in message 9.4.43. If the status of the SO or RSO fields changes from '1' to '0', indicating one of the systems is not operational, then an alarm should be reported.

3. Event records indicate that the railroad preemption request is not being sent prior to the design preemption warning time. The preemption warning time provided for a particular train movement should be determined using the recorded time stamps of message 9.4.40 for when the status of the PEA field(s) changes from '0' to '1' (preemption warning is active) and when the status of the ICO field(s) changes from '0' to '1' (island circuit or the crossing is occupied). If the preemption warning time provided is less than the time specified in the Preemption Design Time field of message 9.4.40, then an alarm should be reported.

4. Event records indicate that a train is being detected on an approach circuit and the associated island circuit; however, there is no recorded event for a railroad preemption request. This is determined by comparing the TPD, ICO, and PEA fields of message 9.4.40. If the status of the TPD and ICO fields changes from '0' to '1' (train has been detected on an approach and associated island circuit) and the PEA field remains at '0' (preemption was not requested), then an alarm should be reported.

5. Event records indicate that the highway traffic signal controller did not receive or did not act on the receipt of a preemption request. This is determined by comparing the PEA field of message 9.4.40 and the Preempt In (Field Termination/Traffic Controller Input) fields in message 9.4.46. If the status of the PEA field changes from '0' to '1' (railroad system has requested preemption), but the status of the Preempt In (Field Termination) field does not indicate receipt of the preempt request or the status of the Preempt In (Traffic Controller Input) does not indicate a valid preemption call into the highway traffic signal controller, then an alarm should be reported.

6. Event records indicate that the grade crossing warning system is not being activated before the specified warning time. The warning time provided for a particular train movement should be determined using the recorded time stamps of message 9.4.40 when the status of the WSA field(s) changes from '0' to '1' (warning system is active) and when the status of the ICO field(s) changes from '0' to '1' (island circuit or crossing is occupied). If the warning time provided is less than the time specified in the Warning System Activation Design Time field of message 9.4.40, then an alarm should be reported. 49 CFR 234.225 requires activation of the grade crossing warning system to occur at least 20 seconds prior to a train occupying the highway-rail grade crossing.

7. Event records indicate that the entrance gate(s) begins to descend prior to the required minimum of three seconds after the grade crossing warning system is activated and the flashing lights begin to operate (49 CFR 234.223). This should be determined by comparing the recorded time stamps of message 9.4.40 when the status of the NGU and WSA fields change. If the status of the NGU field changes from '1' to '0' (entrance gate(s) is no longer up) less than three seconds after the WSA field changes from '0' to '1' (warning system is active), then an alarm should be reported.

8. Event records indicate that the entrance gate(s) reach horizontal position after the required minimum of five seconds prior to a train arriving at the highway-rail grade crossing. This should be determined by comparing the recorded time stamps of message 9.4.40 when the status of the NGD and ICO fields change. If the status of the ICO field changes from '0' to '1' (island circuit or crossing is occupied) less than five seconds after the NGD field changes from '0' to '1' (entrance gate(s) is down), then an alarm should be reported.

9. Event records indicate that the exit gate(s) begins to descend prior to the completion of the track clearance green interval, potentially trapping vehicles within the highway-rail grade crossing. This should be determined by comparing the XGU field of message 9.4.40 and the track clearance green interval status in message 9.4.46. If the XGU field changes from '1' to '0' (exit gate(s) is no longer up) before an indication that the track clearance green interval has terminated, then an alarm should be reported.

10. Event records indicate that an entrance or exit gates(s) has left the vertical position but there is no recorded event indicating the gate(s) has reached the horizontal position within a preset time interval. This should be determined by comparing the recorded time stamps of message 9.4.40 when the status of the entrance or exit gate(s) up and down fields change. If the status of either the NGU or XGU fields change from '1' to '0' (entrance or exit gate(s) have left the vertical position) and there is no recorded event showing the status of the respective NGD or XGD fields changing from '0' to '1' before a present time interval, then an alarm should be reported.

    Alternately, event records indicate that an entrance or exit gate(s) has left the horizontal position but there is no recorded event indicating the gate(s) has reached the vertical position within a preset time interval. If the status of either the NGD or XGD fields change from '1' to '0'(entrance or exit gate(s) have left the horizontal position) and there is no recorded event showing the status of the respective NGU or XGU fields changing from '0' to '1' before a present time interval, then an alarm should be reported. Part 3.3.30 of the *AREMA Communications & Signals Manual of Recommended Practice (C&S Manual)* states that gate arms should fully raise in no more than 12 seconds, or as instructed.

Finally, event records indicate that an entrance or exit gate(s) is in both the vertical and horizontal position in the same message. If the status of the NGU or XGU is '1' (entrance or exit gate(s) is in the vertical position) and the status of the NGD or XGD is '1' (entrance or exit gate(s) is also in the horizontal position), then an error has occurred and an alarm should be reported.

11. Event records indicate that the right-of-way transfer time is longer than the design right-of-way transfer time. This should be determined by comparing the recorded time stamps of message 9.4.46 when the status of the right-of-way transfer time indicates it commences and terminates. If the right-of-way transfer time is longer that the design maximum right-of-way transfer time, then an error has occurred and alarm should be reported.

12. Event records indicate that the track clearance green interval is less than the design track clearance green interval. This should be determined by comparing the recorded time stamps of message 9.4.46 when the status of the track clearance green interval indicates it commences and terminates. If the track clearance green interval is less than the design track clearance green interval, then an error has occurred and an alarm should be reported.

13. Event records indicate that the amount of time from the start of the track clearance green interval to train presence detection on an island circuit is less than the design track clearance green interval. This should be determined by comparing the recorded time stamps of message 9.4.46 when the status of track clearance green interval indicates it commences and of message 9.4.40 when the status of the ICO field changes to '1' (island circuit is occupied). If the time between the start of track clearance green and island circuit occupancy is less than the design track clearance green interval, then an error has occurred and an alarm should be reported.

14. Event records indicate train presence detection on an island circuit, but there is no event record indicating the termination of the track clearance green interval. This should be determined by comparing the status of the ICO field of message 9.4.40 and the status of the track clearance green interval field of message 9.4.46. If the status of the ICO field is '1' (island circuit is occupied) before an indication that the track clearance green interval has terminated, then an error has occurred and an alarm should be reported.

15. Event records indicate train presence detection on an approach and an island circuit, but does not indicate the train direction; or event records indicate a train direction when no train was detected, signifying a possible electrical problem with the circuits or relays. This should be determined by comparing the status of the TPD, ICO, and DIR fields of message 9.4.40. If the status of the TPD field is '1' (train is present on an approach or island circuit), the status of the ICO field is '1' (respective island circuit is occupied), and the status of the DIR field is '2' (train direction is unknown), then an alarm should be reported. Alternatively, if the status of the DIR field is a '0' or '1' (train direction), but the status of both the TPD and ICO fields are not '1', then an alarm should be reported.

16. Event records indicate lock out protection is being provided on a particular track approach. If it is indicated that lock out protection is being provided in message 9.4.45, than an alarm should be reported.

17. Event records indicate a loss of primary power, a switch to battery power, or changes in voltages. This should be determined by monitoring the Power (On/Off) field of message 9.4.45. If the status of the Power (On/Off) field changes, then an alarm should be reported.

18. Event records indicate that either the highway traffic signal controller cabinet or railroad grade crossing equipment bungalow door has been opened, allowing access to the equipment and settings. This should be determined by monitoring the Main Cabinet Door (Open/Closed) field of message 9.4.46 or the Entrance Alarm (Open/Closed) field of message 9.4.45. If the status of either fields change, then an alarm should be reported.

3.1.1 HYBRID SYSTEMS

"Hybrid" systems are existing systems having some level of event recording and/or processing capabilities. This includes a wide variety of existing system configurations of varying age and technology capabilities of technology in both the highway and railroad systems.

Highway agencies and railroads should jointly determine if they will upgrade their respective systems to support the IEEE Standard 1570 serial communication interface. The upgrade would require updating various existing equipment executive software and programs to generate and process the defined ATC and wayside messages. In some instances, upgrades may require completely new installations. In either case, the requirements of 49 CFR 236 Subpart H will need to be met.

Existing event recording devices may also require updates to their executive software or programs to support IEEE Standard 1570. The event recording devices should be able to monitor the status of message fields being sent across the serial communication interface between the highway and railroad gateway devices. This allows events to be recorded and alarms to be reported. If necessary, the communications capabilities of the event recording devices may need upgrading to support the transfer of events associated with alarms to a central office database.

If highway agencies and railroads do not jointly upgrade their respective equipment to support IEEE Standard 1570, then their systems should support a minimum level of monitoring, event recording, and alarm reporting required of legacy systems (see "Legacy Systems"). Highway agencies and railroads may consider future upgrades to support communication capabilities using IEEE Standard 1570.

Figure 6 shows a functional block diagram of a typical hybrid system configuration.

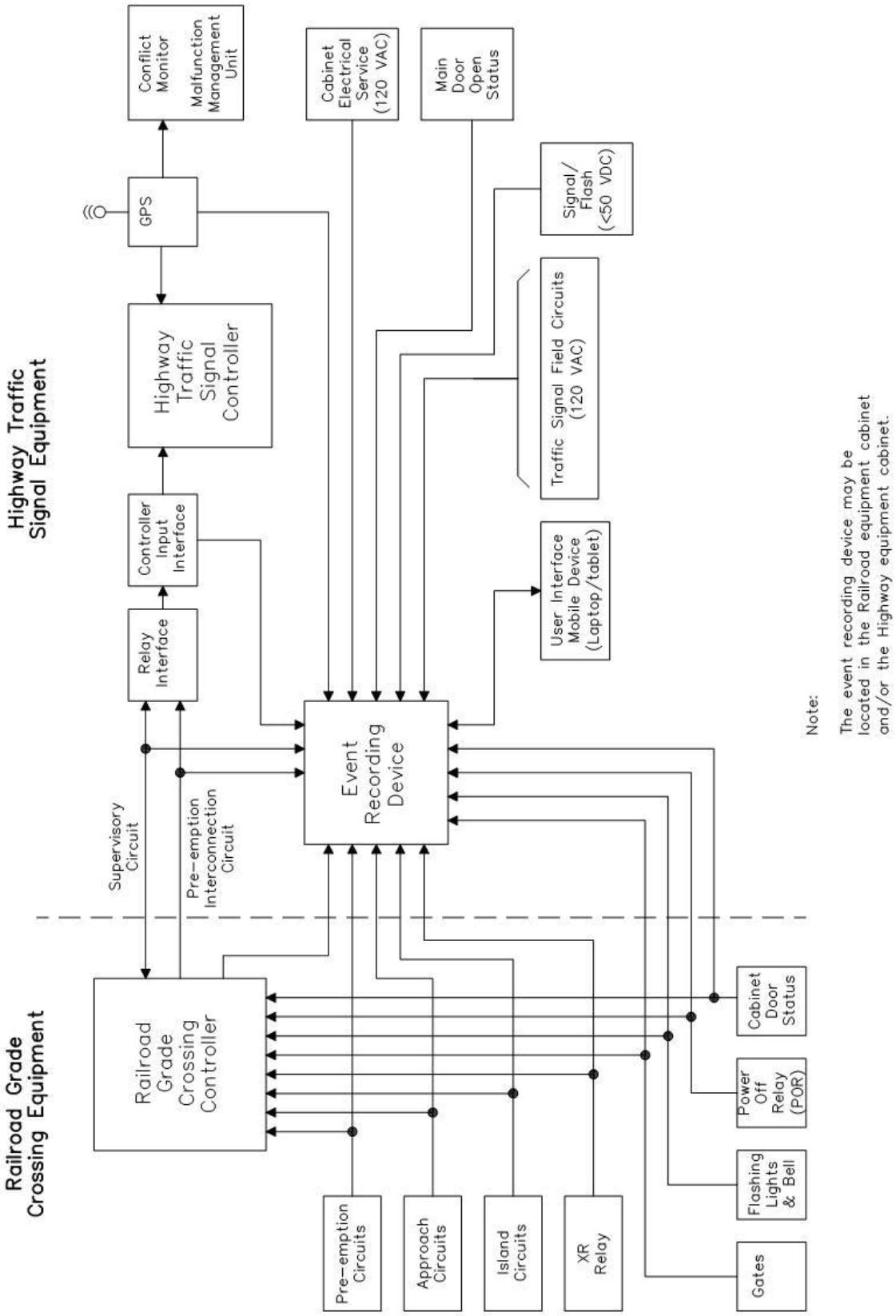

Figure 6: Hybrid System Configuration Functional Block Diagram

3.1.2 LEGACY SYSTEMS

"Legacy" systems are existing systems having no event recording and/or processing capabilities. These systems will need to be modified to include new event recording equipment capable of future communication via IEEE Standard 1570.

Figure 7 shows a functional block diagram of a typical legacy system configuration.

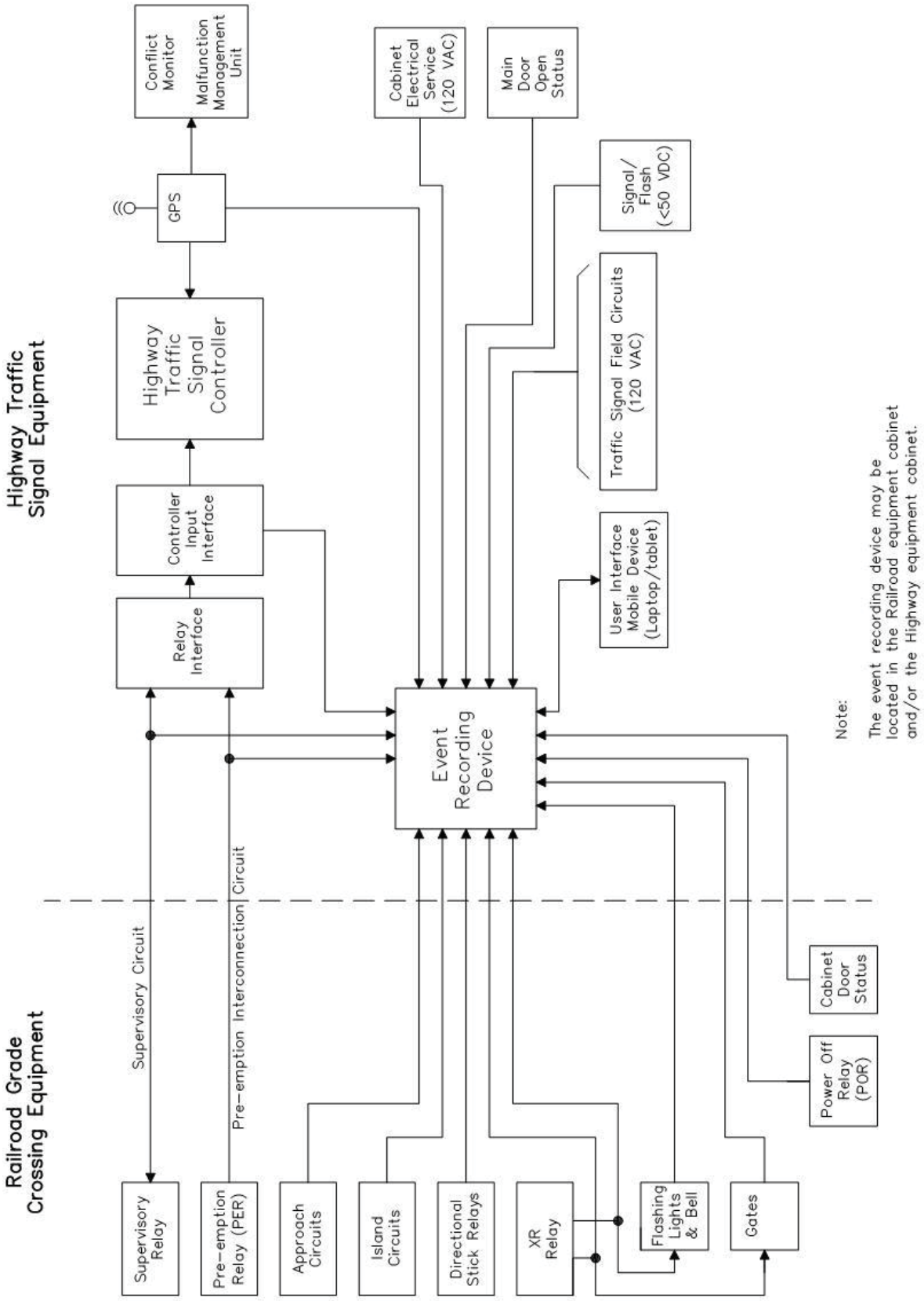

Figure 7: Legacy System Configuration Functional Block Diagram

Event Recording

Legacy system configurations should be equipped with an event recording device to monitor the highway and railroad systems. The recording device(s) should be capable of supporting IEEE Standard 1570 serial communication should the location receive future upgrades utilizing this interface. The recording device(s) should support the number of digital and analog inputs required to monitor the highway and railroad. Event recorders should be able to process the various digital and analog inputs to monitor the status of the highway traffic signal and railroad grade crossing equipment and record the required events as necessary. The minimum events to record, along with explanations, is provided below. These events/circuits are intended for those existing systems that are currently incapable of and/or not utilizing the IEEE Standard 1570 communication protocol.

Highway Events

1. *Preempt Active/Inactive*
   This should record the change in state of preemption controller input based on the MUTCD standard hierarchy (drawbridge, railroad, emergency, transit). Specific to rail operation, there should be one input for each rail preemption circuit entering the highway traffic signal controller cabinet.

   Field Termination should record the first electrical termination in the highway traffic signal controller cabinet from the rail control circuit. A change in status at the first electrical termination in the highway traffic signal controller cabinet should be recorded as an event. This will identify if an active preemption call was received by the highway traffic signal controller cabinet assembly from the railroad control system.

   Traffic Controller Input should record the electrical termination in the highway traffic signal controller cabinet as it provides the preemption input to the highway traffic signal controller. A change in status of the preemption input into the highway traffic signal controller should be recorded as an event. This will identify if an active preemption call was properly routed through interface circuitry to initiate a valid preemption sequence.

2. *Vehicle/Pedestrian Signal*
   This should record phases, overlaps, and displays for vehicle and pedestrian signals. Circuit status should be provided at the termination point used for connecting the highway traffic signal control system with vehicle and pedestrian signal displays ("green", "walk", etc.). This information should be logged for a time period of at least 60 seconds, but not less than the highway traffic signal cycle length, prior to a rail preemption call and for an equal time period after the call for rail preemption is terminated.

3. *Right-of-Way Transfer Time*
   This should record the status of the right-of-way transfer time in the highway traffic signal preemption sequence (when it commences and terminates). The right-of-way transfer time is the amount of time needed for the highway traffic signal equipment to react to a preemption call plus any green, yellow, red, pedestrian walk, or pedestrian clearance time prior to the track clearance green interval.

4. Track Clearance Green Interval
   This should record the status of the track clearance green interval in the highway traffic signal preemption sequence (when it commences and terminates). The track clearance green interval is the portion of the traffic signal sequence after completion of the right-of-way transfer time when the green signal indications are displayed to roadway users in order to vacate the highway-rail grade crossing based on the minimum track clearance distance.

5. *Flash Operation*
   This should distinguish between conditions upon which an intersection operates in flash mode: conflict monitor trigger, manual switch trigger, or time of day programming trigger. In conflict monitor or manual switch mode, the highway traffic signal controller cannot initiate the preemption sequence. In time of day mode, the highway traffic signal controller can initiate the preemption sequence. The input provided from the highway traffic signal controller cabinet electrical bus connected to flash transfer relays should be monitored and a change in status should be recorded as an event.

6. *Cabinet Electrical Service*
   This requires monitoring for deviations in electrical service voltages that would trigger the conflict monitor/malfunction management unit. Any deviation in the electrical service triggering the conflict monitor/malfunction management unit, as defined by the highway agency, should be recorded as an event. This serves to identify the stability of electrical service.

7. *Main Cabinet Door(Open/Closed)*
   This requires monitoring of highway traffic signal controller cabinet access, prompting further examination of the various devices and data programming to determine if changes have been made. This is particularly beneficial if the highway traffic signal controller cabinet has been accessed in between inspections. The input should be provided through an appropriate electrical switch connected to the main highway traffic signal controller cabinet door that detects change in status between when the door is opened or closed. A change in status between "Open" and "Closed" should create an event and an alarm reported.

Railroad Events

1. *Railroad Preemption Request*
   This requires the railroad preemption relay (PER) to be monitored for a change in status (when the relay drops or picks up) and record it as an event. This recorded event serves to identify when an active railroad preemption call was placed.

   Some highway-rail grade crossings may have a second preemption relay installed in order to send an additional preemption request to the highway traffic signal controller. For example, a second preemption request may be sent when the gates reach horizontal, indicating that traffic is no longer permitted to enter the crossing and the highway traffic signal controller can terminate the track clearance green interval and hold the traffic signal green in the parallel direction. The status of any additional preemption relays should be monitored and a change should also be recorded as an event.

2. *Supervisory Circuit*
   This requires the supervisory circuit on the railroad interconnection preemption circuit to be monitored. A change in status of the supervisory relay (when it picks up or drops) should be recorded as an event.

3. *Approach Circuits*
   This requires the approach circuit for each track in each direction to be monitored for train presence detection. A change in status of the approach circuit relay (when it drops or picks up) should be recorded as an event. This recorded event serves to identify when a train is detected entering or exiting an approach.

4. *Railroad Crossing Relay*
   This requires the status of the railroad crossing relay (XR) to be monitored and for a change in status (when the relay drops or picks up) to be recorded as an event. In some newer systems, there may no longer be a physical XR relay to monitor. At these locations, the internal logic in the processors of the railroad grade crossing controller or predictor carries out the function of the grade crossing relay by assigning variables in a logical expression to set the status of the grade crossing warning system. The status of these variables should be monitored and a change should be recorded as an event. This recorded event serves to identify when the railroad grade crossing warning system is activated.

5. *Entrance Gate Status*
   Entrance gates at the highway-rail grade crossing should be monitored for a change in status. This requires the equipment and ability to monitor gate up and gate down contacts in either the interconnection circuits or the gate circuits. A change in status of the gate contacts between "Entrance Gate(s) Up" and "Entrance Gate(s) Not Up" or "Entrance Gate(s) Down" and "Entrance Gate(s) Not Down" should be recorded as an event.

6. *Exit Gate Status (If present)*
   If exit gates are present at the highway-rail grade crossing, they should be monitored for a change in status. This requires the equipment and ability to monitor gate up and gate down contacts in either the interconnection circuits or the gate circuits. Any change in status of the gate contacts between "Exit Gate(s) Up" and "Exit Gate(s) Not Up" or "Exit Gate(s) Down" and "Exit Gate(s) Not Down" should be recorded as an event.

7. *Island Circuit Occupancy*
   This requires the island circuits for each track to be monitored for train presence detection. A change in status of an island circuit relay (when the relay drops or picks up) should be recorded as an event.

8. *Train Direction*
   The direction of a train movement is determined by the status of the directional stick relays on each track. In some newer systems, there may not be physical directional stick relays to indicate train direction. At these locations, the internal logic in the processors of the railroad grade crossing controller or predictor carries out the function of the directional stick relays by assigning them as variables in a logical expression relating train presence detection on the approach and island circuits to the train's direction. Once a train has been detected on an approach circuit and an island circuit consecutively, the train's direction is determined and the appropriate directional stick relay picks up or directional stick variable is set to indicate the direction of the train's movement. The status of the directional stick relays or directional stick variables should be monitored and a change in status should be recorded as an event.

9. *Lock Out Protection*
   If provided, lock out protection should be monitored for each train movement through a highway-rail grade crossing. After a train movement has completed, if the trailing circuit does not clear after a preset time interval, an event record should be created and an alarm reported.

10. *Power (On/Off)*
    This requires the electrical power source for the railroad grade crossing equipment bungalow to be monitored for any loss of power and switch to battery power. The power off relay (POR) switches the power source that feeds the bungalow. When there is a loss of power, the POR drops to switch the bungalow to the battery power supply. A change in status of the power

off relay (when it drops or picks up) should be recorded as an event and an alarm reported. Additionally, any changes in voltages that would result in an alarm being reported, as determined by the operating railroad, should create an event record.

11. *Entrance Alarm (Open/Closed)*
    This requires the bungalow door switch to be monitored for a change in status between "Open" and "Closed". A change in status should create an event and an alarm reported. This may require the installation of an electrical switch in existing railroad grade crossing equipment bungalows that changes state when the door is opened and closed. This event record would allow the railroad to determine when someone has had access to the bungalow and the equipment and therefore, when further examination of various devices and programming may be necessary.

Alarm Reporting

In addition to monitoring the status of various highway and railroad equipment and recording the required events, the device should be able to process this information in order to flag recorded events and/or report alarms. Event recorders should use user-specific logical expressions to relate the status of equipment to determine that the highway and railroad systems are working as designed. As defined by the highway agency and/or railroad, any recorded event or logical combination of events should be flagged as an alarm. A list of situations that should result in the reporting of an alarm along with explanations of how they can be determined is provided below. At a minimum, flagging event records will allow highway and railroad maintenance personnel to determine if a problem exists at a highway-rail grade crossing during regular maintenance or inspections. The following is a list of proposed situations for which an alarm should be reported. These alarms should be determined by monitoring the circuits and recorded events previously described. Event recorders should be capable of processing and relating the recorded events described in order to trigger the alarm(s).

1. Event records indicate that the preemption circuit does not drop or a railroad preemption request was not sent prior to the design preemption warning time. This should be determined by comparing the time stamps of the events recorded when the preemption relay (PER) drops and when an island circuit relay drops, indicating train presence is detected on an island circuit. If the preemption warning time is less than the preemption design time, then an alarm should be reported.

2. Event records indicate that a train is present on an approach circuit and the associated island circuit; however, there is no recorded event for a railroad preemption request. This should be determined by comparing the time stamps of events recorded when a track's approach circuit relay and island circuit relay drops, indicating train presence is detected on an approach and island circuit and when the PER drops. If a track's approach circuit relay and island circuit relay drops and the PER has not dropped, then an alarm should be reported.

3. Event records indicate that the supervisory relay does not pick up after a preemption request, signifying that the traffic controller did not confirm receipt of the preempt message; or the supervisory relay picks up when there is no preemption request, signifying a possible electrical problem in the interconnection. This should be determined by comparing the status of the PER and supervisory relays. If the PER has dropped and there is no event indicating that the supervisory relay has dropped, or if the supervisory relay drops and there is no event indicating that the PER dropped, then an alarm should be reported.

4. Event records indicate that the XR, which activates the grade crossing warning system, does not drop or activate the warning system before the specified warning time. This should be determined by comparing the time stamps of the events recorded when the XR drops and when an island circuit relay drops, indicating a train is detected on an island circuit. If the warning time is less than the design warning time, then an alarm should be reported.

   Alternatively, some newer systems may not have a physical XR to activate the warning system. At these locations, the internal logic in the processors of the railroad grade crossing controller or predictor carries out the function of the grade crossing relay by assigning variables in a logical expression to set the status of the grade crossing warning system. If recorded events indicate that the warning system is activated before the specified warning time, then an alarm should be reported.

   49 CFR 234.225 requires the activation of the grade crossing warning system at least 20 seconds prior to the train occupying the crossing. Train occupancy of the crossing is determined by the train presence detection on the appropriate island circuit.

5. Event records indicate that the entrance gate(s) begins to descend prior to the 49 CFR 234.223 required minimum of three seconds after the grade crossing warning system is activated and the flashing lights begin to operate. This should be determined by comparing the time stamps of the recorded events when the XR drops, indicating activation of the grade crossing warning system, and when the entrance gate(s) begins to descend. If the entrance gate(s) begin to descend less than three seconds after the XR drops, then an alarm should be reported.

6. Event records indicate that the entrance gate(s) reach horizontal position after the required minimum of five seconds prior to a train arriving at the highway-rail grade crossing, or when a train is detected on the island circuit. This should be determined by comparing the time stamps of the recorded events when the gate(s) reach horizontal position and when an island circuit relay drops, indicating a train is detected on an island circuit. If the island relay drops less than five seconds after the gate(s) reach horizontal position, then an alarm should be reported.

7. Event records indicate that the exit gate(s) begins to descend prior to the completion of the track clearance green interval, potentially trapping vehicles in the highway-rail grade crossing. This should be determined by comparing the time stamps of recorded events for when the exit gate(s) leaves the vertical position and when the track clearance green interval has terminated. If the exit gate(s) leave the vertical position before an indication that the track clearance green interval has terminated, then an alarm should be reported.

8. Event records indicate that an entrance or exit gates(s) has left the vertical position, but there is no recorded event indicating the gate(s) has reached the horizontal position within a preset time interval. This should be determined by comparing the time stamps of events recorded when the status of entrance or exit gate(s) change. If the entrance or exit gate(s) have left the vertical position, and there is no recorded event showing the entrance or exit gate(s) has reached the horizontal position before a present time interval, then an alarm should be reported.

   Alternately, event records indicate an entrance or exit gate(s) has left the horizontal position, but there is no recorded event indicating the gate(s) has reached the vertical position within a preset time interval. If the entrance or exit gate(s) have left the horizontal position and there is no recorded event showing the entrance or exit gate(s) have reached the vertical position, then an alarm should be reported. Part 3.3.30 of the *AREMA C&S Manual* states that gate arms should fully raise in no more than 12 seconds, or as instructed.

Finally, event records indicate that an entrance or exit gate(s) is in both the vertical and horizontal position. If the status of the entrance or exit gate(s) indicates they are in the vertical position and also that they are in the horizontal position, then an error has occurred and an alarm should be reported.

9. Event records indicate that the right-of-way transfer time is longer than the design right-of-way transfer time. This should be determined by comparing the time stamps of the events recorded when the status of the right-of-way transfer time indicates it commences and terminates. If the right-of-way transfer time is longer than the design maximum right-of-way transfer time, then an error has occurred and alarm should be reported.

10. Event records indicate that the track clearance green interval is less than the design track clearance green interval. This should be determined by comparing the time stamps of the events recorded when the status of the track clearance green interval indicates it commences and terminates. If the track clearance green interval is less than the design track clearance green interval, then an error has occurred and an alarm should be reported.

11. Event records indicate that the amount of time from the start of the track clearance green interval to train presence detection on an island circuit is less than the design track clearance green interval. This should be determined by comparing the time stamps of the events recorded, when the status of the track clearance green interval indicates it commences and when an island circuit drops to indicate an island circuit is occupied. If the time between the start of track clearance green and island circuit occupancy is less than the design track clearance green interval, then an error has occurred and an alarm should be reported.

12. Event records indicate train presence detection on an island circuit, but there is no event record indicating the termination of the track clearance green interval. This should be determined by comparing the status of the island circuit relays and the status of the track clearance green interval. If the status of an island circuit relay drops, indicating island circuit occupancy, before indication that the track clearance green interval has terminated, then an error has occurred and an alarm should be reported.

13. Event records indicate train presence detection on an approach and island circuit, but the appropriate directional stick relay did not pick up, or a directional stick relay picks up when no train was detected. This indicates there may be an electrical problem with the circuits or relays.

    Alternatively, some newer systems may not have physical directional stick relays to indicate train direction. At these locations, the internal logic in the processors of the railroad grade crossing controller or predictor carries out the function of the directional stick relays by assigning them as variables in a logical expression relating train presence detection on approach and island circuits to the train's direction. Once a train has been detected on an approach circuit and an island circuit consecutively, the train's direction is determined and the appropriate directional stick variable is set to indicate the direction of the train's movement. If recorded events indicate train presence detection on a crossing track's approach and island circuits, but there is no recorded event indicating train direction, or if a recorded event indicates train direction when no train has been detected, then an alarm should be reported.

14. Event records indicate that lock out protection is being provided on a particular track approach. If it is indicated that lock out protection is being provided, than an alarm should be reported.

15. Event records indicate a loss of primary power, a switch to battery power, or significant changes in voltages. If an event record indicates a change in status of the power supply, then an alarm should be reported.

16. Event records indicate that either the highway traffic signal controller cabinet or railroad grade crossing equipment bungalow door has been opened, allowing access to the equipment and settings. If an event record indicates the status of either door changes, then an alarm should be reported.

3.1.3 GENERAL EVENT RECORDING DEVICE FUNCTIONAL REQUIREMENTS

This section describes the general functional requirements for event recording devices to be installed at highway-rail grade crossing locations with highway traffic signal preemption. These requirements are for event recording devices in any of the three system configurations (new, hybrid, and legacy).

The event recorder can be installed in the highway traffic signal controller cabinet, railroad grade crossing equipment bungalow, or in both. Highway agencies and railroads should jointly determine the location of the event recording device(s). The recording device should support time and date stamping of events and have sufficient capacity to record the required events from the highway and railroad for a period of one month prior to overwriting itself. The event recorder should have an internal battery backup to store data in the event of a power loss. For the required highway traffic signal events, the event recorder should dynamically record all required events for a time period of at least 60 seconds, but not less than highway the traffic signal cycle length, prior to a rail preemption call and for an equal time period after the call for rail preemption is terminated.

The event recording device should support two types of user interfaces. A visual display interface should dynamically indicate the status of each input, providing a valuable troubleshooting maintenance tool as well as supporting scheduled maintenance and inspection tasks. This requirement can be satisfied by a series of LED front panel indicators or an LCD alpha-numeric screen. A laptop computer or other portable device interface should provide for initial unit programming at the specific installation location as well as the ability to retrieve and display recorded event logs. If integrated as part of the highway traffic signal controller and/or railroad grade crossing controller, the controller should also support the computer/portable device requirement.

It is recommended that the event recording device support communications with an internet database or back office location to report alarms to the maintaining authorities as they occur. If an event recorder determines that alarm conditions have been met and flags an event record or several event records used to determine such conditions, it should report the alarm and send the associated event records to an internet database or back office system. This allows the highway agency and railroad to act as quickly as possible to investigate the problem. To support these features, the event recording devices should support an Ethernet-based connection to the back office system. This can be achieved by connecting through a high-speed communications link supplied to the equipment cabinet, or through wireless methods such as a cell modem connected to the event recorder. At remote locations, this communications link may not be achievable. The Ethernet connection should be shared by the maintaining agencies through a closed communications network. For new systems using IEEE Standard 1570 communication, the internet database or back office system receiving the reported alarms should support IEEE Standard 1570 so that it can process the alarms and recorded event messages sent to the database. This helps to initiate the required action from the highway agency and/or railroad maintenance personnel, if necessary.

Time Reference Requirements

The event recording device should maintain an accurate time reference. Traditionally, time referencing for highway traffic signal control devices had been based on the 60 Hz AC frequency of the utility generated service. However, it should be noted that on June 14, 2011, the Federal Energy Regulatory Commission stated that it is proposing an experiment that would allow more frequency variation in the nation's power grid. This may adversely impact time referencing systems that rely on electrical frequency for accuracy. Highway traffic signal controllers connected as part of a larger control system architecture may rely on a central device (system field master or remote computer station) to receive a time reference. In the event of power failure to the highway traffic signal controller, an internal crystal-based oscillator backed up by an internal battery should serve to keep time. The accuracy of this backup system would vary based on controller type and manufacturer.

In recent years, a GPS-based time reference system has begun to be used to maintain accurate time in a highway traffic signal controller. Typical installations consist of a small, round antenna installed on top of the highway traffic signal controller cabinet. There are two methods of transmitting the GPS information into the controller. The first method uses a contact closure as a single function input into the controller. (For example, this is typically a manufacturer-defined pin on the "D" connector for a NEMA TS-1 cabinet assembly.) The second method is for a serial connection into an unused communication port (RS232) on the controller.

For the event recorder, a GPS-based time reference should be used to maintain accurate time for both the highway traffic signal and railroad grade crossing recording systems. This should include the existing highway traffic signal controller and conflict monitor/malfunction management unit installed in the cabinet. All devices installed in the highway traffic signal controller cabinet and railroad grade crossing equipment bungalow should have the same time reference for event logging.

Electrical Requirements

The event recording device should be adaptable to accommodate variations in electrical data transmission based on signal cabinet/bungalow architecture. Each highway traffic signal controller and railroad grade crossing architecture utilizes different electrical levels and protocols for in-cabinet communications. NEMA TS-1, for example, employs a single function to single conductor architecture for device-to-device data transmission. A full eight-phase NEMA TS-1 traffic controller has 171 wires connected to it, allowing for +24 VDC (ground true) input/output to the unit. Type 170 and Type 179 use a similar configuration with a 102 conductor interconnection to the controller. NEMA TS2, type 1 uses serial data transmission (SDLC) to interface with other cabinet devices and terminals. The 2070 and other types of device cabinets have the user option to specify a variety of cabinet interface configurations including single function/single conductor or serial interface. For the event inputs identified, the input electrical levels will vary on cabinet type.

Electrical interfacing should conform to NEMA TS-2 "Traffic Controller Assemblies with NTCIP Requirements - Version 02.06" for NEMA-based cabinet assemblies; Caltrans "Transportation Electrical Equipment Specification" for 170-, 179-, and 2070-based cabinet assemblies; and "Advanced Transportation Controller (ATC) Standard" (latest approved version) for ATC-based cabinet assemblies. It should be noted that ATC Version 06.05 was the latest proposed at the time of this writing.

Environmental Requirements

The event recorder should be manufactured such that it meets the minimum environmental and test requirements as defined in NEMA TS-2 "Traffic Controller Assemblies with NTCIP Requirements - Version 02.06" for NEMA-based cabinet assemblies; Caltrans "Transportation Electrical Equipment Specification" for 170-, 179-, and 2070-based cabinet assemblies; and "Advanced Transportation Controller (ATC) Standard" (latest approved version) for ATC-based cabinet assemblies. The recording device should also meet the environmental requirements recommended in *AREMA C&S Manual* Part 11.5.1 "Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment."

Inspection & Testing

Event recording devices should conduct self-diagnostics and testing as recommended in *AREMA C&S Manual* Part 3.1.29. Upon start-up and after reset, the recorders should perform self-diagnostics and the results of self-diagnostic tests should be recorded with a date and time stamp. The recorders should also verify proper operation and perform self-diagnostics periodically, while continuing to monitor and respond to status changes. If the tests are successful, the recorder should locally indicate being operational and, if possible, report being online and operational. If the tests are not successful, the recorder should create an event record and report an alarm. The recording devices should also verify input states by providing multiple sampling or time integration when evaluating the status of each input. Finally, the recorders should include a timer that requires the continuous servicing by the self-diagnostics in order to keep operating. If the timer expires, the recorder should reset itself and perform self-diagnostics upon resetting. This should also create an event record indicating the system was reset.

The event recording device should be tested to determine that it functions as intended when it is installed or modified and at least once a month, as required of grade crossing warning systems in 49 CFR 234. During regular joint inspections, highway agency and/or railroad inspecting personnel should download the recorded data from the event recording device to compare with known train events, if the data is not already regularly uploaded to and monitored from a back office database.

3.1.4 EVENT RECORDER COSTS

The cost of event recording devices varies based on the processing and reporting capabilities as well as storage capacity and recording needs of the highway-rail grade crossing. Larger highway-rail grade crossing locations or locations with more equipment that require additional monitoring and recording may require expanding the event recorder's inputs and outputs. Depending on the amount of information being recorded, event recorders may also need expanded memory so that they can store events for the required one month period prior to overwriting the memory. The geographic location of the highway-rail grade crossing and the available communication options will also impact the cost of event recording devices. For example, remote locations may require additional equipment for effective monitoring and alarm reporting.

Current pricing for basic event recording devices, without expanded inputs and outputs or memory, is between $1,500 and $2,500. Additional analog and digital I/O modules can cost from $500 to $2,000 depending on the size, type, and manufacturer. Memory expansion cards or modules can cost up to $1,000. Optional communication modules or cards typically cost up to $1,500. Given that the proposed event recorder will be required to contain more functionality than existing systems, event recording devices could cost up to $10,000 depending on the size of the location and necessary equipment. Back office systems needed for reporting alarms and remotely monitoring and testing highway-rail grade crossing equipment can cost from $10,000 to $150,000 based on the level of monitoring and automatic testing desired.

The prices for event recording devices capable of supporting IEEE Standard 1570 and monitoring the communication messages will most likely be greater than the costs provided here. These recording devices will need new executive software and the necessary communication options and equipment to support IEEE Standard 1570. Manufacturers will incur expenses for product development, which will in turn increase the costs of the new recording systems. Event recorder manufacturers typically provide railroads with discounted prices for buying in bulk, which vary based on the price of the product and quantity purchased.

3.2 Policy Information

3.2.1 SCOPE

Railroad maintenance standards and requirements for testing and inspecting highway-rail grade crossing signal systems are mandated by the Code of Federal Regulations Title 49 Part 234 Subpart D and AREMA. However, there is no national traffic signal counterpart to these standards and requirements. Traffic signal system maintenance, testing, and inspection processes are typically developed by State and local highway agencies. The following presents information pertaining to minimum maintenance, testing, and inspection policies and practices to be followed by State and local highway agencies for highway-rail grade crossing locations. Relevant 49 CFR 234 sections are also presented. The ultimate goal is to encourage a working relationship between highway agencies and railroads through a joint testing and inspection procedure to ensure that highway-rail grade crossing signal systems and interconnected highway traffic signal systems are communicating correctly and working properly. Achieving this goal will satisfy the four actions recommended in the Safety Advisory 2010-02 noted in Chapter 1.

3.2.2 FREQUENCY OF INSPECTION AND TESTING

Performing preventive inspections and maintenance activities at highway-rail grade crossing locations is considered proactive risk management by State and local highway agencies. The *Traffic Signal Installation and Maintenance Manual* (4) recommends that these preventive inspections and maintenance activities be conducted at a 6-month intervals.

Railroads should perform inspections, testing, and maintenance activities at highway-rail grade crossing locations as required by 49 CFR 234.

Safety Advisory 2010-02 set forth requirements for State and local highway agencies to perform joint inspections in coordination with railroads at highway-rail grade crossing locations. The joint inspections should be performed at a maximum interval of twelve months.

3.2.3 SCHEDULING

It would be desirable for the 6-month preventive inspections and maintenance activities to be scheduled and initiated by the State (district) or local highway agency office with jurisdiction over the highway-rail grade crossing. Ensuring that each highway-rail grade crossing with a jurisdiction is inspected and maintained within the specified interval may be the responsibility of the State (district) or local traffic engineer.

The monthly and quarterly inspections, testing, and maintenance activities conducted by the railroad should be scheduled and initiated as currently done in accordance with 49 CFR 234.

It is encouraged that the annual detailed joint inspections be scheduled and initiated by the State (district) or local highway agency office with jurisdiction over the highway-rail grade crossing. The

State (district) or local traffic engineer would be responsible to coordinate scheduling with the appropriate railroad. The State (district) or local traffic engineer would also ensure that each highway-rail grade crossing location within his/her jurisdiction is jointly inspected within the specified interval.

3.2.4 RESPONSIBILITIES OF PERSONNEL

At least one highway traffic signal technician may conduct each 6-month preventive inspection and maintenance activity, verifying the elements identified under "Procedures". However, if deemed necessary, a traffic engineer may also perform the 6-month preventive inspection and maintenance activity. When two traffic personnel are present, the highway traffic signal technician would be responsible for the functionality of the highway traffic signal system whereas the traffic engineer would be responsible for the signal operations, signs, pavement markings, and other safety concerns.

Each monthly and quarterly inspection, testing, and maintenance activity performed by the railroad should be conducted by at least one railroad inspection/testing personnel. The railroad inspection/testing personnel should be responsible for the functionality of the railroad grade crossing warning system. The railroad inspection/testing personnel should be familiar with the requirements of 49 CFR 234 to ensure that all aspects of the highway-rail grade crossing are reviewed as specified.

Each detailed annual joint inspection may be conducted by at least one highway traffic signal technician, one traffic engineer, and one inspection/testing personnel from the railroad. The highway traffic signal technician would be responsible for the functionality of the highway traffic signal system whereas the traffic engineer would be responsible for the signal operations, signs, pavement markings, and other safety concerns. The railroad inspection/testing personnel should be responsible for the functionality of the railroad grade crossing warning system. Coordination between the highway traffic signal technician, the traffic engineer, and the railroad inspector is important to ensure that all aspects of the interconnected highway-rail grade crossing signal system are properly working.

3.2.5 PROCEDURES

Identification

Highway-rail grade crossings that have interconnection between the highway traffic signal system and the railroad grade crossing warning system should be identified as such. The warning labels shown in Figure 8 may be affixed inside the main door of the highway traffic signal controller cabinet and the railroad grade crossing equipment bungalow, respectively.

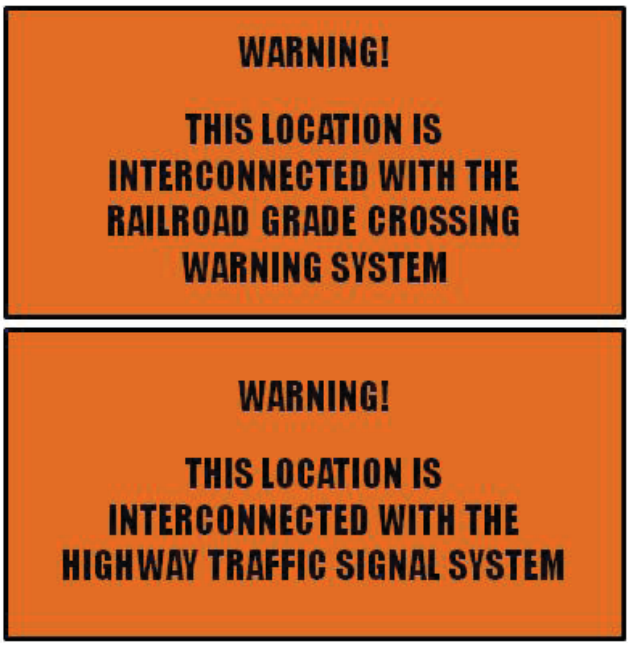

Figure 8: Example Warning Labels

A field example of a warning label is shown in Figure 9. In addition to the warning, the label also includes contact information for the responsible highway agency and railroad.

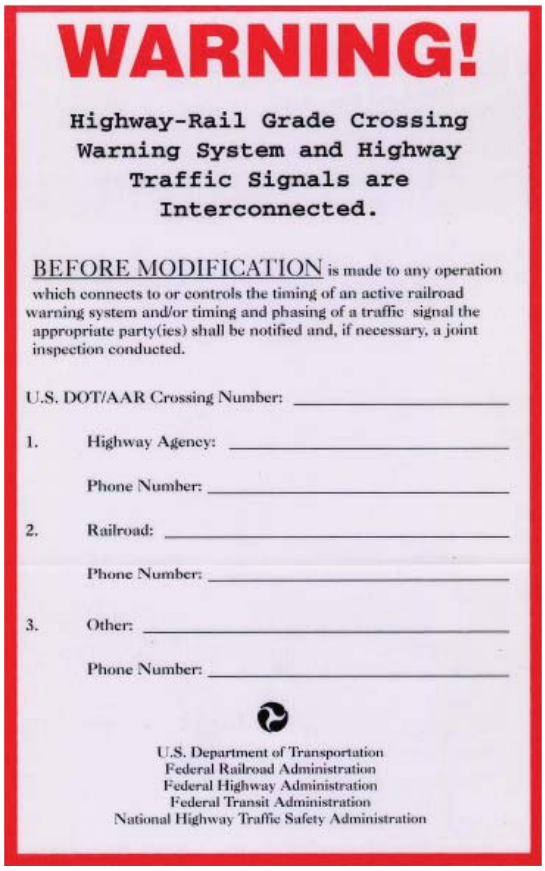

Figure 9: Field Example of Warning Label

Plans

Signed and sealed plans required for proper testing and maintenance of the highway traffic signal system may be kept at each highway-rail grade crossing location within the highway traffic signal controller cabinet. This may also include signed and sealed plans for signing and pavement markings installed in advance of the highway-rail grade crossing on all roadway approaches. It is an effective practice to maintain legible and current plans that contain an accurate database of all programming resident in each of the various control devices. If modifications are made to the highway traffic signal system or to signing and pavement markings, modifying or replacing the plans within the highway traffic signal controller cabinet would be the duty of the highway agencies.

As required by 49 CFR 234.201, plans required for proper testing and maintenance of the railroad grade crossing warning system should be kept at each highway-rail grade crossing location in the railroad grade crossing equipment bungalow. It is the responsibility of the railroad to keep these plans legible and correct. If any modifications are made to the railroad grade crossing warning system, it is the responsibility of the railroad to modify or replace the plans contained in the railroad grade crossing equipment bungalow. Additionally, it should be the responsibility of the railroad to notify the appropriate highway agency of any changes made to the railroad grade crossing warning system that may have an impact on the operation of nearby highway traffic signal systems.

Six-month Highway Preventive Inspections and Maintenance Activities

The 6-month preventive inspections and maintenance activities are intended to verify that basic highway traffic signalization parameters are functioning properly, that appropriate signing and pavement markings are in place and in good condition, and that no other safety concerns are present. The items to be verified by a highway traffic signal technician (and traffic engineer, if present) may include the following:

- Signalization (vehicular and pedestrian, if present) to ensure that indications on all roadway approaches and at all pedestrian crossings are properly aligned and illuminated, when applicable.
- Signing to ensure that appropriate advance warning signs on all roadway approaches are present, visible, and in good condition.
- Pavement markings to ensure that appropriate pavement markings on all roadway approaches are present and in good condition.
- Visibility to ensure that sight triangles on all roadway approaches are clear of obstructions, particularly vegetation growth.
- Pavement condition to ensure that the surface on all roadway approaches is free of significant defects that would present a safety concern.
- Lighting to ensure that luminaires (if present) on all roadway approaches are functioning and providing sufficient illumination.
- Controller cabinet condition to ensure that the internal area is free of debris or animal infestations that may cause system malfunctions.

The issues identified through the 6-month preventive inspection process need to be brought to the attention of the appropriate responsible parties. Problems to be addressed immediately may include signalization, missing signing, and lighting outages. Additionally, seriously deteriorated pavement conditions should be given immediate attention while less significant deteriorations may be addressed in the short-term. Signing and pavement markings in poor condition may be updated at a regularly scheduled interval. It is important that controller cabinet debris or animal infestations be cleared at the time of the inspection.

Monthly and Quarterly Railroad Inspections and Maintenance Activities

The CFR regulations explain in detail the components of the railroad grade crossing warning system that should be inspected, tested, and maintained on a monthly and quarterly (3 month) basis. The purpose is to ensure that the warning system functions as designed, including being visible and audible to highway users approaching the crossing. At each of the specified intervals, railroad inspection/testing personnel should verify the following:

Monthly

- 49 CFR 234.257 — Warning System Operation:
    a. *Each highway-rail crossing warning system shall be tested to determine that it functions as intended when it is placed in service. Thereafter, it shall be tested at least once each month and whenever modified or disarranged.*
    b. *Warning bells or other stationary audible warning devices shall be tested when installed to determine that they function as intended. Thereafter, they shall be tested at least once each month and whenever modified or disarranged.*
- 49 CFR 234.261 — Highway Traffic Signal Preemption:
    Highway traffic signal preemption interconnections, for which a railroad has maintenance responsibility, shall be tested at least once each month.

The railroad having jurisdiction over the highway-rail grade crossing should be responsible for inspection, testing, and maintenance up to the point of interconnection with the highway traffic signal control system. The State or local highway agency should be responsible for inspecting, testing, and maintaining all remaining circuitry and highway traffic signal control devices. The test should ensure that an approaching train activates the railroad grade crossing warning system and initiates the highway traffic signal clearance sequence. The railroad should check contacts and devices interconnected with the highway traffic signals and advanced warning signs to ensure they perform as intended as defined in 49 CFR.

Inspection/testing personnel should also verify the proper operation of the interconnect circuit and observe that highway traffic signal preemption is operating as intended. Ideally, preemption should be verified with the actual passing of a train through the highway-rail grade crossing location; however, this is not always feasible. Under these circumstances, inspection/testing personnel may simulate a train movement by de-energizing the interconnection circuit, thereby activating the preemption sequence. If the crossing is equipped with advanced preemption, inspection/testing personnel should observe a train movement to verify proper operation. Inspection/testing personnel should note any repairs or adjustments made. If the interconnection circuit is discovered to be not operational and/or any inconsistency is discovered, inspection/testing personnel should notify the State or local highway agency having jurisdiction over the highway-rail grade crossing as well as report the findings to the appropriate railroad supervisor. If the railroad equipment is found to be operating properly and the highway traffic signal system does not respond, inspection/testing personnel should notify the State or local highway agency having jurisdiction over the highway-rail grade crossing of the problem. The railroad may request the presence of State or local highway agency personnel during the monthly preemption testing.

Quarterly

- 49 CFR 234.269 — Cut-out Circuits:
  Each cut-out circuit shall be tested at least once every three months to determine that the circuit functions as intended. For purposes of this section, a cut-out circuit is any circuit which overrides the operation of automatic warning systems. This includes both switch cut-out circuits and devices which enable personnel to manually override the operation of automatic warning systems.
- 49 CFR 234.271 — Insulated Rail Joints, Bond Wires, and Track Connections:
  Insulated rail joints, bond wires, and track connections shall be inspected at least once every three months.

  These tests are used to assure that trains are being properly detected on each of the railroad approaches.

Detailed Annual Joint Inspections

The detailed annual joint inspections are intended to verify that all aspects of the interconnected highway-rail grade crossing signal system are properly working. It is desirable that the detailed annual joint inspections be conducted by highway agency and railroad personnel as described.

A highway traffic signal technician and traffic engineer may verify the following:

- Controller equipment to ensure that all installed units are in proper working order and that all connections are tight and secure. In particular, testing of the conflict monitor/malfunction management unit ensures that the interconnected highway-rail system reverts to safe mode in the event of failure. This would include both field testing and automated bench testing of the system.
- Vehicular and pedestrian timings to ensure that all traffic controller settings match the current master timing sheet.
- Preemption to ensure that, upon activation by an approaching train, the highway traffic signal system initiates and properly cycles the preemption sequence as specified on the plans and master timing sheet. This includes ensuring that the minimum activation warning time provided is sufficient to clear the highway-rail grade crossing of vehicular and pedestrian traffic prior to train arrival. Ideally, preemption would be verified with the actual passing of a train through the highway-rail grade crossing location; however, this is not always feasible. Under these circumstances, the railroad personnel may initiate the preemption sequence. Otherwise, the highway traffic signal technician may remove one of the connectors provided from the railroad to the highway traffic signal controller cabinet to activate preemption. This testing process needs to be conducted during coordinated operation, non-coordinated operation, and when other modes of signal operation are active, including emergency vehicle preemption and transit signal priority operation.
- Vehicle/pedestrian detection to ensure that detection systems installed on all approaches/crossings are in proper working order, that all connections within the controller are tight and secure, and that all inputs are being received and processed. Any existing/historical fault indicators need to be noted as problems to be rectified.

Railroad inspection/testing personnel should verify the following:

- 49 CFR 234.225 — Activation of Warning System:
  A highway-rail grade crossing warning system shall be maintained to activate in accordance with the design of the warning system, but in no event shall it provide less than 20 seconds warning time for the normal operation of through trains before the grade crossing is occupied by rail traffic.
- 49 CFR 234.259 — Warning Time:
  Each crossing warning system shall be tested for the prescribed warning time at least once every 12 months and when the warning system is modified because of a change in train speeds. Electronic devices that accurately determine actual warning time may be used in performing such tests.

  Railroads should ensure the grade crossing warning system activates as designed, and in no instance provides less than 20 seconds of warning time. Inspection/testing personnel should observe the crossing warning time and verify that it is in accordance with the designed warning system as shown on the circuit drawings. If an electronic device is installed at the highway-rail grade crossing location to accurately determine actual warning time, the warning time must be observed during a train movement or calculated by measuring the approach track circuits and using the highest timetable speed. If the warning time is found to be less than 20 seconds, inspection/testing personnel should immediately take corrective action and provide appropriate documentation.

- 49 CFR 234.263 — Relays:
  a. *Except as stated in paragraph (b) of this section, each relay that affects the proper functioning of a crossing warning system shall be tested at least once every four years.*
  b. *(1) Alternating current vane type relays, direct current polar type relays, and relays with soft iron magnetic structure shall be tested at least once every two years. (2) Alternating current centrifugal type relays shall be tested at least once every 12 months.*

  Railroad inspection/testing personnel should check relay operation for each track at the highway-rail grade crossing location and in each direction to ensure that the relays are de-energized after testing is complete. Railroads may provide specific instructions for inspection of each relay type and for testing with current and voltage.

- 49 CFR 234.265 — Timing Relays and Timing Devices:
  Each timing relay and timing device shall be tested at least once every twelve months. The timing shall be maintained at not less than 90 percent nor more than 110 percent of the 41 predetermined time interval. The predetermined time interval shall be shown on the plans or marked on the timing relay or timing device. Timing devices which perform internal functions associated with motion detectors, motion sensors, and grade crossing predictors are not subject to the requirements of this section.

During the detailed annual joint inspection process, it is desirable to maintain the normal operation of the highway-rail grade crossing. If normal operation is to be suspended, other provisions should be made prior to the inspection to ensure highway-rail grade crossing safety for all transportation modes at the location.

3.2.6 DOCUMENTATION

For the 6-month preventive inspections and maintenance activities, a report completed by the highway traffic signal technician (and traffic engineer, if present) may include information such as the highway-rail grade crossing location, the technician's name (and traffic engineer, if present) and employee identification number, the date and time, the tasks performed, and the problems noted. A minimum of two copies of the 6-month report may be required, both signed by the highway traffic signal technician (and traffic engineer, if present). One report may be kept within the highway traffic signal controller cabinet and one may be filed at the State (district) or local highway agency office with jurisdiction over the highway-rail grade crossing. Upon the next inspection, the report within the highway traffic signal controller cabinet would be replaced. The report filed at the State (district) or local highway agency office may be discarded after a period of five years. If interim maintenance activities are required to the highway traffic signal system, it is important that signed documentation be attached to the most current report on file.

For the detailed annual joint inspections, a report should be completed by the highway traffic signal technician, traffic engineer, and railroad inspector. The report may include information such as the highway-rail grade crossing location, the participants' names and employee identification numbers, the date and time, the tasks performed, and the problems noted. A minimum of four copies of the joint inspection report may be required, signed by the highway traffic signal technician, traffic engineer, and railroad inspector. One report may be kept within the highway traffic signal controller cabinet, one may be filed at the State (district) or local highway agency office with jurisdiction over the highway-rail grade crossing, one should be kept within the railroad grade crossing equipment bungalow, and one should be filed in the office of a railroad supervisory official having jurisdiction, as required by 49 CFR 234.273. The reports within the highway traffic signal controller cabinet and the railroad grade crossing equipment bungalow would be replaced upon the next joint inspection. The report filed at the State (district) or local highway agency office may be discarded after a period of five years. The report filed with the railroad supervisory official should be kept until the next report for that test is filed and at least for one year, also as required by 49 CFR 234.273. If interim adjustments have been made to the highway traffic signal control system or railroad grade crossing warning system, it is important that signed documentation be attached to the most current report on file.

Several example inspection and diagnostic forms are attached in Appendix F. These forms can be modified by highway agencies and railroads for use during the 6-month preventive inspections and maintenance activities and the detailed annual joint inspection of highway-rail grade crossings.

3.2.7 REFERENCE DOCUMENTATION

The following reference documents may be consulted when performing inspections and maintenance activities:

- *Manual on Uniform Traffic Control Devices* (MUTCD) (7)
  - » Part 8 – Traffic Control for Railroad and Light Rail Transit Grade Crossings
- *Traffic Engineering Handbook* (10)
- *Traffic Control Devices Handbook* (11)
- *Code of Federal Regulations* (6)
  - » Title 49 – Transportation; Part 234 – Grade Crossing Signal System Safety and State Action Plans; Subpart D – Maintenance, Inspection, and Testing

- *AREMA Communications and Signals Manual* (9)
  - » Section 3 – Highway-Rail Grade Crossing Warning Systems; Part 3.1.10 – Recommended Functional/Operating Guidelines for Interconnection Between Highway Traffic Signals and Highway-Rail Grade Crossing Warning Systems
  - » Section 3 – Highway-Rail Grade Crossing Warning Systems; Part 3.3.1 – Recommended Instructions for the Maintenance and Test of Automatic Highway-Rail Grade Crossing Warning Systems
  - » Section 3 – Highway-Rail Grade Crossing Warning Systems; Part 3.3.30 – Recommended Instructions for Inspection and Test of Highway-Rail Grade Crossing Warning System Installation Before Placing In Service
- *Railroad-Highway Grade Crossing Handbook* (12)

CHAPTER 4. MODEL STRATEGY FOR ESTABLISHING REGULAR JOINT INSPECTIONS OF INTERCONNECTED SYSTEMS

The following presents a model strategy to establish regular joint inspections of interconnected highway-rail grade crossing signal systems. "Regular" joint inspection is recommended on an annual (12 month) basis. The annual inspection cycle coincides with FRA-mandated 49 CFR 234 inspection, testing, and maintenance procedures currently required of railroads. As previously stated, the ultimate goal is to encourage a working relationship between highway agencies and railroads to ensure that highway-rail grade crossing locations are being proactively maintained to minimize the occurrence of vehicle-train collisions. This generic model strategy is intended to assist with formulating and establishing more stringent processes and procedures than what is generally the current practice.

4.1 Pre–Inspection

Prior to the inspection taking place, the highway agency should coordinate with the railroad to schedule times and locations. Given that there is currently no national highway traffic signal inspection program counterpart to the FRA regulations, it should be the responsibility of the highway agency to initiate the inspection. This will promote participation by both agencies having jurisdiction over a highway-rail grade crossing location.

It is important that personnel involved in the joint inspections be knowledgeable of preemption operation at highway-rail grade crossings. Limited personnel resources may preclude intra-agency participation; therefore, agencies may be supported by additional resources including outside entities. For example, smaller jurisdictions such as counties or towns may work with the State Department of Transportation or with private contractors to perform inspection, testing, and maintenance tasks. In these instances, the jurisdictional highway agency should be responsible for coordinating with all outside parties involved to ensure participation. When scheduling, consideration may be given to railroad timetables such that the inspection is conducted simultaneously with an actual train movement through the highway-rail grade crossing under inspection.

As part of the pre-inspection preparation, participating highway agency and railroad personnel should meet and review documentation related to the crossing(s) being reviewed. Documentation that should be part of the inspectional process includes the most current signal as-built plan, signal timing and operations forms, and any previous inspection reports. Highway agency and railroad personnel (or representatives) should also identify and note any changes that have occurred since the last annual inspection or are planned to occur at a time after the upcoming annual inspection is to be conducted. This information should be brought to the inspection and shared with all participants.

4.2 Inspection

The recommended annual joint inspection of highway-rail grade crossings with interconnected signal systems is intended to verify that all aspects of the interconnection and of each individual system component are working properly. In order to make these verifications, there are a number of critical items that should be checked and tested during the inspection. The following are sample prompts for these items; however, additional items may be appropriate.

- ☐ *Does a preemption call from the railroad activate the highway traffic signal and any other warning devices? Are signals, active advance warning signs, etc. functioning as intended?*
- ☐ *Does the grade crossing warning time provided match the time shown on the most current grade crossing plan? Are flashers, bells, gates, etc. functioning as intended?*
- ☐ *Does the preemption sequence match the most current signal plan?*
- ☐ *What is the required track clearance green time? Is the calculated time consistent with what is shown on the signal plan and programmed in the field?*
- ☐ *What is the calculated required total preemption warning time? Is the actual total preemption warning time consistent with what is required by calculation?*
- ☐ *Does preemption override basic controller times?*
- ☐ *Does preemption work properly under free and coordinated operation? Does the preemption work properly under every coordination plan?*
- ☐ *Is right-of-way transfer time consistent with defined preemption timing?*
- ☐ *When does the highway traffic signal controller release the intersection back to normal operation?*
- ☐ *Is the highway traffic signal controller programmed to cycle during preemption? If so, does it cycle properly?*
- ☐ *Does the rail preemption operation involve multiple locations? If so, does the preemption operation work according to defined plans?*
- ☐ *What is the electrical/mechanical condition of the interconnect circuit/contact in the railroad grade crossing equipment bungalow and/or highway junction box?*
- ☐ *Does the interconnect circuitry support required fail safe operation?*
- ☐ *Do installed standby or backup electrical power source systems operate as designed?*
- ☐ *Do installed special features (supervisory circuit, power failure monitoring circuit, etc.) function as designed?*
- ☐ *Do actual intersection characteristics (signal displays, stop line locations, pavement markings, signing, etc.) match the most current as-built plan? Are modifications or additional measures necessary? If so, document findings.*
- ☐ *Highway agencies and railroads should jointly establish their own unique checklist based on particular needs. The checklist would likely be a subset of current FRA and future FHWA regulations. Several inspection checklists and forms are provided in Appendix F as practical examples for use in developing and adopting specific jurisdictional processes and procedures.*

Updated or upgraded signal systems may have the capability to be monitored remotely, which does not require personnel to be on-site. However, it is recommended that inspecting and testing be conducted on-site to visually confirm acceptable condition and verify proper functionality of all relative traffic control devices including pavement markings, signing, etc. This will serve to ensure that no critical item is overlooked that may not be identified through remote monitoring.

It is recommended that highway agency and railroad personnel download and review data stored within an event recording device (if installed). The proposed minimum required events/circuits to be monitored and recorded have been identified in the "Technical Information", as listed in Table 7.

Table 7: Minimum Proposed Events/Circuits to be Monitored and Recorded

HIGHWAY	RAILROAD
Preempt (Active/Inactive)	Supervisory Circuit
Vehicle/Pedestrian Signal	Railroad Preempt Request
Right-of-Way Transfer Time	Approach Circuits
Track Clearance Green Interval	Railroad Crossing Relay
Flash Operation	Entrance Gate Status
Cabinet Electrical Service	Exit Gate Status
Main Cabinet Door (Open/Closed)	Island Circuit Occupancy
	Train Direction
	Lock Out Protection
	Power (On/Off)
	Entrance Alarm (Open/Closed)

This data archive will help identify abnormalities in the operation of interconnected highway-rail grade crossing signal systems, particularly with railroad preemption sequencing. It also allows personnel to determine if either control cabinet/bungalow has been accessed, flagging instances where changes to operations may have been made without being manually documented on work forms and thus requiring further investigation. The ability to download and review archived data eliminates the reliance on an isolated crossing event or simulated activation as the sole basis for determining whether or not all aspects of the system are working properly.

All inspection activities should be documented according to the inspection and testing form jointly adopted by the highway agency and railroad. Any findings needing further investigation, repair, or modifications made during the inspection should be clearly noted and brought to the attention of appropriate highway agency and/or railroad personnel. The form(s) should be signed and dated by the personnel performing the inspection and testing activities and filed. Consideration may be given to universally adopting the 49 CFR 234 mandate for recording and filing of inspection and test results.

4.3 Post-Inspection

It is important that any issues identified during the annual joint inspection are addressed immediately. This requires coordination and cooperation between the highway agency and railroad. Highway agencies and railroads should establish agreements to facilitate partnerships and meet common goals and objectives. The agreements should clearly define the immediate follow-up and continuous maintenance obligations of each agency. The responsibilities of each agency in terms of furnishing and funding specific elements at highway-rail grade crossings with interconnected signal systems should also be established. For example:

- ☐ *The railroad or its contractor will furnish and install a relay to provide simultaneous/advance preemption to the existing highway traffic signal and/or proposed traffic signal/advance flasher.*
- ☐ *The railroad or its contractor will provide traffic control in accordance with MUTCD guidelines.*
- ☐ *The highway agency or its contractor will furnish and install or replace appropriate pavement markings and signs in accordance with MUTCD guidelines.*
- ☐ *The highway agency agrees to trim and maintain trees and vegetation for adequate visibility of the crossing signals and advance warning signs.*

Post-inspection activities may also include responding to issues at interconnected highway-rail grade crossing locations in between annual joint inspections. Issues relating to incorrect operation or system failure (highway, railroad, or both) may be identified by motorists, pedestrians, highway agency personnel, railroad personnel, train conductors, emergency personnel, etc. They may also be identified through alarms registered by an event recording device (if installed). Abnormalities in the events being recorded can be programmed to create an alarm, which is logged within the device. The device may also send a remote notification of the alarm to either or both of the responsible agencies to alert them of a potential problem.

The highway agency and railroad should establish protocols to respond to potential issues with the operation of interconnected highway-rail grade crossing signal systems. This includes identifying a point of contact to receive comments and concerns, as well as a single point of authority to make decisions regarding necessary modifications to resolve problems with the grade crossing operation. Additional consideration may be given to personnel and protocol for remotely monitoring and addressing event recording device alarms.

Each agency may have or adopt independent inspection, testing, and maintenance activities to be conducted at intervals less than 12 months. For example, 49 CFR 234 specifies components of the grade crossing warning system that are to be inspected, tested, and maintained on a monthly and quarterly (3 month) basis by FRA. Six-month preventive inspection and testing activities have been proposed for highway agencies. Interim independent activities and modifications should be documented and filed to keep a record for subsequent joint inspections.

4.3.1 AGREEMENTS

Current practices establish agreements between highway agencies and railroads prior to the design and construction of improvement projects. These agreements are required to define the responsibilities of both parties to include a detailed scope of work, a method for completing work, a reference to appropriate plans and specifications, and a maintenance strategy. For federal-aid projects, the agreements must also explicitly identify the crossing, describe the improvements being made, provide a cost estimate, and establish a proposed work schedule (as required by 23 CFR 464.216 and 23 CFR 464.218).

One strategy is the use of a "master agreement". This arrangement can be structured to specify the responsibilities of an individual project or for several projects. Depending on the desires of the participating highway agencies and railroads, the agreement can also cover the entire project or specific project tasks. In situations where only partial project responsibilities are defined, subsequent provisions can be enacted through a change order to the master agreement.

Cooperation and coordination between highway agencies and railroads is required for the joint inspection process to be successful. It is also important to ensure that identified problems are addressed and resolved in a timely manner to support safe operation of highway-rail grade crossing locations. Several "best practices" identified by highway agencies and railroads to promote effective partnerships include:

- Establishing open lines of communication between the agencies;
- Identifying points of contact in each agency with the authority to make decisions;
- Developing agreements to address critical issues such as insurance, rights-of-entry, liability, easements, construction safety, and recurring maintenance;
- Training design, construction, and maintenance personnel; and,
- Providing standard process manuals for project development and maintenance.

Developing an agreement between highway agencies and railroads helps to facilitate partnerships and meet common objectives. Much like the agreements formed for construction projects, similar agreements can be written for conducting the joint inspection. The agreements should clearly state the responsibilities of each agency during the process, as well as define the responsibilities of each agency immediately following the inspection and in between the next scheduled inspection.

Two sample agreements are attached in Appendix G. These agreements can be modified by highway agencies and railroads for the joint inspection of highway-rail grade crossings. The first is a railroad-highway master agreement addressing the installation, maintenance, and improvement of warning devices. The second is a diagnostic checklist that also specifies the responsibilities of each agency in terms of furnishing and funding specific elements at a highway-rail grade crossing location.

4.4 Funding Sources

Federal, State, and local government agencies as well as the railroad industry administer funds for highway-rail grade crossing improvements. The major source of Federal funding is the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Also known as Section 130 funds, these monies can be used for several types of highway-rail grade crossing safety improvement projects, including track circuit improvements and interconnection. State and local agency monies are typically used for maintenance of highway traffic control devices, roadway approaches, and vegetation at the highway-rail grade crossing. Railroad monies are commonly used for improvements within the railroad right-of-way.

Current practice does not use these funding sources for the conduct of inspections at highway-rail grade crossing locations. The inspections are usually funded through the general operating budget of the State (district) or local highway agency office, accounting for the time requirement to complete and document the inspection. Since the identified funding sources allow for improvements and maintenance, highway agencies and railroads should seek to use these monies for intermediate activities as well as for the detailed annual joint inspection of highway-rail grade crossing locations. Installation of the event recording device(s) at the location should also be considered in funding allocations.

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2. United States Department of Transportation, Federal Railroad Administration Safety Advisory 2010-02. Federal Register. Volume 75, Number 190. Friday, October 1, 2010. http://www.fra.dot.gov/downloads/safety/sa201002.pdf

3. United States Department of Transportation Federal Railroad Administration National Highway-Rail Grade Crossing Inventory database. http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/crossing/crossing.aspx

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15. "Guideline For Inspecting and Testing Preemption of Interconnected Traffic Control Signals and Railway Crossing Warning Systems." TP 13755. Transport Canada. http://www.tc.gc.ca/media/documents/railsafety/TP13755.pdf

16. "Mn/DOT Annual Traffic Signal and Railroad Preemption Inspection Form". Version 11/21/2007. http://www.dot.state.mn.us/trafficeng/signals/signalworksheets/html

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19. "Strategies for Improving the Project Agreement Process Between Highway Agencies and Railroads". SHRP2 Report S2-R16-RR-1. Executive Summary and Appendix C. http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-R16-RR-1.pdf

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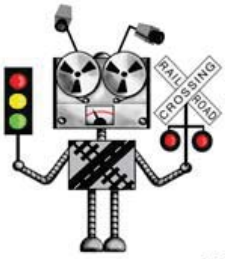
APPENDIX A: IGOR INFORMATIONAL BROCHURE

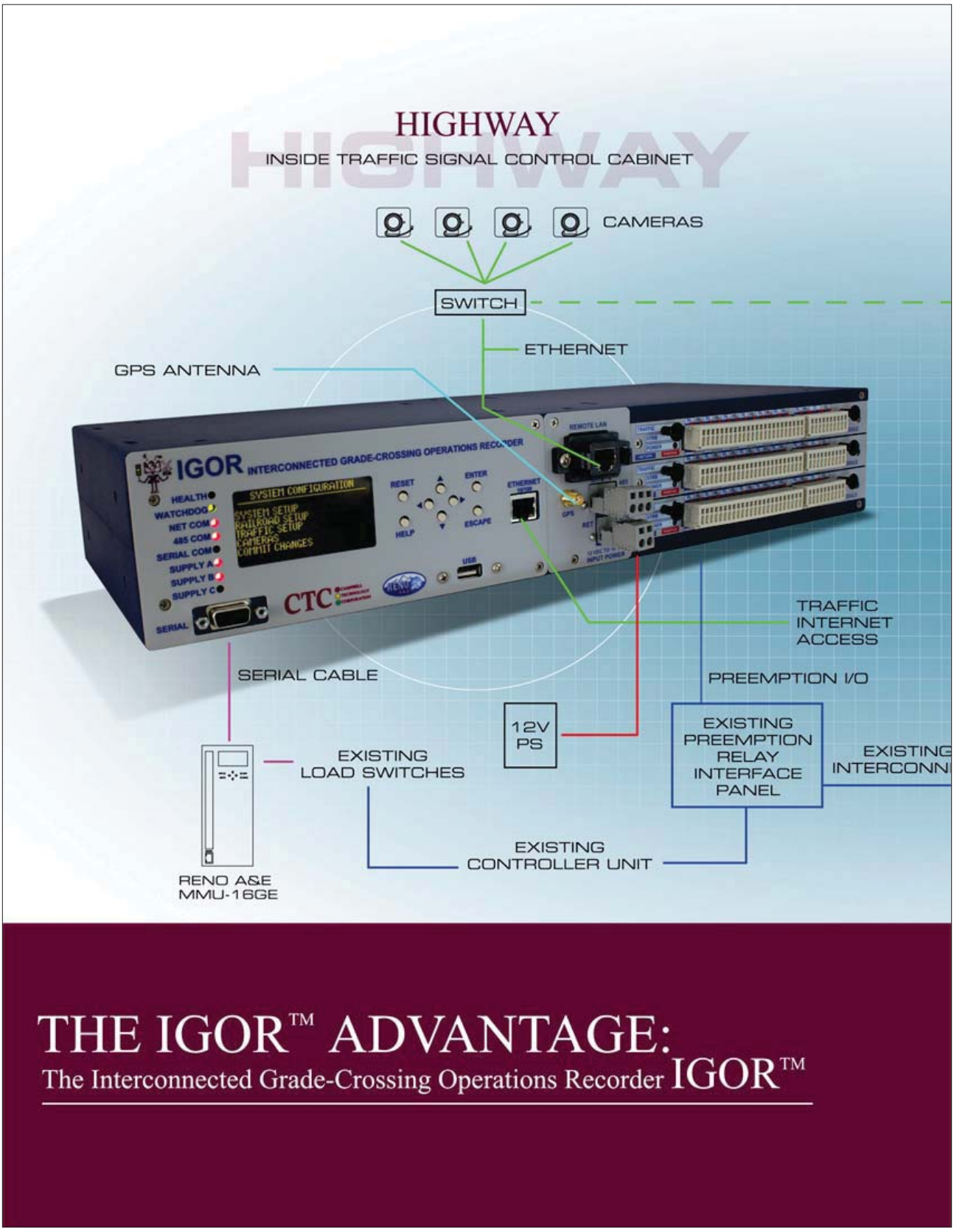
INTRODUCING

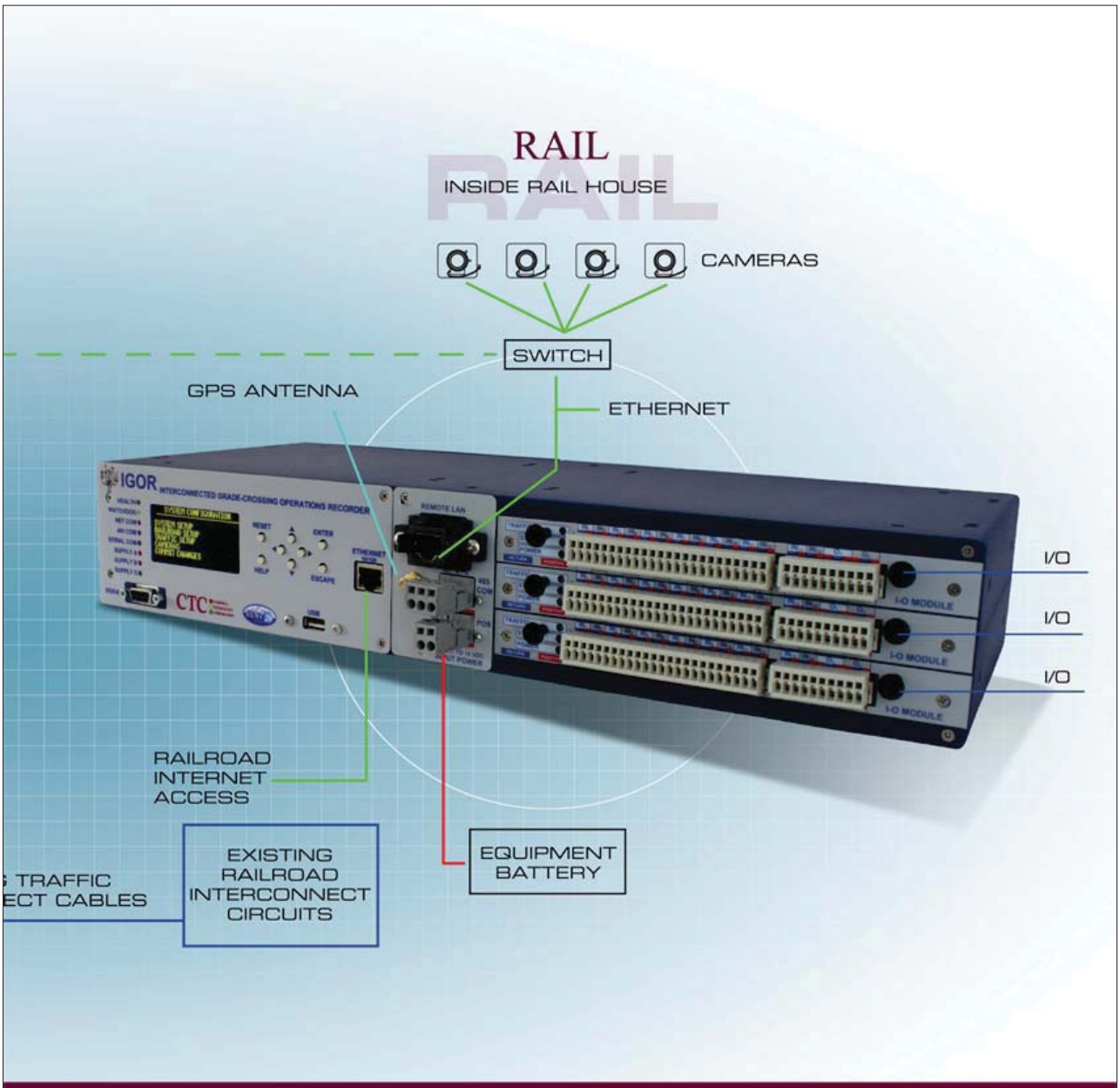
IGOR: INTERCONNECTED GRADE-CROSSING OPERATIONS RECORDER



IGOR™

INTERCONNECTED GRADE-CROSSING OPERATIONS RECORDER


HIGHWAY
INSIDE TRAFFIC SIGNAL CONTROL CABINET
CAMERAS
SWITCH
ETHERNET
GPS ANTENNA
IGOR
INTERCONNECTED GRADE-CROSSING OPERATIONS RECORDER
CTC
TRAFFIC INTERNET ACCESS
SERIAL CABLE
PREEMPTION I/O
12V PS
EXISTING PREEMPTION RELAY INTERFACE PANEL
EXISTING LOAD SWITCHES
EXISTING CONTROLLER UNIT
RENO A&E MMU-16GE
THE IGOR™ ADVANTAGE:
The Interconnected Grade-Crossing Operations Recorder IGOR™



- Manufactured by Reno A&E, utilizing total solid state construction
- User friendly menu-driven design for ease of use and low maintenance
- Industry standard default settings; user definable custom configurations
- System neutral recording device totally independent of all monitored devices
- Encrypted data capture to assure tamper proof data retention
- Reno A&E's Quality Management System received ISO 9001 approval
- 100% solid state hard drive for video storage
- Complete isolation from power supply to eliminate the possibility of "grounds"

Why IGOR™

- Documentation to support joint crossing inspections and testing
- An essential Quality Assurance tool
- Risk Mitigation
- Accident Prevention
- Compliance with FRA and NTSB recommendations
- Supports FRA required testing

IGOR™ Records

- R-Y-G-DW-W state of all traffic signals
- Right-of-Way Transfer Time
- Track Clearance Green Times
- Operation of Gate Down circuits
- Status of railroad gates and flashing lights
- OPIONAL: HD-Video (up to 4 cameras at each processor)

APPENDIX B: HIGHWAY AGENCY AND RAILROAD QUESTIONNAIRES

Highway Agency Questionnaire

1. What is involved in the process for the initial inspection of newly installed locations that have interconnected at grade rail and highway traffic signal control systems? Is there an approved checklist or required procedures that are required to be followed? If so, could you provide a sample of this checklist/test procedure? Is the rail carrier required to be present during initial testing and final deployment?

2. Does your agency perform regularly scheduled preventative maintenance/testing of these rail / highway traffic control preemption facilities? If so, what are the time intervals that the maintenance/testing are preformed? If testing is performed, is there a written test procedure that the test personnel reference/used to perform the tests? If there are written test procedures, were they jointly co-authored by the railroad or assembled with input from the railroad? Are the results of the testing work recorded and copies maintained for future use?

3. What, if any, special equipment is specified or installed in such facilities that are used to assist the agency in a preventative maintenance program?

4. Are there any devices installed in these facilities that record events or system status elements which can be used to assist the agency in a preventative maintenance program? If yes, are these devices now required for all new installations? If yes, could you please provide the amount of use (number of grade crossings in the state versus the amount that have recording capability), the manufacturer and part numbers most commonly used recording devices?

5. At a regularly scheduled maintenance/testing, what agencies are required to be in attendance? Are these additional agencies required to observe the testing and sign the inspection/test reports (if any)?

6. Are your facilities remotely monitored? If yes, please describe method and operation of these remote monitoring facilities (example; operation control center, manned 24 hours per day)?

7. Can you provide a description or standard plans that your state uses for the interconnection between rail and highway traffic signal control systems? (For example, two conductor, normally closed circuit activation)?

8. Do any of your facilities currently have (or in the future may have) standby battery back-up systems to support critical functions within the facilities? If yes, is both the railroad and highway traffic signal control preemption circuitry supported by this electrical power back-up system?

9. In addition to a rail preemption circuit, is there any other information/data currently being exchanged between rail and highway traffic signal control facilities at the field level?

10. Does your agency have any future plans for modifying how rail and highway traffic signal control facilities are interconnected?

Railroad Questionnaire

Testing Procedure Questions

1. Can you please provide your grade crossing test procedures?

2. Can you describe your formal process for the initial inspection of newly upgraded or installed interconnected grade crossings that have railroad preemption systems? Is there an approved checklist or required procedures that are required to be followed? If so, could you provide a sample of this checklist/test procedure? Is the highway authority required to be present during initial testing and final deployment?

3. Does the railroad's written test procedure for grade crossings include a specific test procedure for those crossings with preemption? Does the test procedure vary by state?

4. Does the railroad perform regularly scheduled testing of traffic preemption beyond what is required by 49 CFR 234.261? How often is the test performed?

5. Are there any states in which your railroad performs a joint inspection of the traffic preemption with the highway authority? If so, at what intervals does this occur? Do both parties sign off on the inspection?

6. What percentage of your grade crossings is remotely monitored? If so, please describe the monitoring method.

Preemption Design Questions

1. Beyond AREMA standards, does your railroad have standard designs or practices for preemption circuits, including standard cable sizes? If so, can you provide samples?

2. Other than the preemption request circuit, is any information currently exchanged between the grade crossing controller and the traffic signal controller?

Event Recorder Questions

1. How many grade crossings on your railroad are equipped with event recorders?

2. What models of event recorders are currently installed at your grade crossings, and how many of each model are in service? Are event recorders required for all upgraded or new grade crossing installations? Are these event recorders standalone devices or integrated into another device, such as a predictor or controller? Can you provide manufacturers and models of event recorders currently being installed at upgraded and new installations?

3. What specific alarms and inputs/outputs do you normally record at crossings? Do you record alarms and inputs/outputs relating to preemption?

4. Are these recording devices used to assist in testing and monitoring of the grade crossing and preemption?

5. How long is event recorder information stored? Is it regularly transmitted to a control center or downloaded by field personnel, or is it only utilized if an incident occurs? Is there a procedure that personnel follow in the handling of this data? If field personnel download data, how often is this done? Is it part of the maintainer's monthly/quarterly/yearly tests?

Policy Questions

1. Do you have any concerns in the development of a joint preemption test with the highway authority?

2. What requirements would you like to see as part of a joint preemption test?

3. Would you consider a device that would perform a self-test of the preemption? If so, at what interval do you feel self-tests should occur?

APPENDIX C: EXAMPLE BLOCK DIAGRAMS/WIRING DIAGRAMS

- AREMA C&S Manual: Recommended Vital Circuit Design Guidelines for Highway Traffic Signal Interconnection
- Illinois Commerce Commission: Specifications and Design Criteria for Traffic Signal Control Equipment at Locations Interconnected with Railroad Warning Devices, Chicago
- Minnesota DOT: Double Break Railroad Preempt Interconnect Circuit with Supervisor, Gate Down, and Supervisor Latch
- Minnesota DOT: Railroad Double Break Interconnect Circuit with Supervisor and Gate Down Logic

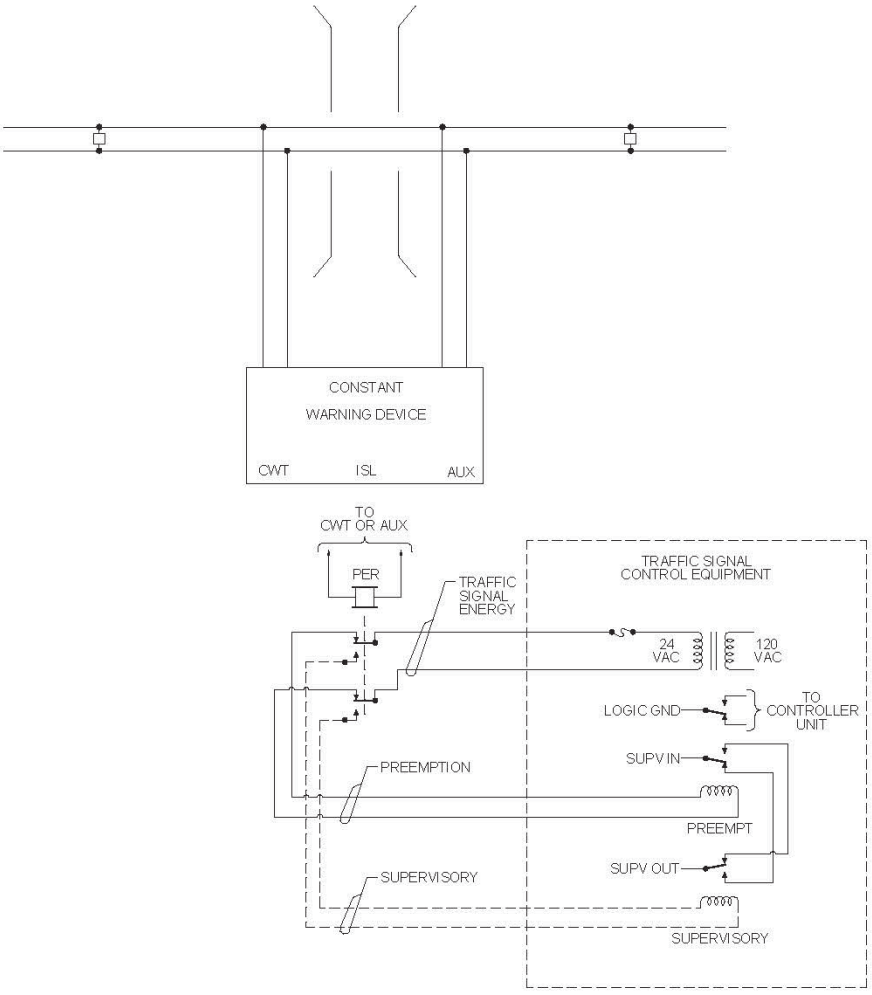


Figure 163010-1: Constant Warning Time Application for Interconnection

For simultaneous preemption interconnection applications, PER is connected to the CWT output directly or through a repeater relay.

For advance preemption interconnection applications, PER is connected to the AUX output directly or through a repeater relay.

Supervisory circuit wiring is shown for reference purposes.

Traffic signal circuitry is shown for illustration purposes only.

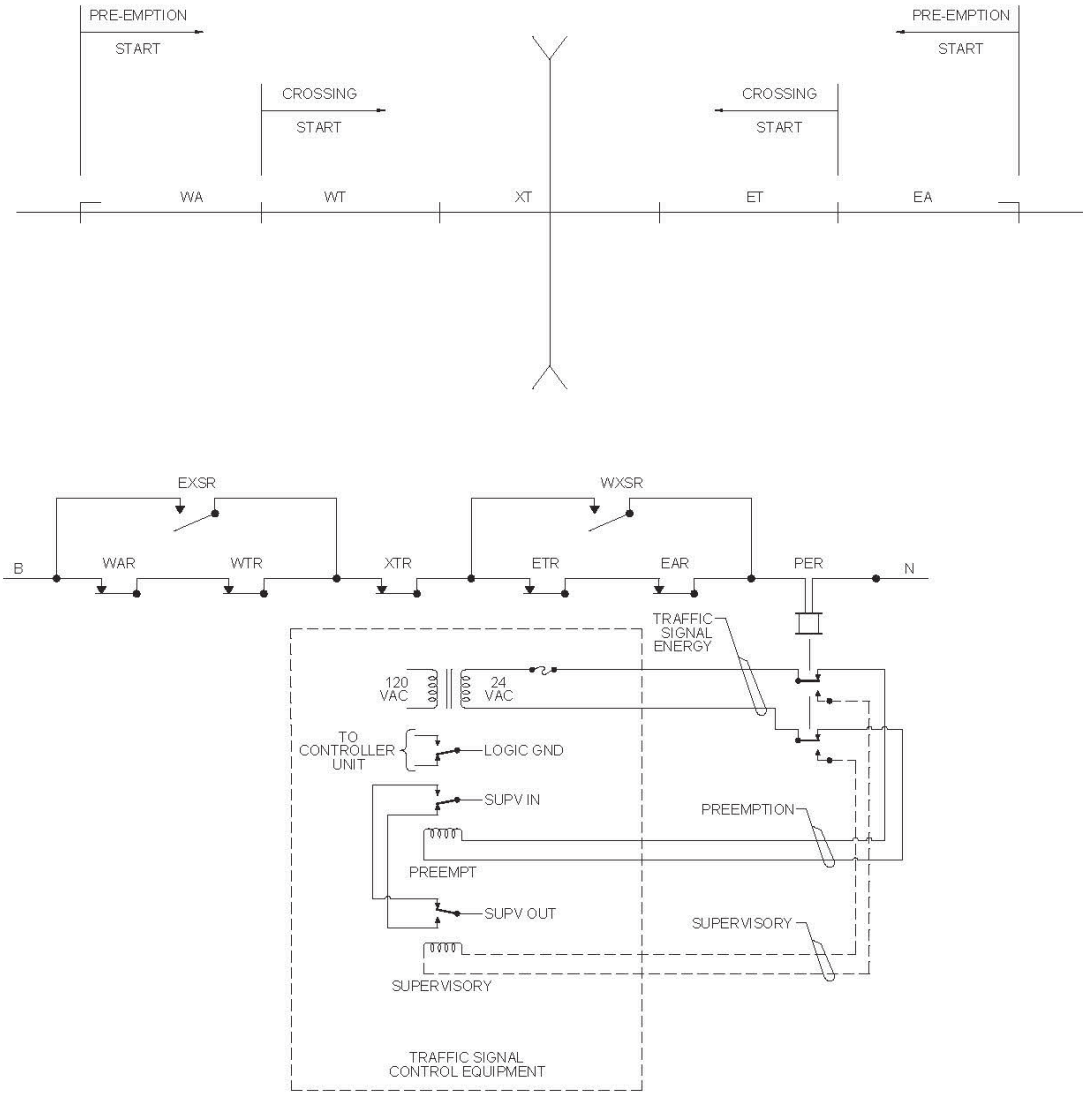


Figure 163010-2: Conventional Track Circuit Logic for Advance Preemption

Supervisory circuit wiring is shown for reference purposes.

Traffic signal circuitry is shown for illustration purposes only.

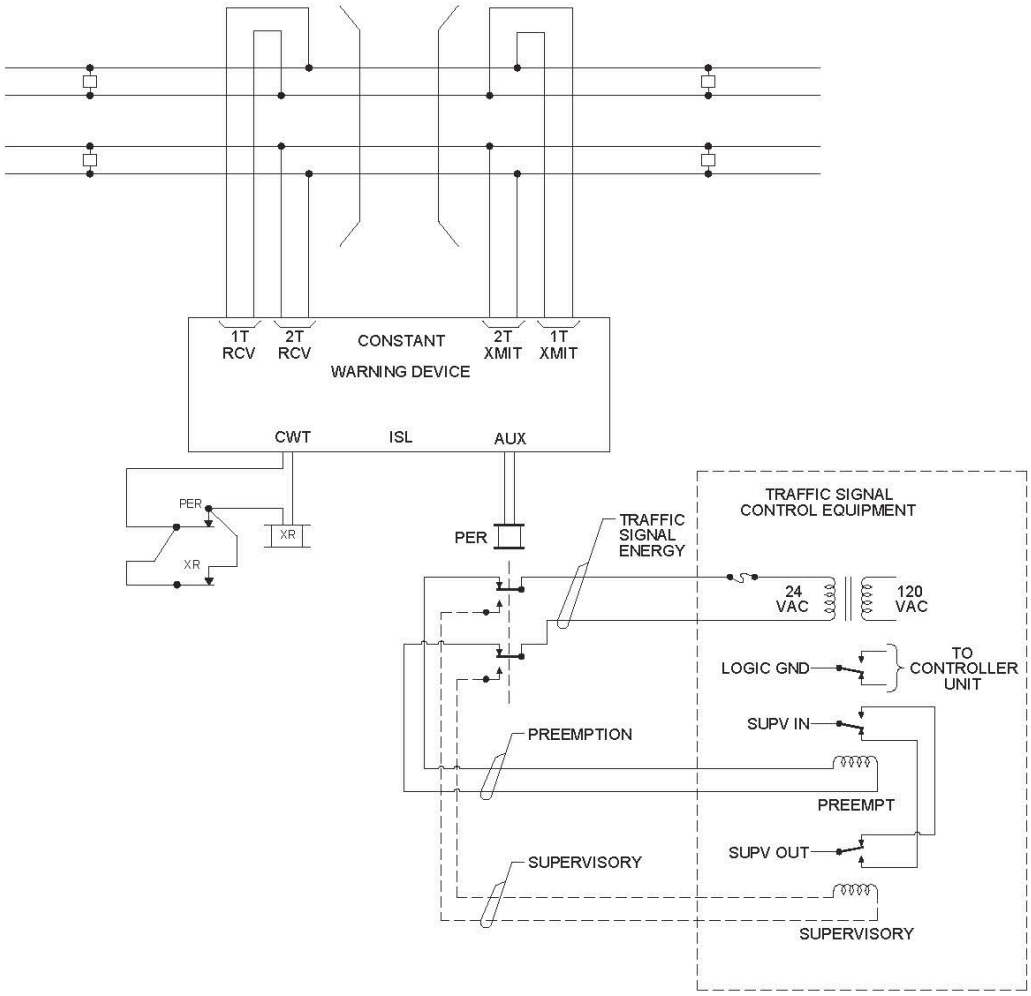


Figure 163010-3: Second Train Logic

Supervisory circuit wiring is shown for reference purposes.

Traffic signal circuitry is shown for illustration purposes only.

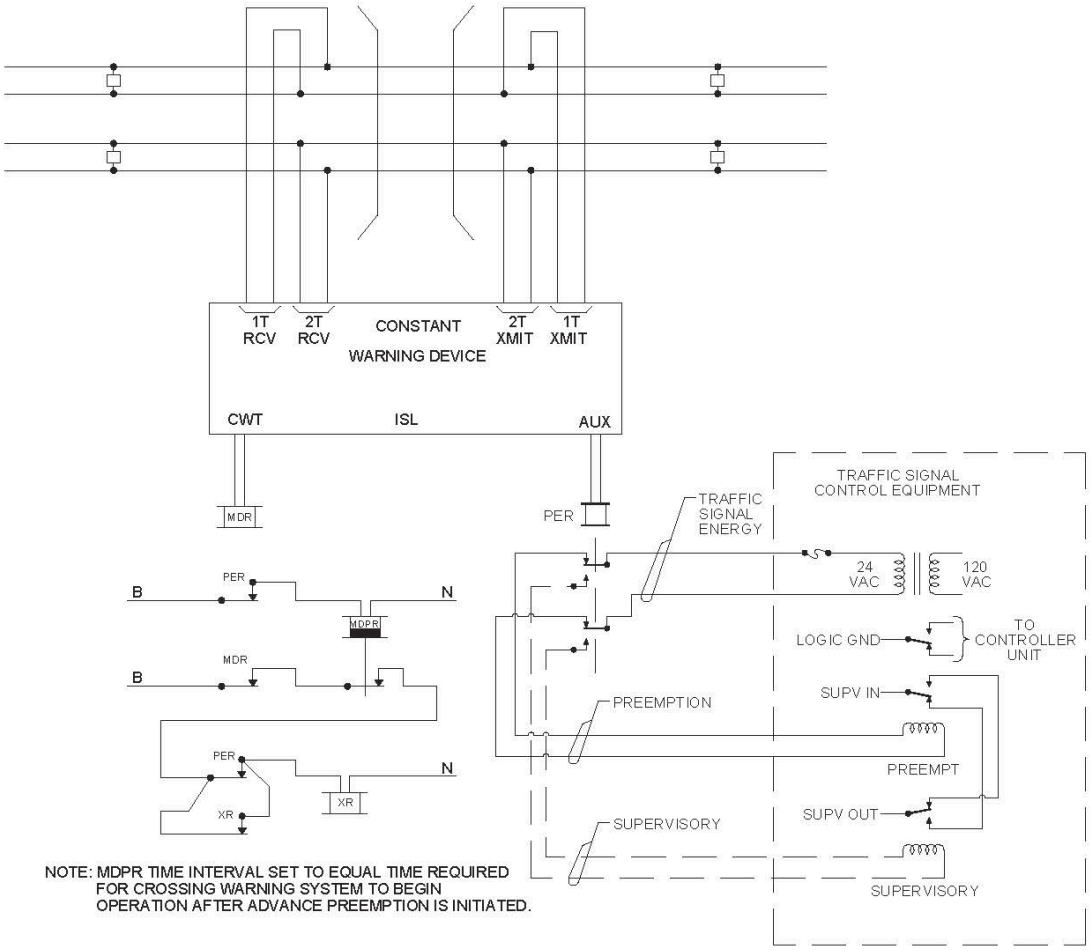


Figure 163010-4: Timer for Constant Time Between APT and CWT

Supervisory circuit wiring is shown for reference purposes.

Traffic signal circuitry is shown for illustration purposes only.

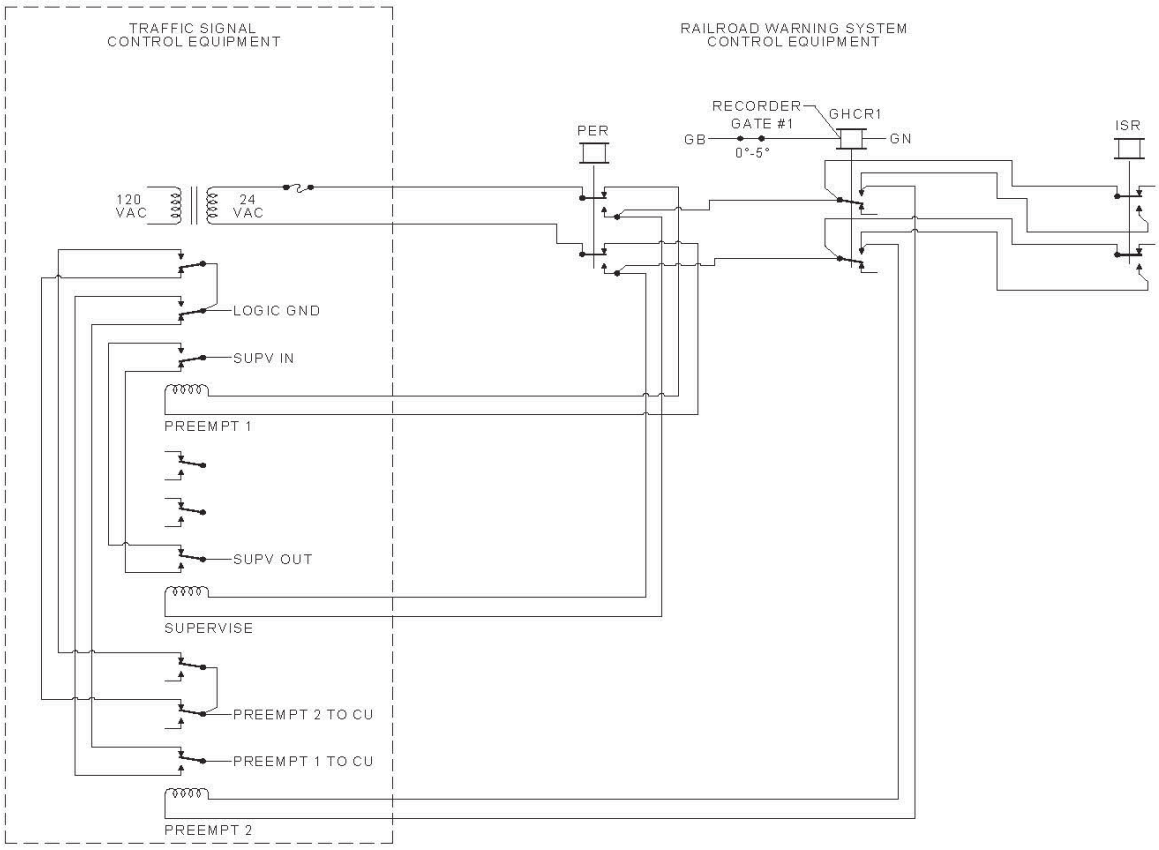


Figure 163010-5: Gate Down Logic With One Gate on Roadway Approach to Highway Traffic Signal

When gate down logic is required, only the gate controlling vehicular movement toward the traffic signal is circuited.

Supervisory circuit wiring is shown for reference purposes.

Traffic signal circuitry is shown for illustration purposes only.

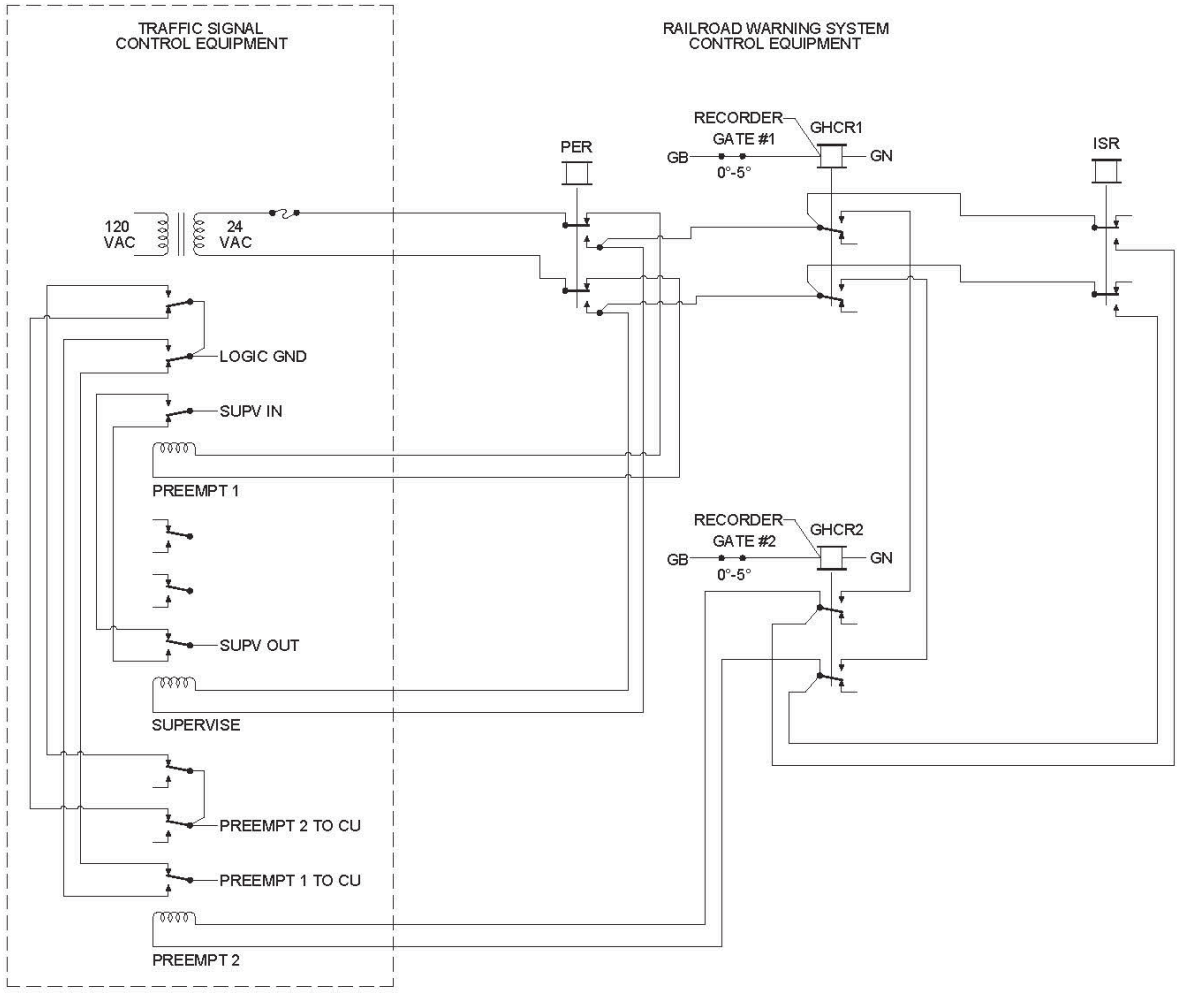
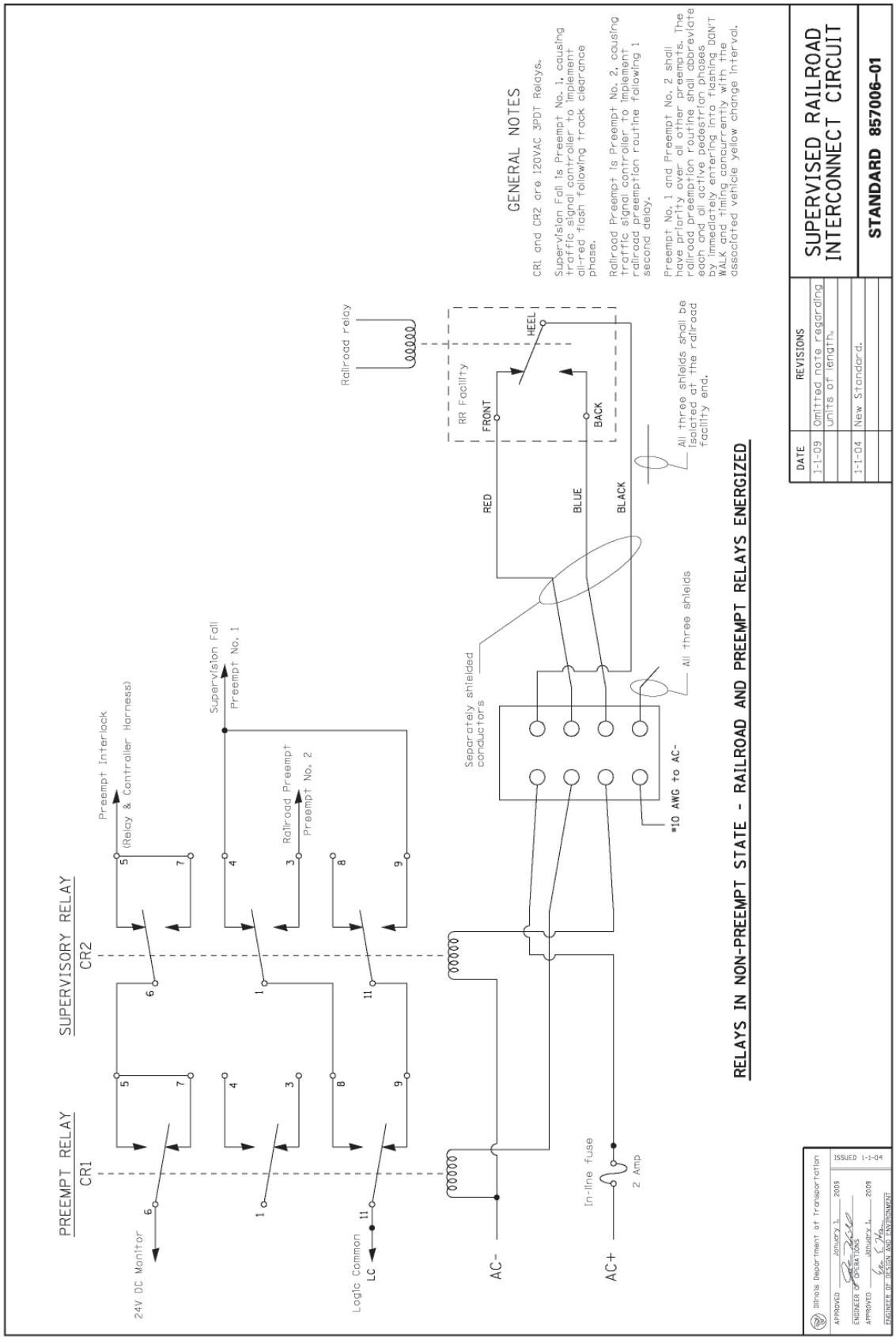


Figure 163010-6: Gate Down Logic With Two Gates on Roadway Approach to Highway Traffic Signal

When gate down logic is required, only the gate controlling vehicular movement toward the traffic signal is circuited.

Supervisory circuit wiring is shown for reference purposes.

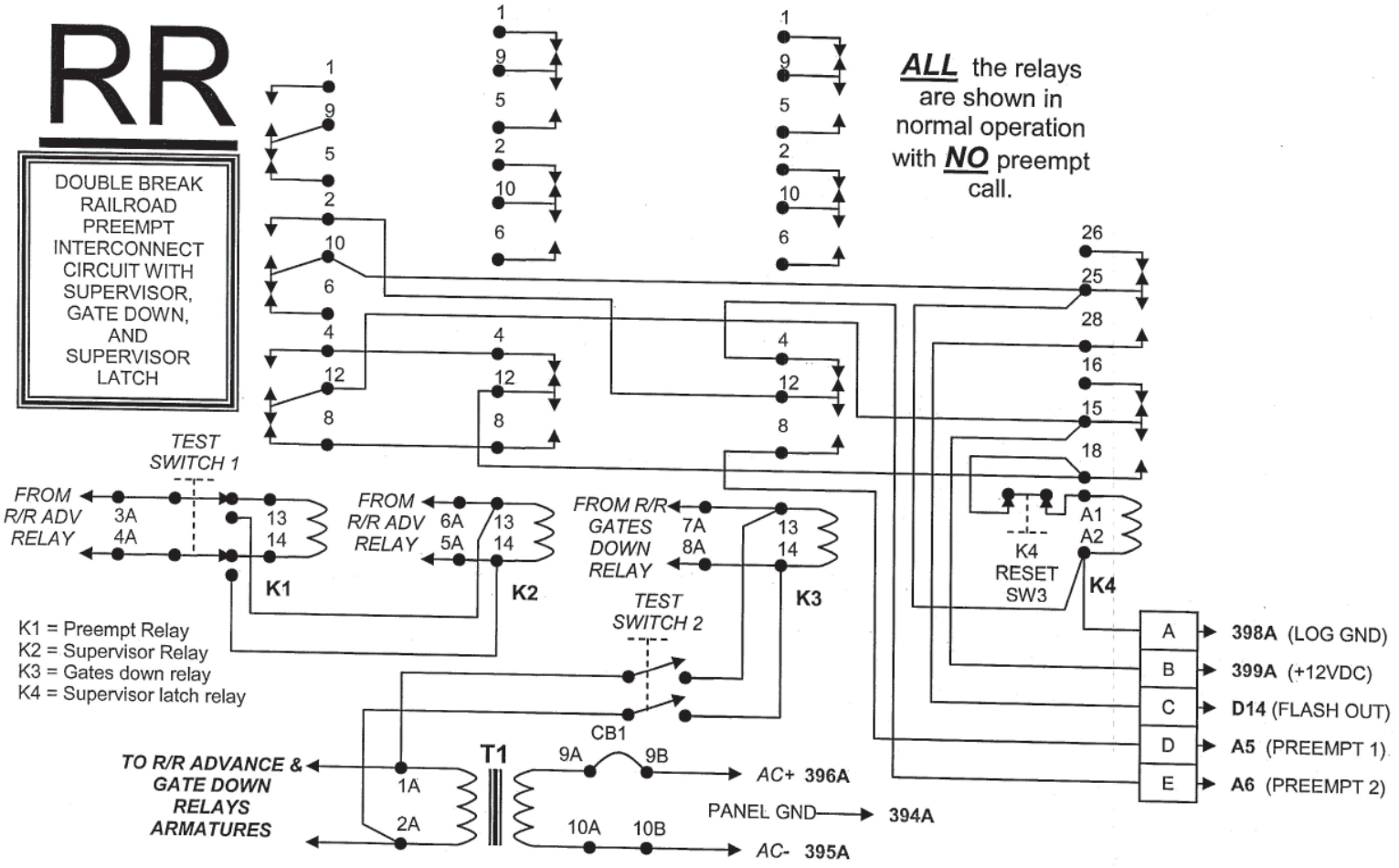
Traffic signal circuitry is shown for illustration purposes only.


PREEMPT RELAY
CR1
SUPERVISORY RELAY
CR2
Preempt Interlock
(Relay & Controller Harness)
Supervision Fail
Preempt No. 1
Railroad Preempt
Preempt No. 2
24V DC Monitor
Logic Common
LC
AC-
AC+
In-line fuse
2 Amp
Separately shielded conductors
All three shields
*10 AWG to AC-
All three shields shall be isolated at the railroad facility end.
Railroad relay
RR Facility
FRONT
HEEL
BACK
RED
BLUE
BLACK
RELAYS IN NON-PREEMPT STATE - RAILROAD AND PREEMPT RELAYS ENERGIZED
GENERAL NOTES
CR1 and CR2 are 120VAC 3PDT Relays.
Supervision Fail is Preempt No. 1, causing traffic signal controller to implement all-red flash following track clearance phase.
Railroad Preempt is Preempt No. 2, causing traffic signal controller to implement railroad preemption routine following 1 second delay.
Preempt No. 1 and Preempt No. 2 shall have priority over all other preempts. The railroad preemption routine shall abbreviate active and inactive pedestrian phases by timed delay entering flashing DON'T WALK and timing concurrently with the associated vehicle yellow change interval.
DATE
REVISIONS
1-1-09
Omitted note regarding units of length.
1-1-04
New Standard.
SUPERVISED RAILROAD INTERCONNECT CIRCUIT
STANDARD 857006-01
Illinois Department of Transportation
APPROVED
January 1, 2009
ENGINEER OF OPERATIONS
APPROVED
January 1, 2009
ENGINEER OF DESIGN AND ENVIRONMENT
ISSUED 1-1-04

Minn DOT

RR

DOUBLE BREAK RAILROAD PREEMPT INTERCONNECT CIRCUIT WITH SUPERVISOR, GATE DOWN, AND SUPERVISOR LATCH



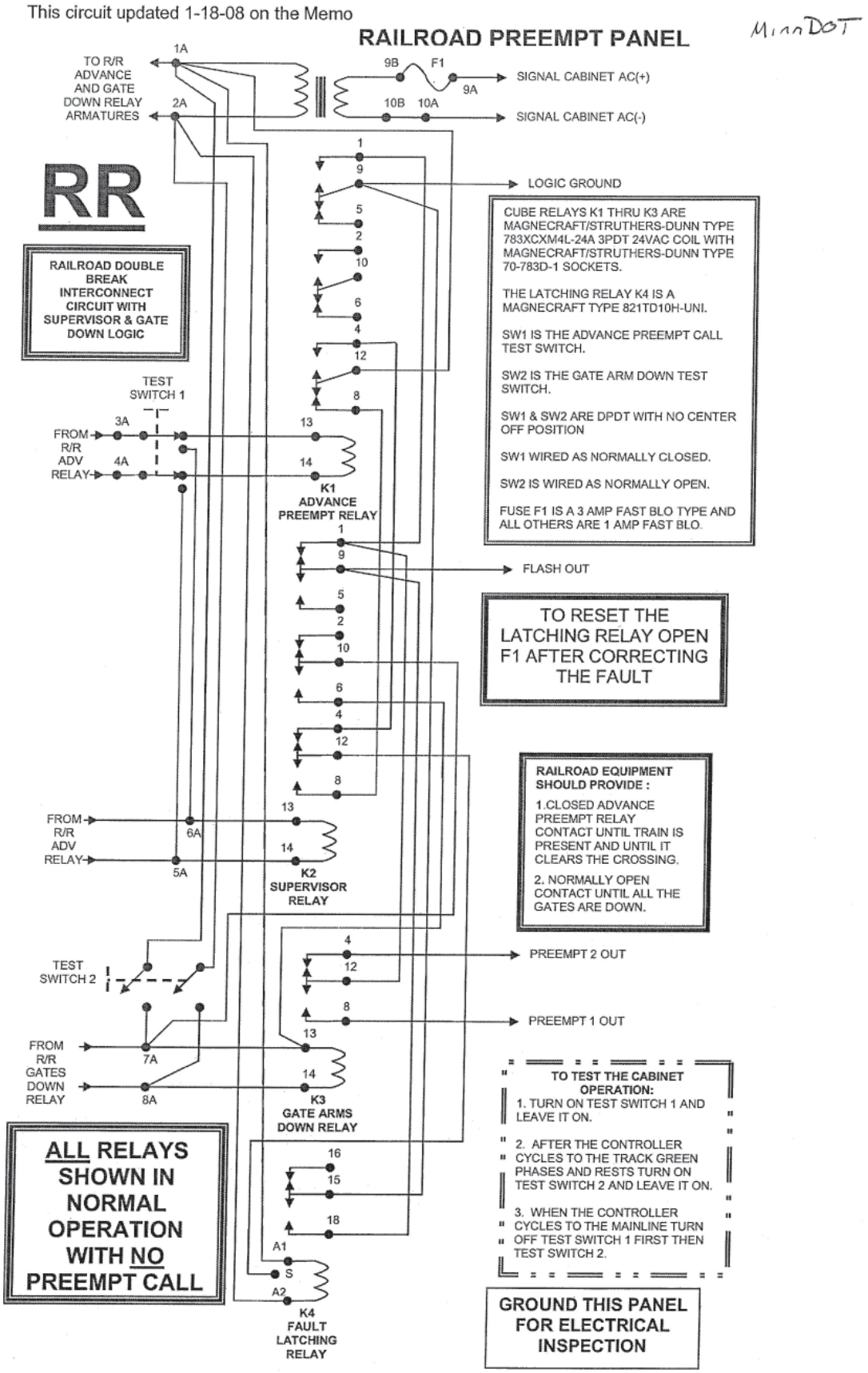
The railroad provides a closed contact to hold K1 energized until a train approaches. It then opens that contact relaxing K1 and energizing K2 causing a preempt 2 call to the controller. When the gates are all down the gates down relay calls preempt 1 to move the controller into the mini cycle.

To TEST the cabinet operation:

1. Turn on TEST SWITCH 1 and leave it on.
2. After the controller cycles to the track green phases and rests turn on TEST SWITCH 2 and leave it on.
3. When the controller enters the mini cycle, turn off TEST SWITCH 1first then TEST SWITCH 2.

The supervisor latch relay delay should be set for a time long enough that relay chatter caused by the bungalow ends before it can time out (usually less than 5 sec.). To reset the supervisor latch relay push reset switch S3 after correcting any fault.

NOTE: The AC+, AC-, GND, and terminals A thru E hookup refer to Myers 2007 TS2 Cabinets.


This circuit updated 1-18-08 on the Memo
MnnDOT
RAILROAD PREEMPT PANEL
RR
RAILROAD DOUBLE BREAK INTERCONNECT CIRCUIT WITH SUPERVISOR & GATE DOWN LOGIC
TO R/R ADVANCE AND GATE DOWN RELAY ARMATURES
1A
2A
9B
F1
9A
10B
10A
SIGNAL CABINET AC(+)
SIGNAL CABINET AC(-)
LOGIC GROUND
CUBE RELAYS K1 THRU K3 ARE MAGNECRAFT/STRUTHERS-DUNN TYPE 783XCXM4L-24A 3PDT 24VAC COIL WITH MAGNECRAFT/STRUTHERS-DUNN TYPE 70-783D-1 SOCKETS.
THE LATCHING RELAY K4 IS A MAGNECRAFT TYPE 821TD10H-UNI.
SW1 IS THE ADVANCE PREEMPT CALL TEST SWITCH.
SW2 IS THE GATE ARM DOWN TEST SWITCH.
SW1 & SW2 ARE DPDT WITH NO CENTER OFF POSITION
SW1 WIRED AS NORMALLY CLOSED.
SW2 IS WIRED AS NORMALLY OPEN.
FUSE F1 IS A 3 AMP FAST BLO TYPE AND ALL OTHERS ARE 1 AMP FAST BLO.
TEST SWITCH 1
FROM R/R ADV RELAY
3A
4A
K1 ADVANCE PREEMPT RELAY
FLASH OUT
TO RESET THE LATCHING RELAY OPEN F1 AFTER CORRECTING THE FAULT
RAILROAD EQUIPMENT SHOULD PROVIDE :
1.CLOSED ADVANCE PREEMPT RELAY CONTACT UNTIL TRAIN IS PRESENT AND UNTIL IT CLEARS THE CROSSING.
2. NORMALLY OPEN CONTACT UNTIL ALL THE GATES ARE DOWN.
FROM R/R ADV RELAY
6A
5A
K2 SUPERVISOR RELAY
TEST SWITCH 2
PREEMPT 2 OUT
PREEMPT 1 OUT
FROM R/R GATES DOWN RELAY
7A
8A
K3 GATE ARMS DOWN RELAY
TO TEST THE CABINET OPERATION:
1. TURN ON TEST SWITCH 1 AND LEAVE IT ON.
2. AFTER THE CONTROLLER CYCLES TO THE TRACK GREEN PHASES AND RESTS TURN ON TEST SWITCH 2 AND LEAVE IT ON.
3. WHEN THE CONTROLLER CYCLES TO THE MAINLINE TURN OFF TEST SWITCH 1 FIRST THEN TEST SWITCH 2.
ALL RELAYS SHOWN IN NORMAL OPERATION WITH NO PREEMPT CALL
A1
S
A2
K4 FAULT LATCHING RELAY
GROUND THIS PANEL FOR ELECTRICAL INSPECTION

4

Preventive Maintenance

Preventive maintenance is defined as a set of checks and procedures to be performed at regularly scheduled intervals for the upkeep of traffic signal equipment. It includes inspection, recordkeeping, cleaning, and replacement based on the function and rated service life of the component. Some of the major items under this category are:

- Group relamping
- Signal lens cleaning
- Signal head alignment
- Signal pole and mast arm inspection
- Detector amplifier tuning
- Signal controller operations inspection
- Conflict monitor testing

Preventive maintenance is intended to ensure reliable mechanical and electrical operation of the signals and signal control equipment, thereby reducing equipment failures, response maintenance, road user costs, and liability exposure. The emphasis in preventive maintenance is on checking all equipment for proper operation and taking positive steps to repair or replace defective equipment.

This chapter provides a checklist of recommended preventive maintenance tasks and time intervals for maintenance. It also provides recommended practices

and helpful practical hints for each of the recommended tasks. Geographic and climactic variables should be considered when applying the recommendations.

MAINTENANCE CHECKLIST

The following sections provide general guidelines to aid the signal mechanic or technician in the performance of the individual tasks. Specific requirements unique to each manufacturer as provided in the manufacturers' maintenance manuals should be followed.

Where there are no manufacturer's maintenance recommendations, the minimum preventive maintenance tasks and time intervals summarized in Table 4–1 can be used as a guide. As shown, preventive maintenance tasks should be performed on detector equipment every 3 months; on signal controller cabinets, signals, and related equipment at 6- or 12-month intervals; on controller equipment generally on an annual basis. Repainting of cabinets, signal heads, poles, and mast arms is recommended every 2 to 5 years.

TABLE 4–1
Preventive Maintenance Checklist

Task	Recommended Interval: MONTHS 3	6	12	YEARS 2 to 5
Cabinet (per unit)				
• lubricate hinges and lock			X	
• clean filters		X		
• replace filters			X	
• check weatherproof seal (gasket)			X	
• check anchor bolts			X	
• check for water accumulation and duct sealant			X	
• check ground rod clamp and wire			X	
• check wiring schematics and records		X		
• check operation of fan and heater		X		
• check radio interference filter and lightning arrester			X	
• check circuit breaker		X		
• check ground fault receptacle		X		
• measure voltages at service inputs in cabinet		X		
• check and record current being drawn		X		
• repaint exterior (if originally painted)				X
• snow removal	As necessary			
Signal Heads (per unit)				
• clean lenses, signs, and reflectors			X	
• replace lamps			X	
• check alignment		X		
• check for wear on the span wire, signal wire and mechanical hardware (clevis pins, clamps)		X		
• check mast arms, free swinging signals; check clevis and chain		X		
• check for cracks or rust in the hardware		X		
• check for bent hoods, wing nuts, hinges		X		
• replace substandard parts		X		
• replace defective lenses and reflectors		X		
• check locking ring (surface); install proper locking devices as required		X		
• check condition of back plates (if used)		X		
• repaint exterior of signal (if originally painted)				X
• perform nighttime check for visibility		X		

(continued)

TABLE 4-1
(Continued)

Task	Recommended Interval: MONTHS 3	6	12	YEARS 2 to 5
Mast Arms and Poles (per unit)				
• inspect for rust and spot paint as required			X	
• inspect joints for rust and cracks at arm/upright location and at base plate			X	
• inspect anchor bolts for rust and tightness			X	
• inspect horizontal and vertical angle of the arm			X	
• repaint exterior (if originally painted)				X
Span Wire and Poles (per unit)				
• inspect poles			X	
• check span wire			X	
• check clamps and hardware			X	
• check guy wire, anchors, and guards			X	
Push Buttons (per unit)				
• check and actuate push buttons on each end of actuated crosswalks and visually verify pedestrian signal operation; verify timing		X		
• check push button lamp (if one exists) for operation		X		
• check push button signs; clean or replace if necessary		X		
• check push button sign alignment		X		
Detectors (per approach)				
Sensors				
• visually inspect roadway along loop detector saw cut for exposed wires, cracks, potholes, etc.	X			
• check alignment for sonic, magnetic, and radar-type detectors; verify call inputs to controller phases	X			
• check anchorage for pressure detector frame and contact units	X			
Amplifiers				
• check if the detector is detecting vehicles within its design zone of detection	X			
• tune the detector if necessary	X			
• check if the connectors are tight and secure	X			
Junction Boxes and Handholes (per unit)				
• check integrity of the splices		X		
• check the ground rod and clamp connection, and bonding of conduits		X		
• check the insulation			X	
• check for abnormal amount of water			X	
• check lid for abnormal condition and fit			X	
Electromechanical Control Equipment (per unit)				
Dial Assembly				
• check for wear on key follower			X	
• check for burned, pitted, or discolored contacts			X	
• check for key positions			X	
• check for cycle gear size and mesh			X	
• check dial motor operation			X	
• check all dials according to manufacturer's recommendations			X	
• if controller is part of a system, check offset			X	
• check duration of the advance pulse			X	

TABLE 4-1
(Continued)

Task	Recommended Interval: MONTHS 3	6	12	YEARS 2 to 5
Cam Assembly				
• check for end play			X	
• clean and lubricate as required by manufacturer			X	
• visually inspect for abnormal wear or cracks			X	
• check for burned, pitted, or discolored contacts			X	
• check spring tension on contacts			X	
• check for loose wiring to contacts			X	
• check for operation of advancing mechanism to conform with manufacturer's requirements			X	
• check if all connections are secure and tight			X	
• visually inspect wires for wear, rubbing, deterioration of insulation			X	
• install dust cover as required			X	
Relays				
• check for burned, pitted, or discolored contacts			X	
• check for tight and secure fit into the sockets			X	
• for latch-type relays, check for latch operation per manufacturer's recommendations			X	
Flashers				
• check flash rate			X	
• check operation			X	
• check for burned, pitted, or discolored contacts			X	
• check for tight and secure fit into the sockets			X	
Switches				
• verify operation of each switch position			X	
Terminal Connections				
• check visually for signs of corrosion or any abnormal condition			X	
• tighten all terminal connections			X	
Solid State, Analog, and Microprocessor-based Control Equipment (per unit)				
General				
• check if the time settings match the master time sheet		X		
• check if all indicator lamps on the modules are working; replace failed lamps			X	
• check for extension by detector actuation			X	
• check if modules are fitting tight and secure into the frame			X	
• check if connectors are tight and secure			X	
• wipe dust off controller, detectors, and auxiliary equipment	X			
Conflict Monitor				
• replace with bench-tested unit			X	
Load Switches				
• check if load switch packs are fitting tight and secure into their chassis			X	

(*Continued*)

TABLE 4-1
(Continued)

Task	Recommended Interval			
	MONTHS			YEARS
	3	6	12	2 to 5
Auxiliary Logic				
• check operation			X	
Relays				
• check mercury relays (if used) for excessive splash			X	
Flashers				
• check if firm in socket; check on/off ratio and flash rate.			X	
Switches				
• check for loose wires			X	
Terminal Connections				
• check for discoloration and tightness			X	
Interconnected Equipment (per unit)				
• check if controller operates in the mode selected by the supervisory master (i.e., time-based coordinator)		X		
• disconnect from the master supervisory system and check for "free" or backup operation		X		
• check any special equipment per manufacturer's recommendations			As required	
Miscellaneous				
• record all changes in timing, wiring, or any function			As required	
• periodically check electric bill for indication of leaky insulation			Monthly	
• record current flow at unmetered installations			As required	

Sophisticated test equipment and procedures can be time consuming and expensive and may not provide a realistic benefit-cost ratio. The recommended checks and inspections in the following preventive maintenance descriptions will permit the signal mechanic or technician to use visual and auditory senses, experience, common sense, and basic test equipment to evaluate the actual field condition.

The signal mechanic or technician should be trained in the maintenance and protection of traffic in accordance with the *Manual on Uniform Traffic Control Devices* and applicable state or local standards. Before any on-the-street checks or tests are performed, the signal mechanic or technician should install all the applicable warning signs, channelization devices, and similar controls necessary to ensure safe operation of the intersection during preventive maintenance.

Each maintenance inspection should be conducted by at least one signal mechanic. An inspection report should be completed for each inspection indicating the location, date, inspector's name, a list of all maintenance tasks performed, and troubles found. Two copies of each inspection report should be required, one to be kept at the intersection, and the other to be stored in a central file.

Sample inspection report forms, based on the preventive maintenance tasks listed in the preceding section, are provided in Appendix F. Recommended codes to be used by the field inspector to complete the inspection reports are listed in Table 4-2. Additional discussion of recommended maintenance recordkeeping practices is provided in Chapter 7.

APPENDIX E: RAILROAD 49 CFR TESTING AND INSPECTION REGULATION DETAILS

The following is a summary of the monthly, quarterly and annual requirements for inspection and testing at highway-rail grade crossings and the current standard inspection and testing practices from the railroad industry as a whole.

Warning System Operation

Monthly Tests

The 49 CFR regulations explain in detail the method by which the railroad carrier must warn the public of an oncoming train at an active at-grade crossing. Active crossings are crossings that have automatic flashing lights, bell and gates as well as any other active warning device which may support the Automatic Highway Warning System (AHWS).

Currently, every AHWS system in the country is tested monthly by the railroad carrier as defined by CFR Rule 234.257 – Warning System Operation:

a. Each highway-rail crossing warning system shall be tested to determine that it functions as intended when it is placed in service. Thereafter, it shall be tested at least once each month and whenever modified or disarranged.
b. Warning bells or other stationary audible warning devices shall be tested when installed to determine that they function as intended. Thereafter, they shall be tested at least once each month and whenever modified or disarranged.

Railroad testing procedures generally direct inspecting personnel to ensure that warning system equipment is visible and audible to highway users approaching the crossing and that they operate together with the flashers.

Quarterly Tests

The 49 CFR also defines inspections at highway-rail grade crossings that must be completed at least once every 3 months or quarterly:

CFR Rule 234.269 - Cut-out circuits, railroads must test any cut-out circuits at least once every three months to determine that the circuit functions as intended. These are usually tests of specialty circuits used to bypass or override the operation of the automatic warning systems, or in some cases even preempt or activate the crossing warning system.

CFR Rule 234.271 requires the inspection of insulated rail joints, bond wires, and track connections, at least once every three months. These tests are used to assure that trains are being properly detected on each of the railroad approaches.

Annual Tests

In addition to the monthly and quarterly testing, a complete test of the grade crossing occurs once every year. The annual inspection is normally performed by different personnel from those that perform the monthly and quarterly tests. Several components of highway-rail grade crossing warning systems that are not required to be tested in the monthly or quarterly inspections must be inspected in the annual inspection. These tests include those for flashing light alignment and flash rate, lamp voltage, hold clear devices and timing relays.

> CFR Rule 234.265 requires that timing relays and timing devices are tested at least once every twelve months. Railroad testing procedures instruct inspection personnel to observe the time delay of starting circuits and cut-out circuits and check that they are between 90 and 110 percent of the predetermined time interval shown on the plans.
>
> CFR Rule 234.263 - Relays, defines the required inspections and the inspection frequency for different types of relays associated with the grade crossing warning system. Railroad testing procedures generally instruct inspecting personnel to check relay operation for each track and in each direction and to ensure that the relays are de-energized after testing is complete. Some railroads provide specific instructions for inspection of each relay type and for testing with current and voltage.

Warning Time

CFR Rule 234.225 - Activation of warning system, states:

> A highway-rail grade crossing warning system shall be maintained to activate in accordance with the design of the warning system, but in no event shall it provide less than 20 seconds warning time for the normal operation of through trains before the grade crossing is occupied by rail traffic.

Once every 12 months, railroads are required to test the prescribed crossing warning time as stated in the CFR, Rule 234.259 - Warning time:

> Each crossing warning system shall be tested for the prescribed warning time at least once every 12 months and when the warning system is modified because of a change in train speeds.

Railroads' testing procedures generally describe the purpose of this as to ensure the grade crossing warning system activates as it is designed to, and in no event provides less than 20 seconds of warning time.

Inspection personnel are instructed to observe the crossing warning time and verify that it is in accordance with the designed warning system as shown on the circuit drawings.

If the crossing is equipped with an electronic recording device that accurately records warning times, it may be used to perform the test. If no such device is installed, the warning time must be found by observing a train movement or calculating the warning time by measuring the approach track circuits and using the highest timetable speed.

If the warning time is found to be less than 20 seconds, inspecting personnel are directed to immediately take corrective action. Corrective action must also be taken if the warning time is consistently found to be less than the designed warning time.

Highway Traffic Signal Preemption

The required inspection of highway traffic preemption is defined in CFR Rule 234.261 - Highway traffic signal pre-emption:

> Highway traffic signal pre-emption interconnections, for which a railroad has maintenance responsibility, shall be tested at least once each month.

The majority of railroad testing procedures identify the test frequency for highway traffic signal preemption as when the traffic preemption system is placed in service, is modified or disarranged,

and at least once per month. Railroad test procedures also typically state that the railroad is only responsible for maintenance and testing up to the point of interconnection with the highway traffic control system, and that the local authority is responsible for maintenance and testing of all remaining circuitry and traffic signal control devices.

The test purpose generally described is to ensure that an approaching train activates the crossing warning devices and highway traffic signals and that they are operating properly.

Railroads' testing procedures generally instruct testing personnel to check contacts and devices interconnected with the highway traffic signals and advanced warning signs to ensure they perform as intended.

Inspection personnel are also instructed to verify the proper operation of the interconnect circuit and to observe the traffic preemption is operating as it is intended. Some railroads specify that this can be done by observing a train movement and verifying that the warning signs and traffic signal preemption are activated. If observing a train movement is not possible, inspecting personnel must simulate a train movement by de-energizing the interconnection circuit thereby activating the preemption sequence. If the crossing is equipped with advanced preemption, some railroad testing procedures require inspection personnel to observe a train movement to verify proper operation.

Inspection personnel are instructed to note any repairs or adjustments made during the inspection. If the interconnection circuit is discovered to be not operational and/or any inconsistency is discovered, inspection personnel are instructed to notify the local roadway authority and report it to their supervisor. If the railroad equipment is found to be operating properly and the traffic signal system does not respond, inspection personnel are instructed to notify the local roadway authority of the problem.

Some railroads state that it may be necessary to have a local highway authority representative present to assist with tests and perform maintenance and repairs if necessary. A few states have developed detailed joint inspection procedures for highway-rail grade crossings equipped with traffic preemption.

APPENDIX F: SAMPLE INSPECTION AND DIAGNOSTIC REVIEW FORMS

- Mn/DOT Annual Traffic Signal and Railroad Preemption Inspection Form
- North Carolina Department of Transportation Highway - Railroad Interconnection and Preemption Inspection Form (Instructions)
- State of Nevada Department of Transportation Railroad Safety Diagnostic Review Form - Quiet Zones

Mn/DOT ANNUAL TRAFFIC SIGNAL AND RAILROAD PREEMPTION INSPECTION FORM

1. LOCATION DATA

CITY:	COUNTY:	OPERATING AGENCY:
HIGHWAY INTERSECTION:		Mn/DOT DISTRICT:
RAILROAD COMPANY:	RAILROAD INVENTORY NUMBER:	

2. RAILROAD PREEMPTION PHASING SEQUENCE

CRITICAL PHASES		TRACK CLEARANCE PHASE(S)	PREEMPT HOLD OR CYCLE PHASES
Vehicle:	**Pedestrian:**		

3. RAILROAD DATA

RR ACTIVE WARNING DEVICES:	GATE-DOWN LOGIC INSTALLED?
Flashers, no gates.	
DETECTOR MODEL/TYPE:	
MAXIMUM TRAIN SPEED (MPH):	NUMBER OF TRACKS:
NUMBER OF TRAINS PER DAY (and any helpful additional information):	
DATE OF MOST CURRENT RAILROAD PLANS (in bungalow):	
APPROACH AND ISLAND LENGTHS (FEET): Island: Approaches:	

4. TRAFFIC SIGNAL HARDWARE DATA

CONTROLLER MODEL:	OPERATION (pretimed/actuated):
EVP PRESENT?	CONFIRMATION LIGHTS PRESENT?
ROADWAY CHANGES?	
WORKING MANUAL PREEMPTION SWITCH IN CABINET?	
LOOPS UPSTREAM OF TRACKS (if vehicles must stop before tracks)?	
TYPE OF BACKUP POWER:	

5. RAILROAD EQUIPMENT PROGRAMMED TIMINGS

Equipment Response (Buffer) Time:		**sec.**
Extra Warning Time (overspeed tolerance, wide/angled crossings):		**sec.**
Minimum Warning Time:	**20**	**sec.**
Advance Preemption Time:		**sec.**
Total Warning Time (excludes equipment response/buffer time):	**20**	**sec.**

6. NOTES

7. FIELD TESTING AND INSPECTION

Weather Conditions:

Test #	1	2	3	4
Train's Direction of Travel				
	Cumulative Time (sec)			
Preempt call received at				
Railroad flasher activated at				
Gate descent started at	no gates	no gates	no gates	no gates
Gate descent completed at	no gates	no gates	no gates	no gates
End of track clearance green (start of track clearance yellow) at				
Train arrived at				
Measured Total Warning Time:				
Railroad equipment and lamps functioned:				
Track clearance and preempt hold/cycle phases operated as expected:				

8. REVIEW TEAM (INCLUDING TELEPHONE NUMBERS)

MAXIMUM WARNING TIME NEEDED BY TRAFFIC SIGNAL: **23.2 sec**

DOES MEASURED WARNING TIME MEET OR EXCEED MAXIMUM WARNING TIME NEEDED BY TRAFFIC SIGNAL?

HIGHWAY	INSPECTION DATE:
RAILROAD	

North Carolina Department of Transportation
Highway – Railroad Interconnection and Preemption Inspection Form
(Instructions)

Date of Inspection: _____ Recorded By: _____

Inspection Team Members: _____

_____

Signal Inventory No.: _____ DOT Crossing No.: _____

Railroad Co: _____ RR Representative: _____

Railroad Milepost: _____ RR Rep. Phone: (_____)_____

Division: _____ County: _____ City or Town: In / Near _____

Date of Last Inspection: _____

Intersection

Route Number: _____ Name: _____

at

Route Number: _____ Name: _____

The highway number (US, NC, SR) and name on the top line should be the road that crosses the tracks. The highway number and name listed on the bottom line should be the intersecting roadway at the preempted signalized intersection.

It is important to note that in doing these inspections, there are three primary objectives that you are to achieve:

- **Verify that the total railroad warning time is adequate to accommodate preemption time required by signal plans.**
- **Identify railroad preemption phasing and timing required for traffic signal.**
- **Verify operation and condition of both railroad and traffic signal control equipment.**
- **Verify safe operation of preemption sequence and ensure that vehicles are clear of crossing dynamic envelope as train approaches.**

General Information

1. **Using Signal Plans** – Make sure the location is the correct location by checking the following items:

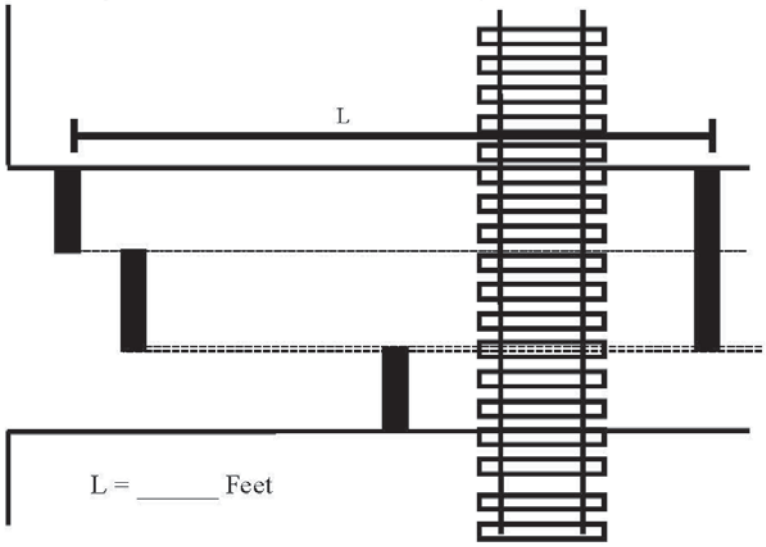
a. Signal inventory number shown on the signal plans is the same as shown on the signal cabinet.
b. All street names and route numbers in the field are the same as shown on the plans.
c. DOT Railroad Crossing Number, which should be posted on the Railroad equipment.
d. Name of Railroad Company operating on tracks at location.

2. Take **photos** (*if new installation or upgrade*) to show:
   a. All intersection and track approaches,
   b. Clear location of tracks as it relates to the intersection,
   c. Location of traffic signal cabinet and railroad cabinet/bungalow,
   d. Inside of traffic signal cabinet to show existing equipment,
   e. Inside of railroad signal cabinet/bungalow to show equipment,
   f. Span arrangement showing signal heads and signs,
   g. Pavement markings and locations of stopbars and crosswalks.

Geometric Inspection

3. Calculate track clearance green by current standard (Greenshield's formula).

Distance To Measure To Calculate Track Clearance Green Time (Greenshield's Formula)



If an approach has multiple stopbars, measure the distance from the stopbar behind the track to the farthest stopbar (closest to intersection).

Measure from stopbar behind track to stopbar at intersection. If calculation is less than 10 sec., use 10 sec. minimum.

a.) Calculation for Greenshield's Formula:
2 sec. x L/20 (L = distance divided by 20 feet per car)
+ 4 sec. (start-up delay)
_____ Seconds = Greenshield's Formula Green Time

b.) If Simultaneous Preemption is used, total amount of Track Clear Green required is
Greenshield's Formula Green Time = [ ] Seconds

c.) If Advance Preemption is used, calculate Track Clear Green Time:

Amount of Advance Preemption = _____ (Min Green)
(Should be 6-8 Seconds) + _____ (Ped Clear)
+ _____ (Yellow Clear Before Preempt)
+ _____ (Red Clear Before Preempt)
Amount of Advance Preemption = [ ] Seconds
+ Greenshield's Formula Green (From 3a): _____
Total Amount of Track Clear Green Time = [ ] Seconds

You will need to enter the appropriate calculated Track Clearance Green time into the chart in Item 10 of this form.

d.) Is the calculated time above for the type of preemption used at this crossing (advance or simultaneous) consistent with what is shown on the signal plans and/or programmed in the field? **Yes** **No**

4. Compare actual intersection geometrics with what is shown on the signal design plans. (This check includes stopbar locations, signal head displays and configuration, signing, etc.) List any differences below: _____

Note any additional signing needs (example: "*DO NOT STOP ON TRACK*", "*LOW VEHICLE MAY DRAG*", "*ONCOMING TRAFFIC MAY HAVE [HAS] EXTENDED GREEN*" etc.). _____

This inspection looks at lane designs, traffic islands, pavement markings, grades, etc. Take note of the condition of railroad crossing surfaces, and the condition of the pavement itself along with pavement markings. Markings such as stop-bars and crosswalks need frequent maintenance. Remember stop bar locations are critical to the calculation of controller timings.

Signal head displays should match the signal plan. Signs should be in place as shown on the plans. The presence of a "DO NOT STOP ON TRACK" sign is recommended for installations where the potential exists for vehicles to queue up on the tracks.

Traffic Signal Operation Inspection

5. Intersection Operation: **Fully Actuated** **Semi-Actuated** **Pre-Timed**

6. Do vehicle and pedestrian heads (if present) appear to be L.E.D. and conform to the current design standards? **Yes** **No**

   NOTE: Countdown pedestrian heads should not be used at railroad preemption locations.

7. Are pedestrian signal heads programmed to clear concurrently with Yellow Clear Before Preempt? **N/A** **Yes** **No**

8. Are blankout signs Fiber Optic or L.E.D.? **N/A** **Yes** **No**

9. Note controller timing for preemption operation. Compare timing shown on the signal plans to times programmed into controller in field. Appendix A may be used to document the times if needed. If timing requires changing, cross out existing time and circle new time.

10. Calculate the total preemption warning time required based on the type of crossing warning system used at this location (Also Enter this Time in Item 34a):

If 4 Quadrant / Exit Gates are Present:

Function	Seconds
Equipment Reaction Time	4
Delay Time	
Min Green Before Preempt	
Ped Clear Before Preempt #	
Yellow Clear Before Preempt *	
Red Clear Before Preempt *	
Track Clearance Green	
Exit Gate Drop Time	11
Gates Horizontal Before Train	5
Total Warning Time Required	

If No Gates or 2 Quadrant Gates:

Function	Seconds
Equipment Reaction Time	4
Delay Time	
Min Green Before Preempt	
Ped Clear Before Preempt #	
Yellow Clear Before Preempt *	
Red Clear Before Preempt *	
Track Clearance Green	
Track Clearance Yellow	
Track Clearance Red	
Total Warning Time Required	

If Ped Clear Time is timed concurrently with Yellow Clear Before Preempt, enter only the exclusive amount of Ped Clear Time that is not displayed concurrently with the Yellow Clear.

For example, Ped Clear Time shown on the plan and programmed on the controller is 5 seconds and the Yellow Clear Before Preempt time is 4 seconds. Since 4 seconds of Ped Clear Time will be displayed during the Yellow Clear Before Preempt, only 1 additional second is needed for Ped Clear time (5-4=1). If more Yellow Time is displayed than Ped Clear time, use 0 for this calculation. (Typically this time should be 0-2 seconds.)

* For Yellow and Red Clear Before Preempt, use the times shown on plans and controller if Overlap P (**D) is used. If 0.0 is shown on the plans and programmed on the controller, use the yellow and red clearance times for the normal phase that has the highest total clear time required. If this phase is the Track Clearance Phase, use the times for the next highest phase.

** *Note: Overlap P is available on all 2070 controllers and some types of NEMA controllers. On some older NEMA controllers, Overlap D (or the last overlap available) is used instead.*

For most newer controllers, Overlap P can be programmed to overlap with all parent phases. The purpose of Overlap P is to help ensure a constant transition time into preemption. Since the railroad equipment is programmed to provide us with set number of seconds of warning and then activate with for another set amount of time, it is important that our signal transition time remain constant and not vary. With the use of advance preemption, it is important that we serve the (yellow and red) clearance time before preempt designed for and not transition to Track Clear Green too quickly. A quick transition and lead to termination of Track Clear Green before the gates are fully horizontal and possibly a vehicle getting trapped on the tracks or in the throat. Overlap P is an overlap that operates concurrently with all normal phases, but it also must terminate before the signal can serve the preemption clearance phases. On some older equipment where Overlap P is not available, Overlap D may used instead to serve the same purpose. Yellow and Red times for Overlap P (D) are determined as stated below.

To determine the Yellow Clear and Red Clear times Before Preempt, find the phase that has the **highest total** *clear time (yellow + red). Do not use a higher yellow time from one phase and a higher red from another. For example, say Phase 1 requires 4.0 seconds of yellow and 2.5 seconds of red (6.5 total seconds), and Phase 2 requires 4.7 seconds of yellow and 1.5 seconds of red clearance (6.2 total seconds). For this calculation, use both the yellow and red times of Phase 1 since it requires the highest total clearance time. However, if Phase 1 is a phase used during the Track Clearance Phase and has the highest total time, use the highest total time of a phase that is not directly used for track clearance.*

For Track Clearance Green, use the time calculated in Item 3 for the type of preemption used.

11. Is the phase/movements used during the Track Clearance phase also an exclusive phase/move during normal operation? (No, if normal phase also has an overlapping turning movement that does not operate during Track Clearance phase.) **Yes** **No**

If the Track Clearance Phase(s) are also a phase movement that can occur during normal operation, additional measures must to taken to ensure a safe transition to preemption. If this phase(s) is green, and there are no other clearances required before preempt can begin, the Track Clear Green may begin timing immediately, thus eliminating 6-8 seconds from your before preemption cycle. This is not good when trying to sync the signal phasing with the operation of railroad gates. If this is Yes, the 2 items below may be used to help provide consistent transition times.

Note that if the phase has an overlapping movement on another approach (right turn overlap), then this movement must clear before Track Clear Green can begin counting, so there will still be Yellow and Red Clear that must terminate before preempt can begin.

Are all parent phases used in normal operation programmed for Overlap "P" ("D") on the controller. **N/A** **Yes** **No**

See explanation above (Item 10) for use of Overlap P (D).

Is Track Clearance Phase programmed as an exclusive phase that does not operate during normal operation (ex, TC Phase = Phase 9)? **N/A** **Yes** **No**

Sometimes the Track Clearance Phase may be programmed as a unique phase (ie, 9), even though the movements in the phase are the exact same as the movements in a phase used in normal operation. For example, in a split side street pattern, phase 4 exclusively serves the movement across the tracks. This phase (movement) would also need to be served during Track Clearance. In this case, the TC Phase may be programmed as Phase 9. If the signal is in Phase 4 during normal operation when a preempt call is received, the controller will "transition" from Phase 4 to prepare to serve Phase 9. In this case, the Phase 4 Yellow and Red times are served in the controller, even though the yellow and red are not actually displayed in the field. (Since both phases display green, the signal will continue to display green during the transition, even while Phase 4 yellow and red times are served in the controller and Phase 4 is terminated.)

North Carolina Department of Transportation
Highway-Railroad Interconnection and Preemption Inspection Form

12. Observe operation of the signal, including control equipment in the cabinet and field equipment for proper operation. Is equipment operating properly and does the operation coincide with the signal plans? **Yes** **No**

    If No, identify any malfunctions or discrepancies observed. Include: bulbs out, signal heads in need of repair, pavement conditions, pavement markings, signage, etc. _____

    _____

    _____

    Make sure controller is timing intervals properly (the controller should display the active interval with it's timing counting down), some older controllers require a key to be depressed, or a switch to be toggled in order for the display to come up. Make sure detectors are picking up and dropping out vehicle calls (detectors may be programmed for extend and/or delay). Controller should be resetting the gap timer for each detector actuation received for the phase currently timing. En sure all signal head displays are visible.

13. If protective/permissive phasing is used and/or "yellow trap" backup protection is required for normal signal operation, ensure Phase Omits are used and NOT Red Revert. **N/A** **Pass** **Fail**

    Red revert should NOT be used at railroad preemption locations where protective/permissive phasing is used or where backup protection is required to avoid a "yellow trap." Phase Omits or some other form of backup protection should be used at preempted locations.

14. Activate the railroad preemption sequence from the cabinet and observe operation.

    Does sequence match the signal plans? **Yes** **No**

    Does preemption override minimum green times? **Yes** **No**

    If no, list reasons for nonconformance here: _____

    _____

    _____

    In the absence of a train, this can be done via the preempt test switch in the cabinet, or if a test switch is not present, request that the crossing signal maintainer activate preemption from the RR crossing control equipment case/bungalow. In the absence of a test switch, and the crossing maintainer is not immediately available, you may activate preemption by removing one of the interconnection conductors from it's terminal (WARNING-120VAC present on interconnect circuit). Preemption should be activated during the timing of a MINIMUM GREEN INTERVAL, controller should force out of minimum green to enter preemption. Observe controller and intersection signals during this test. Controller should run the TRACK CLEARANCE PHASE(S), and enter into the dwell phases. Some signals dwell in a single phase during preempt, others cycle several phases that are compatible with the train movement during preempt. Consult signal plan for preemption phasing. Keep preemption activated long enough for the signal to cycle through all of it's dwell (PREEMPT HOLD) phases (for a cycling preempt). For preempts that dwell in a single phase(s) (ex. Phases 2 and 6), the controller should remain in preempt long enough to time PREEMPT/DWELL MINIMUM GREEN and then go to rest. Also, observe the operation of the BLANK-OUT SIGNS. Make note of any signs that are out or not easily visible. When preemption call is released, controller should cycle to preemption exit phase(s), and blank-out signs should extinguish. Some blank-out signs extinguish as soon as the track call is released, some stay on through the yellow and red clearances out of preemption and extinguish when the preempt exit phase turns green. Consult signal plans for sign on-off sequencing.

15. If intersection has multiple preempts programmed, verify that Railroad Preempt is highest priority. **N/A** **Pass** **Fail**

    Some locations have multiple preemptions (ie, railroad and a form of emergency vehicle preemption). If multiple preemptions are activated simultaneously (or if one preempt is called while the controller is serving another preempt), railroad preemption shall be set for a higher priority to ensure that it is served when needed.

16. If crossing has multiple through line tracks, perform second train sequence test (preempt re-service). Does **preempt call release** immediately when gates **begin** to rise? **N/A Pass Fail**

Note: This is very important to the correct operation of preempt re-service.

Some crossings have two or more tracks that vehicular traffic must cross. When multiple tracks are present, the possibility exists that back to back preemption events can occur. This procedure checks to make sure the controller will retime the track clearance phase(s) should the preempt call be dropped by the first train (leaving the crossing), and then reapplied one or two seconds later by a second train (approaching the crossing). To perform this test activate the preemption, allow the controller to time a few seconds of the track clearance green interval, not exhausting the time. After these few seconds, remove the preempt call for one or two seconds and then reapply the call. The controller should immediately start to retime the track clearance phase(s) green interval at the beginning of the preset time. If the controller does not retime the track clearance phase(s), either special programming may need to be added to the controllers "write-protect" area, or the controller may not be appropriate to control a multi-track preemption location. In some special cases, a controller lacking second train sequence operation may be used in conjunction with special internally illuminated blank-out sign sequences. If a special blank-out sign sequence is needed, contact the NCDOT - Traffic Engineering and Safety Systems Branch for information.

Also, please note that the point in which the preempt call is released is very important to the proper operation of PREEMPT RE-SERVICE. When the possibility of second trains exists, the preempt call should be released as soon as the gates begin to rise, not when they reach the fully vertical position.

Traffic Signal Electrical Inspection

17. Signal equipment manufacturer (controller, cabinet and conflict monitor)

Type of Controller (Circle): **NEMA 170 2070 Other:** _____
Controller Manufacturer and Model: _____
Type of Cabinet (Circle): **TS-1 TS-2 170 Other:** _____
Cabinet Manufacturer and Model: _____
Conflict Monitor/MMU: _____

18. Cabinet Mounting (Circle): **Base Pedestal Pole**

19. Discuss location with Traffic Signal Technician Supervisor and note any issues or recent trouble calls at this location (maintenance problems, spares, etc.): _____

_____

_____

20. Check to make sure that phases used only during preemption are omitted during normal operation. **N/A Pass Fail**

There are phases that are often used exclusively during preemption (track clearance phase with a left arrow, a left turn during preemption dwell, etc.), that are not used in normal operation. It is very important that these phases are omitted during normal operation so that they are not served except during preemption. If these phases are not omitted, hidden clearances or left turn (yellow) trap situations may occur. The best way to test for this situation is to do the following: Identify the phases that are to be omitted. Look at the controller display. Is there a vehicle call present on the phase? If not, use the cabinet vehicle detector test switches to place a call on the phase, then watch to see if the controller serves the phase in sequence. If the phase is not served, then it is omitted from the sequence. If the phase is served, it is not omitted and the omit circuits and/or programming need to be added.

21. Check track interconnect circuit (relay for NEMA, AC isolator for 170 and 2070) for conformance to fail safe operation (normally energized). **Pass Fail**

The interconnection circuit is the communication link between the traffic signal equipment and the railroad crossing signal equipment. In order to interface the interconnection circuit with the traffic signal controller, one of two devices are commonly used. The track call relay is used in all NEMA traffic signal controller cabinets used in North Carolina. AC isolator cards are used for the same purpose in type 170 and 2070 cabinets. The normal operation state of the track call relay/ AC isolator card is very important to ensure that the preempt INTERCONNECT CIRCUIT is functioning properly. The INTERCONNECT CIRCUIT is normally a two-conductor cable running from the traffic signal cabinet to the crossing signal cabinet. The circuit shall be of the closed circuit principle, that is, the traffic signal controller (track relay/AC isolator) is normally energized and the circuit is wired through a closed contact of the energized control relay of the grade crossing warning system." When a train approaches, the control relay in the crossing signal cabinet de-energizes and breaks the interconnection circuit to the track call relay coil, or AC isolator, in the traffic signal cabinet, thus activating the preemption sequence.

This normally energized circuit arrangement is considered "FAIL-SAFE." In the railway-signal industry, a device is considered "FAIL-SAFE" if it fails in its most restrictive mode (i.e. in preemption). In the case of the interconnection circuit, if there is a break in either or both wires of the circuit, the traffic-signal controller unit would respond as if a train is approaching, clearing motor vehicles off the tracks, even though a train may indeed not be approaching. The signal will stay in the preemption mode until the circuit is repaired.

TO CHECK THE RELAY (IN NEMA CABINETS) for "FAIL-SAFE" wiring, make sure a train movement is not imminent or occurring, then identify the track call relay. Look at the contacts (most relays have a clear cover) and see if they are pulled in against the coil. If you cannot tell, try gently pulling the relay out of the socket, it you feel or hear the relay click, then it is normally energized and is FAIL-SAFE. If the relay does not click, it is not in conformance. If it is not practical to remove the relay from its socket, disconnect one of the interconnection conductors from its terminal (WARNING-120VAC present on interconnect circuit). If the signal goes to preemption when the wire is removed, it is FAIL-SAFE. If preemption does not activate, the circuit is not in conformance. Please note that to bring the circuit into conformance, the relay wiring has to be changed in both the railroad crossing signal cabinet and the traffic signal cabinet.

TO CHECK THE AC ISOLATOR CARD (IN TYPE 170 AND 2070 CABINETS) FOR "FAIL-SAFE" WIRING, make sure a train movement is not imminent or occurring, then identify the AC isolator card wired to the preempt interconnect circuit; it is installed in the input file. Identify the channel of the isolator card in which the interconnect circuit is wired. Remove one of the interconnect conductors (WARNING-120VAC present on interconnect circuit. When the conductor is removed, the associated led indicator should illuminate and the signal should enter preemption. If there is no response, the circuit is not in conformance. The AC isolator card, as with the relay, can be set-up to operate in either normally closed (FAIL-SAFE) or normally open situations. If the AC isolator card does not operate FAIL-SAFE, the card simply needs the necessary adjustments (i.e. internal DIP switch settings on the card) to make it operate normally closed (FAIL-SAFE). As with the track call relay, the wiring has to be changed in the RR signal cabinet, if indeed a change is necessary.

22. Perform the following tests while signal is in **flash mode**:

a.) Check **blankout sign(s)** during flash (make sure controller switch is off during test). Blankout sign(s) should still illuminate for preemption during flash. **N/A Pass Fail**

If for some reason the signal is transferred into the flash mode by the conflict monitor, the blank-out signs are still required to operate. To test this operation, follow this procedure: (1) Switch signal into flash during the main street green interval. (2) Switch power to controller to "OFF". (Be sure to keep flash activated and controller powered down until all of the following tests are executed). (3) Activate preemption by the preempt test switch, or by using other methods described earlier in this document. (4) Observe blank-out signs. If they are "ON," they meet this requirement. If they remain "OFF," they are not in conformance.

b.) Check **flash color** of signals. Do flash colors match signal plans? **Yes No**

While signal is in flash, CHECK FLASH COLOR of signal heads for each approach and compare to signal plan (note any non-conformances).

c.) Check **start-up sequence**. **Pass Fail**

The start-up phase colors and intervals should always be displayed when exiting a flashing condition. In most cases, the start-up interval is the main street phase green interval, or the green of whatever phase(s) flash yellow. START-UP is supposed to automatically activate when exiting a flashing condition. Be sure that the correct START-UP or initialization phase(s) and interval are programmed correctly in the controller unit. To test this function, (1) power the controller up and make sure the flash switch on the inside of the cabinet door is in the "flash" position. (2) Check the controller display; the controller should be timing the minimum green interval of the initialization phase. (3) After the controller counts down for several seconds, toggle the flash switch to the "Auto" position. If the controller resets to the beginning of the minimum green in the initialization phase, START-UP is working properly. If controller continues to time without resetting, the operation is not in conformance.

23. Ensure that the controller is not programmed for late night flash. **Pass** **Fail**

Traffic signals utilizing railroad preemption should not be programmed for late night flash. They should only flash in the event of an equipment malfunction.

Railroad Crossing Signal Electrical Inspection

24. Identify the railroad signal warning equipment used (advance signal heads, flashers, cantilevers, 4 quadrant gates, etc.)_____

_____

Record all railroad-highway grade crossing warning equipment used at the crossing. This may include crossbucks, mast flashers, cantilevers with flashers, bells, (2 quadrant) gates, 4 quadrant gates, and advance traffic signal heads. Also note if railroad flashers are LED.

25. What is the condition of the interconnect circuit / contact in the railroad cabinet and/or junction box? _____

_____

Ask the Railroad Signal Maintainer to point out the preemption connection and check the condition of the wire and the terminals. At most locations, an intermediate connection may also exist in a nearby junction box. This is likely the place where the cable from the railroad bungalow is connected to the cable leading to the signal cabinet. This connection must be tight, free of corrosion, and in good condition.

26. Identify the general type of railroad signal equipment (motion detector, predictor, ac/dc, etc.)

_____

Look in the railroad signal cabinet (bungalow) and identify the type of controller used for the railroad warning equipment. The name of the controller should be printed on the front of the unit (Harmon PMD-3, Safetran GCP-3000-2, etc). Notify the Rail Division if the type of equipment has changed from the previous inspection.

27. Perform the following tests with a shunt placed across the rails in the island circuit or while a train is present:

a.) Observe traffic signal **preemption operation**. **Pass** **Fail**

Observe the traffic signal for proper preemption operation. The signal should remain in preemption long enough to run through the "track clearance" phase(s) and cycle through all dwell phases at least once.

b.) Examine **RR flashers** and focus. **Adjusted** **Pass** **Fail**

While the crossing system is in active operation, examine the RR flashers and make sure all the lamps are working, and are focused to the approach for which they are intended.

c.) Examine **RR flash sequence** (all approaches should alternate together). *Note: Gate tip light burns solid.* **Adjusted** **Pass** **Fail**

Examine RR flasher flash sequence. All sets of RR flashers should alternate together for the same approach. This includes the lights on the gates (except for the tip gate light, which burns solid).

d.) Observe when preempt call to traffic signal is released. Preempt call should be released as soon as practical. **Pass** **Fail**

The preempt call should be released as soon as the crossing signal gates BEGIN to RISE (this is especially important if there are multiple through tracks). If no gates are present, the call should be released when the RR flashers are extinguished.

28. What is the general condition of the railroad-crossing surface?

Poor **Fair** **Good** **Excellent** **New**

Details: _____

Check the condition of the crossing surface. If it is POOR or FAIR, explain in the line above (loose or worn timbers, broken pavement, broken rubber, etc).

Type of Crossing Surface: _____

1) Section Timber
2) Full Wood Plank
3) Asphalt
4) Concrete Slab
5) Concrete Pavement
6) Rubber
7) Metal Sections
8) Other Metal
9) Unconsolidated
10) Other _____

Select the number of the material of the crossing surface from the list above.

Railroad Crossing Signal Track Circuit Inspection

29. Obtain the circuit length as shown on plan of record in the railroad signal cabinet. *(Measure from edge of travel lane/impact area)*

From Plans – Northbound/Eastbound approach: _____ Southbound/Westbound approach: _____

Measured in Field – Northbound/Eastbound approach: _____ Southbound/Westbound approach: _____

Each railroad cabinet (bungalow) should contain a set of plans for the highway-grade crossing warning signals. Record the approach lengths shown on the plans.

Using a wheel on the rail (not on the ground next to the rail), measure the distance from the edge of the crossing to the shunt/starter (beginning of approach circuit). This distance may vary from previous inspections or what is shown on the plans by ~25 feet +/- due to errors during measurement or exact starting and finishing points. Additionally, railroads may measure/record the approach circuit differently (from centerline of roadway, edge of roadway, or end of island circuit). Ask the maintainer where the measurement is determined from. We (NCDOT) want our distance measured from the edge of the crossing surface (potential impact point) to the shunt. Both directions/approaches of the crossing must be measured. Generally, the shunt distance will be the same for each track on a multi-track approach, so it is not necessary to measure each track on each approach, unless the multiple tracks represent separate lines/branches (not considered as 2 parallel or passing tracks). If the measured distance has noticeably changed from the previous inspection, please notify the Rail Division.

30. Check the condition of bonds (Head Bonds & Long Bonds) _____

Bonds will only be found at the rail joints on jointed track. In general, bonds will not be used on welded track. Head bonds are the short copper wires welded to the top or side of the rail. Long bonds have shafts that are driven into the sides of the rail, about midway between the top and bottom of the rail. Short and long bonds will be used only on track with no train wayside signals (Dark Territory). If the track has train wayside signals (Signalized Territory), there will only be short bonds installed. At a track switch, you could also find two (2) copper wires (Spring Bonds) side by side between the rails where the rails come together from each direction as well as long bonds.

31. Obtain maximum train speed for the crossing from railroad maintainer / inspector (*using Timetable Speed or Railroad Permanent Speed Restriction*).

Railroad Northbound / Eastbound approach: _____ MPH

Railroad Southbound / Westbound approach: _____MPH

(NOTE: City / Town ordinance does not apply – federal preemption of local or state laws, RR activities are interstate commerce)

Ask the Railroad maintainer for the train speed limit from as listed in the most recent timetable book. Use this speed or a permanent speed restriction set by the railroad. Some cities or towns may have a speed ordinance for the railroad, but the railroad is not required to obey it. Also, do not factor in "temporary slow order" conditions when determining speed. In some cases the speed limit may be higher on one approach than the other (due to yard limits, curve restriction, etc.). <u>If the train speed has changed from the previous inspection, please notify the Rail Division.</u>

32. Calculate amount of warning time provided by track circuitry: _____ Seconds

(<u>Shortest Approach Length</u>) (Minus) Equipment Reaction Time
(1.47) (Train Speed in MPH)

To calculate total warning time, multiply train speed (in MPH) by 1.47 (to convert MPH to feet/second), and then divide this speed into the distance for the shortest approach you measured. Then subtract the appropriate warning time for the RR equipment to obtain the programmed time:

Predictor (GCP 3000)	*4 Seconds*
Motion Detector (PMD 1&2)	*3 Seconds*
Motion Detector (PMD-3R)	*2 Seconds*
Harmon (HXP) (SCX)	*4 Seconds*
Audio Frequency Overlay (AFO)	*5 Seconds*
AC/DC	*0 Seconds*

33. Is crossing signal equipped with **advance preemption**? **Yes** **No**

Note: If advance preemption is utilized, an actual train movement **must** be observed.

Observed total warning time of actual train movement: _____ Seconds

Advance preemption is used at many crossings, especially at four quadrant gate installations. When advance preemption is used, the traffic signal preemption begins prior to the crossing signals being activated. When advance preemption is first activated, the motoring public may not yet be ware that a train is approaching. It is important to note that when ADVANCE PREEMPTION is used, it is possible for the time difference between initiation of preemption and activation of the crossing signals to be increased by a decelerating train approaching the crossing. It is imperative that the time difference does not increase to the point where the traffic signal track clearance green interval ends (i.e. traffic signal turns red) before the crossing signals activate.

In order to check ADVANCE PREEMPTION a train movement MUST be observed through the crossing. Note how much time expires from the time the preempt call is received and when the crossing signals activate. Observe if there is adequate time remaining in the track clearance green interval to clear vehicles off the track after the entrance gate is fully horizontal.

34. If Railroad crossing signal equipment is designed for constant warning time (i.e. predictor):

    a) How much warning time is programmed in the unit? _____ Seconds

    If the RR controller is a predictor, record how much warning time is programmed for the highway grade crossing warning devices. This should be the total amount of time preemption begins in advance of an approaching train. This time should provide a constant crossing warning time for every train, irregardless of speed. Note that a train accelerating/decelerating in the approach can vary the warning time displayed at the crossing.

    b) How much time does railroad program for flashers to flash before train arrival? _____ Seconds

    Railroads typically limit the amount of time their equipment will activate in advance of an approaching train. FRA regulations require at least 20 seconds of activation. For most preempted crossings, warning devices will normally activate 30-35 seconds before train arrival. This time can vary at each crossing and is based on individual railroad policy.

    c) If railroad provides advance preemption, how many seconds of advance warning time is programmed? _____ Seconds

    This is the amount of time between the time the railroad equipment detects an approaching train and the time the railroad flashers activate (first flash). This should usually be 6-8 seconds if used.

    NOTE: The total of b) and c) above should equal the total amount of warning time programmed in the predictor (a) if advance preempt is used (a = b+c OR a-b = c).

35. Compare preemption time required with RR advance warning time.

    a) Total Preemption Warning Time Required (from Item 10): _____ Seconds

    Enter total warning time calculated in Question 10.

    b) Total Warning Time Programmed on Railroad Predictor (if used) (from Item 34a): _____ Seconds

    Enter total warning time programmed on predictor from Question 33a. This time should be greater than or equal to the time shown in 34a.

    c) Total Warning Time Available from Track Circuitry (From Item 32): _____ Seconds

    Enter total warning time calculated from Question 32. This time should be greater than or equal to the times shown in both 35a and 35b.

Track Circuitry Warning Time (c) should be greater than or equal to the Total Preemption Time Required (a) and the time programmed on the predictor (b) (if used). If (a) and/or (b) is greater than (c), immediate action must be taken (a <= b <= c).

Documentation

36. Mark-up a copy of the signal plan (if necessary). Show any field changes in red. The team leader should sign and date the changes on the plan and submit them to Traffic Engineering for an updated Plan of Record.

    You may need to mark-up a copy of the signal plan to clearly show actual stop-bar locations, or other field findings. Changes to signal design shall be reflected on marked up field copy and sent to Traffic Engineering.

37. Document any changes made in the field. (i.e. timing, etc.) _____

    _____

    _____

    _____

    If there are issues that were corrected in the field or still need to be addressed, list them in the space above. This should include anything related to pavement markings, signage, trees or brush that need trimming, and timing changes made to the preemption and/or warning time.

38. Are there any suggested signal / railroad revisions? (consider any geometric or environmental changes in the area.) _____

    _____

    If there are issues that were corrected in the field or still need to be addressed, list them in the space above. This should include anything related to pavement markings, signage, trees or brush that need trimming, and timing changes made to the preemption and/or warning time.

39. General comments: _____

    _____

    _____

    Add any other comments or useful information about this location here.

Send copy of this Inspection Form and any marked-up plans to:

	Traffic Signal Issues	Rail Crossing Issues
Mail:	NCDOT Traffic Engineering Branch Signals and ITS Unit Attn: Rob Ziemba, PE 1561 Mail Service Center Raleigh N.C. 27699-1561	Mr. Drew Thomas, PE NCDOT Rail Division Engineering and Safety Branch Capital Yard 1556 Mail Service Center Raleigh, N.C. 27699-1556
Office/ Delivery:	750 North Greenfield Parkway Garner, NC 27529 (919) 773-2800	Capital Yard 862 Capital Boulevard Raleigh, NC 27603 (919) 733-5564

STATE OF NEVADA DEPARTMENT OF TRANSPORTATION
RAILROAD SAFETY DIAGNOSTIC REVIEW FORM – QUIET ZONES

TEAM MEMBER: _____ AGENCY: _____ REVIEW DATE: _____

CROSSING DATA		HIGHWAY DATA		
DOT Number:		Location:		
Railroad Company:		Road Speed: Posted_____	Realistic 85th Percentile_____	
Railroad Milepost:		Highway AADT:		
Train Speed: Passenger_____	Freight_____	School Bus AADT:		
Track Class:		Highway Function Class:		
Number of Tracks & Type:		Principal Arterial or U.S. Route?	☐ Yes	☐ No
Number of Trains: Passenger_____	Freight_____	Transit Buses:	☐ Yes	☐ No
Crash History:	Property Damage	Hazmat Vehicles:	☐ Yes	☐ No
	Injury	Commercial Vehicles:	☐ Yes	☐ No
	Fatality	National Highway System:	☐ Yes	☐ No
Principal Rail Line: ☐ Yes ☐ No		Level of Service:	☐ Design	☐ Current

TYPE OF EXISTING WARNING DEVICES AT CURRENT CROSSING

Automatic Gates:	2-Quad ☐	4-Quad ☐	Median ☐	Pedestrian Gates:	☐ Yes ☐ No
Flashing Lights:	LED ☐	Bulbs ☐	Median ☐	Cantilever Flashing Lights:	☐ Yes ☐ No
Crossbucks:	Double Faced ☐		Single Faced ☐	Bells:	☐ Gong ☐ Electronic
Crossbucks Retroreflective 2-sided:	Yes ☐		No ☐	Emergency Notification	☐ Yes ☐ No
Multi Track Sign: 2-Track ☐ 3-Track ☐ 4-Track ☐ 6-Track ☐				STOP Signs:	☐ Yes ☐ No
Advanced Warning Signs: W10-1 ☐ W10-2 ☐ W10-3 ☐ W10-4 ☐				Humpback W10-5 Sign	☐ Yes ☐ No
Other Signs:				Sign Condition:	
Pavement Markings: Stop Bars ☐ RxR ☐ No Passing ☐ Lane Lines ☐ Dynamic Envelope ☐ Other ☐ Condition:					

DRIVER PERCEPTION

Overall awareness of railroad crossing, including visibility and effectiveness of possible signs, signals and markings.	☐ Acceptable ☐ Recommend Improvement
Horizontal and vertical alignment considerations.	☐ Acceptable ☐ Recommend Improvement
Sight Distance 1: *Distance to see xing.* North/East Side of Xing _____' South/West Side of Xing _____'	☐ Acceptable ☐ Recommend Improvement
Sight Distance 2: *Need _____' down tracks from _____' down road.* North/East Side Looking East/North _____' Looking West/South _____' South/West Side Looking East/North _____' Looking West/South _____'	☐ Acceptable ☐ Recommend Improvement
Sight Distance 3: *Distance down road to see _____' down tracks if #2 not acceptable.* North/East Side Looking East/North _____' Looking West/South _____' South/East Side Looking East/North _____' Looking West/South _____'	☐ Acceptable ☐ Recommend Improvement
Sight Distance 4: *16' from rail at a stop need _____' down tracks.* North/East Side Looking East/North _____' Looking West/South _____' South/West Side Looking East/North _____' Looking West/South _____'	☐ Acceptable ☐ Recommend Improvement
Nighttime visibility, including ambient lighting.	☐ Acceptable ☐ Recommend Improvement
Skew of Xing: _____° Does skew limit perception?	☐ Yes ☐ No
Are there simultaneous train movements on multiple tracks? Can standing boxcars blocking the view?	☐ Yes ☐ No ☐ Yes ☐ No
Mitigation of inadequate perception: ☐ Additional Signage: ☐ Luminaires Where: ☐ Automatic Warning Devices: ☐ Multiple Track Removal ☐ Other:	
Do drivers/pedestrians violate warning devices? Describe:	☐ Yes ☐ No

VERTICAL CURVE

Elevation Difference in 30' perpendicular to track: North/East _____" South/West _____"	☐ Acceptable ☐ Recommend Improvement
Low clearance vehicles using crossing: ☐ Low Boys ☐ Bottom Dumps ☐ Other Trucks ☐ Farm Equipment Mitigation over 3 inches: ☐ W10-5 ☐ Detour Signage ☐ Modify Approaches ☐ Other:	

STORAGE/QUEUING

Nearest intersection:	North/East _____' Name_____	South/West _____' Name_____	
Are there signals the intersections within 1,000 feet?		☐ Yes	☐ No
Is there adequate storage capacity to the North/East? If 'No' then how much is needed? _____'.		☐ Yes	☐ No
Is there adequate storage capacity to the South/West? If 'No' then how much is needed? _____'.		☐ Yes	☐ No
What mitigation is recommended for queuing?			

ADA/PEDESTRIANS/BICYCLES

Is there routine pedestrian and/or bicycle traffic?	☐ Yes	☐ No
Is this a bike route or a proposed bike route? If proposed, when will it be constructed _____?	☐ Yes	☐ No
If proposed bike route, determine if soon enough to be considered in project. ☐ Yes ☐ No Added width needed _____'.		
Bike lane needs: Width _____' Stripping: Lane Line____ RxR____ Bike Symbol____ Signs: W10-1 AWS____		
Bike Route or Trail: Width or Shoulder Width: _____' Signage: Bike Route:_____ Other:		
Is the sidewalk width adequate (36" is standard)?	☐ Yes	☐ No
Are sidewalks or widening proposed? How wide? _____'. When?_____ Consider in project?_____	☐ Yes	☐ No
Are there curb cuts at nearby intersections and a clear path present to curb cuts at nearby intersections?	☐ Yes	☐ No
Vertical obstructions (standard is none between 27" to 80" above ground).	☐ Yes	☐ No
Slope of sidewalk transition (standard is 12:1 or less).	☐ Yes	☐ No
Landing platform (standard is level and 5' x 5' or more).	☐ Yes	☐ No
Surface smoothness (standard is wheelchair passable, no broken or buckled asphalt, edges< ¼ ", etc.)	☐ Yes	☐ No
Panel length (crossing surface panel needs to extend 1' behind back of sidewalk to be standard).	☐ Yes	☐ No
Are flange gaps 2½", or less, or flange fillers installed?	☐ Yes	☐ No
Are crossing panels long enough (surface must minimum 1' past edge of walkway)?	☐ Yes	☐ No
Can full flange fillers be used in low speed applications?	☐ Yes	☐ No
Mitigation:		

HIGHWAY SECTION

Is there a nearby intersection within 1,000 feet of the crossing?	☐ Yes	☐ No
Does the intersection warrant preempt control for the signals? See TWG Page 22.	☐ Yes	☐ No
Are the advance warning signs in good condition?	☐ Yes	☐ No
Is there adequate storage capacity?	☐ Yes	☐ No
Is there a queuing problem? See queuing review above.	☐ Yes	☐ No
Is the driver's attention being diverted?	☐ Yes	☐ No
Is there an adequate approach landing platform?	☐ Yes	☐ No
Can the road approach be adjusted?	☐ Yes	☐ No
Are curb and gutter present?	☐ Yes	☐ No
Does the crossing warrant highway guardrail (35 mph and above)?	☐ Yes	☐ No
If guardrail is present, does it require upgrading?	☐ Yes	☐ No
Guardrail end treatment: MBCT ☐ BCT ☐ Diaphragm ☐ Parabolic Flare ☐ Other ☐		
Are drainage culverts present? Size _____' Location _____.	☐ Yes	☐ No
Do culverts, drop inlets, etc. need to be adjusted?	☐ Yes	☐ No
Utilities adjustment needed? Overhead Lines ☐ Buried Lines ☐ Gas Vent Riser ☐	☐ Yes	☐ No
Roadway width _____' Number of Travel Lanes _____ Is Road Wide Enough? Yes/No Pavement Condition_____		
Development Type: Residential ☐ Industrial ☐ Commercial ☐ Open Space ☐ Institutional ☐		
Heavy Truck Use: Evaluate locating stop bar up to 50' from xing to give trucks time to gain speed & reduce time to clear xing or add flash time in Railroad Section. Stop Bar location: Feet from nearest rail North/East_____' South/West_____'		

RAILROAD SECTION

Is the track on a curve? Degree of curve: _____° Super elevation: _____" Cross level: _____%	☐ Yes	☐ No
Are active warning devices needed? Type of circuitry: AC-DC ☐ CWT ☐ MS ☐	☐ Yes	☐ No
Do railroad signals give adequate warning time? How much time is there? _____ seconds. See TWG.	☐ Yes	☐ No
Are active advance warning signs warranted? (Where stopping sight distance is inadequate.)	☐ Yes	☐ No
Can multiple tracks be removed?	☐ Yes	☐ No
Should interties be used? See TWG Page 22.	☐ Yes	☐ No
Are presignals warranted? See TWG Page 24.	☐ Yes	☐ No
Are barrier gates warranted? See review below.	☐ Yes	☐ No
Does the track height need to be adjusted?	☐ Yes	☐ No
Is the surface smooth?	☐ Yes	☐ No
Is surface rehabilitation required to facilitate signal installation?	☐ Yes	☐ No

STOP AND YIELD SIGNS

THE FOLLOWING CONSIDERATIONS MUST BE MET IN EVERY CASE WHERE A STOP SIGN IS INSTALLED:		
STOP or YIELD signs may be used by road authority if there are two or more TADT and xing is ***passive.***	☐ Yes	☐ No
Will enforcement & judicial officials enforce STOP signs equally with roadway intersections?	☐ Yes	☐ No
Would installation of a STOP sign create a less dangerous situation than would exist with a YIELD sign?	☐ Yes	☐ No

ANY OF THE FOLLOWING CONDITIONS INDICATE THAT A STOP SIGN MIGHT REDUCE RISK AT A CROSSING:		
Maximum train speeds equal, or exceed, 30 mph.	☐ Yes	☐ No
Highway traffic mix includes buses, hazmat carriers and/or large trash or earth moving equipment.	☐ Yes	☐ No
Train movements are 10 or more per day, five or more days per week.	☐ Yes	☐ No
Is the rail line used by passenger trains?	☐ Yes	☐ No
The rail line is regularly used to transport a significant quantity of hazardous materials.	☐ Yes	☐ No
The highway crosses two or more tracks, particularly where both tracks are main tracks or one track is a passing siding that is frequently used.	☐ Yes	☐ No
The angle of approach to the crossing is skewed.	☐ Yes	☐ No
The line of sight from an approaching highway vehicle to an approaching train is restricted such that approaching traffic is required to substantially reduce speed.	☐ Yes	☐ No

STOP AND YIELD SIGNS

*THE FOLLOWING CONSIDERATIONS SHOULD BE WEIGHED **AGAINST** PLACING STOP SIGNS:*		
There are active warning devices.	☐ Yes	☐ No
Highway is other than secondary in character. Maximum 400 AADT - rural , 1,500 AADT - urban.	☐ Yes	☐ No
STOP sign would cause queuing onto nearby road.	☐ Yes	☐ No
The roadway is a steep ascending grade to or through the crossing, sight distance in both directions is unrestricted in relation to maximum closing speed, and heavy vehicles use the crossing. (SD4 is good.)	☐ Yes	☐ No

ACTIVE TURN RESTRICTION SIGNS

AN ACTIVE TURN RESTRICTION SIGN (NO RIGHT/LEFT TURN) SHOULD BE DISPLAYED IF EITHER OF THE FOLLOWING:		
There is parallel street within 50' of tracks where a turning vehicle could proceed around lowered gates.	☐ Yes	☐ No
A signalized intersection interconnected and preempted by the approach of a train and all existing turn movements toward railroad crossing should be prohibited.	☐ Yes	☐ No

REVIEW FOR FLASHING LIGHTS & AUTOMATIC GATES – MANDATORY FOR PUBLIC XINGS

ACTIVE DEVICES WITH AUTOMATIC GATES SHOULD BE CONSIDERED AT CROSSINGS WHENEVER AN ENGINEERING STUDY BY A DIAGNOSTIC TEAM DETERMINES ONE OR MORE OF THE FOLLOWING CONDITIONS EXISTS:		
Is the crossing on the National Highway System, U.S marked route or a principal arterial?	☐ Yes	☐ No
If inadequate sight distance exists in one or more quadrants and ALL of the following are 'Yes':		
a. Is it physically or economically unfeasible to correct the sight distance deficiency?	☐ Yes	☐ No
b. Is no acceptable alternate access available? If access exists, then close the crossing.	☐ Yes	☐ No
c. On a life cycle cost basis, would the cost of providing acceptable alternate access or grade separation exceed the cost of installing active devices with gates?	☐ Yes	☐ No
Do regularly scheduled passenger trains operate in close proximity to industrial facilities?	☐ Yes	☐ No
Is the crossing in close proximity to schools, industrial plants or commercial areas where there is higher than normal usage of school buses, heavy trucks or trucks carrying dangerous materials?	☐ Yes	☐ No
Based on the number of passenger trains and/or the number and type of trucks, does the diagnostic team consider the crossing a higher than normal risk that a train-vehicle collision could result in death or injury to rail passengers?	☐ Yes	☐ No
Are there multiple main or running tracks through the crossing?	☐ Yes	☐ No
Does the expected accident frequency (EAF) for active devices without gates exceed 0.1?	☐ Yes	☐ No
Does the traffic from a nearby highway intersection queue on or across the tracks?	☐ Yes	☐ No
Does the diagnostic team have other reasons?	☐ Yes	☐ No

OPTIONAL USE OF AUTOMATIC GATES – ONLY OPTIONAL AT PRIVATE XINGS

ACTIVE DEVICES WITH AUTOMATIC GATES SHOULD BE CONSIDERED AS AN OPTION WHEN ECONOMICALLY THEY CAN BE JUSTIFIED AND WHEN ONE OR MORE OF THE FOLLOWING CONDITIONS EXISTS:		
Do multiple tracks exist?	☐ Yes	☐ No
Are there 20 or more trains per day?	☐ Yes	☐ No
Does the posted highway speed exceed 40 mph in urban areas, or exceed 55 mph in rural areas?	☐ Yes	☐ No
Does the AADT exceed 2,000 in urban areas, or exceed 500 in rural areas?	☐ Yes	☐ No
Are there multiple lanes of traffic in the same direction of travel?	☐ Yes	☐ No
Does the product of the number of trains per day & AADT exceed 5,000 urban, or 4,000 rural?	☐ Yes	☐ No
Has an engineering study indicated the absence of active devices would result in the highway facility performing at a level of service below Level C?	☐ Yes	☐ No

Does the expected accident frequency (EAF) exceed 0.075?	☐ Yes	☐ No
Is this a new project or are the current active devices being replaced?	☐ Yes	☐ No
Does the diagnostic team have other reasons?	☐ Yes	☐ No

CANTILEVER FLASHING LIGHTS

Two or more lanes the same direction.	☐ Yes	☐ No
High speed highways regardless of number of lanes.	☐ Yes	☐ No
High percentage of truck traffic.	☐ Yes	☐ No
Objects on the side of the highway can obstruct the visibility of mast mounted flashing lights.	☐ Yes	☐ No
Horizontal or vertical curves or other topographical features obstruct the mast mounted flashing lights.	☐ Yes	☐ No
Trucks parked by roadside, blocking warning devices.	☐ Yes	☐ No

WARNING/BARRIER GATE SYSTEM

Crossings with passenger trains.	☐ Yes	☐ No
Crossing with high-speed trains.	☐ Yes	☐ No
Crossing in quiet zones.	☐ Yes	☐ No
Crossing in quiet zones with short medians.	☐ Yes	☐ No
As otherwise deemed necessary by the diagnostic review team. Describe.	☐ Yes	☐ No

PEDESTRIAN TREATMENTS

Can devices be designed to avoid stranding pedestrians between sets of tracks?	☐ Yes	☐ No
Can audible devices be added if determined necessary?	☐ Yes	☐ No
Would swing gates operate safely for disabled individuals?	☐ Yes	☐ No
Can the activation of gates, flashers and bells be delayed for a period of time at the crossing station using a Train to Wayside Controller to reduce traffic delays at LRV stations?	☐ Yes	☐ No
Are skirted gates or other warning devices needed?	☐ Yes	☐ No

CLOSURE

CROSSING SHOULD BE CONSIDERED FOR CLOSURE WHEN ONE OR MORE OF THE FOLLOWING APPLY:		
Does the crossing have nearby acceptable alternate vehicle and pedestrian access?	☐ Yes	☐ No
On a life cycle cost basis, would improvement exceed cost of providing acceptable alternate access?	☐ Yes	☐ No
If an engineering study determined any of the following:		
a. FRA Class 1,2, or 3 track with daily train movements		
1. AADT less than 500 in urban areas, acceptable alternate access within ¼ mile, and the median trip length would not increase by more than ½ mile.	☐ Yes	☐ No
2. AADT less than 50 in rural areas, acceptable alternate access within ½ mile, and the median trip length would not increase by more than 1½ miles.	☐ Yes	☐ No
b. FRA Class 4 or 5 track with active rail traffic.		
1. AADT less than 1,000 in urban areas, acceptable alternate access within ¼ mile and the median trip length would not increase by more than ¾ mile.	☐ Yes	☐ No
2. AADT less than 100 in rural areas, acceptable alternate access within 1 mile, and the trip median length would not increase more than 3 miles.	☐ Yes	☐ No
c. FRA Class 6 or higher track with active rail traffic.		
AADT less than 250 in rural areas, acceptable alternate access within 1½ miles, and the median trip length would not increase by more than 4 miles.	☐ Yes	☐ No
Does an engineering study determine the crossing should be closed because railroad operations will occupy or block the crossing for extended periods of time on a routine basis and it is not physically or economically feasible to grade separate or shift train operations to another location? Such locations would typically include the following areas:		☐ Yes ☐ No
a. Rail yards.		
b. Passing tracks primarily used for holding trains while waiting to meet or be passed by other trains.		
c. Locations where train crews are routinely required to stop trains because of cross traffic on intersecting lines, or switch cars.		
d. Switching leads at the ends of classification yards.		
e. Where trains are required to "double" in or out of yards and terminals.		
f. In the proximity of stations where long distance passenger trains are required to make extended stops to transfer baggage.		
g. Locations where trains must stop or wait for crew changes.		
If there are types of vehicle traffic that are required to stop and Sight Distance 4 is not sufficient and automatic warning devices cannot be installed.		☐ Yes ☐ No

GRADE SEPARATION

CROSSING SHOULD BE CONSIDERED FOR GRADE SEPARATION WHEN ONE OR MORE OF THE FOLLOWING APPLY:		
Is the highway part of the designated Interstate Highway System?	☐ Yes	☐ No
Is the highway designed to have full control access?	☐ Yes	☐ No
Does the highway posted speed exceed 70 mph?	☐ Yes	☐ No
Does the AADT exceed 100,000 in urban areas or 50,000 in rural areas?	☐ Yes	☐ No
Is the maximum authorized train speed over 110 mph?	☐ Yes	☐ No
Is there an average of 150 or more trains per day or 300 million gross tons per year?	☐ Yes	☐ No
Is there an average of 75 or more passenger trains per day in urban areas or 30 or more in rural?	☐ Yes	☐ No
Crossing exposure (product of trains per day & AADT) exceeds 1,000,000 in urban, 250,000 rural.	☐ Yes	☐ No
Passenger train exposure exceeds 800,000 in urban areas and 200,000 in rural areas?	☐ Yes	☐ No
The expected accident frequency (EAF) for active devices exceeds 0.5?	☐ Yes	☐ No
Vehicle delays exceed 40 vehicle hours per day?	☐ Yes	☐ No

GRADE SEPARATION

CONSIDER CROSSINGS FOR GRADE SEPARATION WHEN ONE OR MORE APPLY AND LIFE CYCLE COSTS CAN BE FULLY ALLOCATED:		
Is the highway part of the designated National Highway System?	☐ Yes	☐ No
Is the highway designed to have partial control access?	☐ Yes	☐ No
Does the highway posted speed exceed 55 mph?	☐ Yes	☐ No
Does the AADT exceed 50,000 in urban areas or 25,000 in rural areas?	☐ Yes	☐ No
Is the maximum authorized train speed over 100 mph?	☐ Yes	☐ No
Is there an average of 75 or more trains per day or 150 million gross tons per year?	☐ Yes	☐ No
Is there an average of 50 or more passenger trains per day in urban areas or 12 or more in rural?	☐ Yes	☐ No
Crossing exposure (product of trains per day & AADT) exceeds 500,000 in urban, 125,000 rural?	☐ Yes	☐ No
Passenger train exposure exceeds 400,000 in urban areas and 100,000 in rural areas?	☐ Yes	☐ No
The expected accident frequency (EAF) for active devices exceeds 0.2?	☐ Yes	☐ No
Vehicle delays exceed 30 vehicle hours per day?	☐ Yes	☐ No
Does the engineering study indicate that the absence of a grade separation will result in the highway facility performing at a level below service 10% or more of the time?	☐ Yes	☐ No

NEW CROSSINGS

ONLY PERMITTED AT EXISTING RAILROAD TRACKS AT-GRADE WHEN ALL FOLLOWING APPLY & NOT ON MAINLINES:		
On public highways or streets where there is a clear and compelling need (other than enhancing the value or development potential of the adjoining property).	☐ Yes	☐ No
Grade separation cannot be economically justified (benefit to cost ratio on a fully allocated cost basis is less than 1.0 (usually the crossing exposure exceeds 50,000 in urban areas & 25,000 in rural areas)	☐ Yes	☐ No
There are no other viable alternatives.	☐ Yes	☐ No
Rail operations will not block the crossing.	☐ Yes	☐ No

IF A CROSSING IS PERMITTED, THE FOLLOWING CONDITIONS SHOULD APPLY:		
The crossing will be equipped with active devices with gates.	☐ Yes	☐ No
The plans and specifications should be subject to the approval of the highway agency having jurisdiction over the roadway (if other than a State agency), the State DOT and/or other State agency vested with the authority to approve new crossings, and the operating railroad.	☐ Yes	☐ No
All costs associated with the construction of the new crossing should be borne by the party or parties requesting the new crossing, including providing financially for the ongoing maintenance of the crossing surface and traffic control devices where no crossing closures are included in the project.	☐ Yes	☐ No
Whenever new public highway-rail crossings are permitted, they should fully comply with all applicable provisions of this proposed recommended practice.	☐ Yes	☐ No
Whenever a new highway-rail crossing is constructed, consideration should be given to closing one or more adjacent crossings.	☐ Yes	☐ No

QZ QUALIFICATIONS

PUBLIC CROSSINGS	PRIVATE CROSSINGS
☐ Public Authority Maintains 1+ Side of Crossing	☐ No Public Road Authority – Private Name: _____
☐ Freight Line Part of Main Rail System or Transit with Freight	☐ Freight Line Part of Main Rail System or Transit with Freight
☐ Crossing = Road + Walkways + Paths	☐ Crossing = Road + Walkways + Paths
☐ Minimum Length ⅛ Mile	☐ Minimum Length ½ Mile
☐ Party Responsible for Initial & Ongoing Costs _____	☐ Cannot Force Private Party to Pay. Who Will? _____
☐ Party Responsible for Private Costs _____	☐ Private w/Public Use = Whistle NRS705.43 = QZ Application
☐ Night Ban or ☐ 24-Hour Ban?	☐ Night Ban or ☐ 24-Hour Ban?
☐ Annual Review to New NSRT Needed?	☐ Annual Review to New NSRT Needed?
☐ Minimum Warning = Lights & Gates & No Train Horn Sign	☐ Minimum Warning = X-Buck & No Train Horn Sign

RECOMMENDATION SUMMARY – PRIMARY & SUPPLEMENTARY DEVICES

("X" = Risk Reduction " ◯ " = Needed But No/Minimal Risk Reduction)

☐ Closure	☐ STOP AHEAD Signs – where inadequate stopping distance
☐ Grade Separation	☐ YIELD Signs
☐ Crossing Relocation – Where?	☐ YIELD AHEAD Signs – where inadequate stopping distance
☐ Automatic Gates	☐ Do Not Stop on Tracks XX' Behind (for queuing)
☐ Flashing Lights & Gates	☐ Humpback Warning Sign
☐ Median Gates & Flashing Lights	☐ Humpback Detour Signage – Where?
☐ Side Lights	☐ No Train Horn Sign
☐ Cantilever Flashing Lights	☐ Additional Signage – What?
☐ Circuitry, Timing, Intertie Adjustments? – What?	☐ Pavement Markings – When 40 mph or automatic devices
☐ Bells	☐ Dynamic Envelope with "KEEP CLEAR" wording
☐ Stationary Horns – Clear with FHWA – No Annual Review	☐ Medians with Non-Mountable Curb – 100' (60' if intersection)
☐ Presignals or ☐ AAWS?	☐ Channelization – What Device?
☐ 4-Quadrant Gates	☐ Parking & Pedestrian Channelization? - What?
☐ Activation Method & Timing on Exit Gates for 4-Q Gates	☐ Luminaires - Where?
☐ Barrier Gates or ☐ Skirted Gates?	☐ Storage Improvement for Queuing – What?
☐ Active Turn Restriction Signs? – Where?	☐ Maintenance – Who?
☐ One-Way Streets with Gates	☐ Approach Modification (Humpback) – What?
☐ Active Second Train Coming Sign	☐ Landing Platform Improvement
☐ Pedestrian Lights & Gates	☐ Road Approaches/Road Widening
☐ Pedestrian Amenities, Swing Gates? – What?	☐ Surface Rehabilitation
☐ Night Crossing Closure With Night-Only Ban	☐ Fixed Object Removal or ☐ Guardrail?
☐ Retroreflective Double-Faced Crossbucks	☐ Utility & Culvert Adjustments? – Where?
☐ Retroreflective Post Tape	☐ Additional ADA – What?
☐ Emergency Notification Sign	☐ Route School & Transit Buses Outside QZ, Best Xing, Etc.
☐ Multi-Track Signs # Tracks	☐ Automated Enforcement (future – 92% reduction)
☐ Advance Warning Signs W10- W10- W10-	☐ Other
☐ STOP Signs	☐ Other

ALTERNATIVE SAFETY MEASURES – REQUIRES FRA APPROVAL

☐ Photo Enforcement	☐ Programmed Enforcement
☐ Education – 3 Year Before & After Studies required	☐ Shorter Medians
☐ Shorter Medians with Barrier Gates	☐ Other

RECOMMENDATION DESCRIPTION

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PRECONSTRUCTION MITIGATION

What interim measures are needed?
If improvements are needed but will not be done, document reasons.
If no improvement needed, document adequacy of current devices.

TYPE OF PROTECTION DURING CONSTRUCTION

☐ Detour with Flagger protection during the day.	☐ Combination daylight flagging and stop signs.
☐ 24 hour Flagger protection.	☐ Construction of half of crossing at a time with work zone detour.
☐ Reopen main crossing at night with existing protection.	☐ Temporary signal protection (only under stringent conditions).
☐ Work zone traffic control with lane closures and detours with railroad flagging during working hours.	
☐ Other:	

NEVADA PUBLIC UTILITY COMMISSION AUTHORITY REQUIRED FOR IMPROVEMENTS

☐ New Crossing	☐ All Automatic Warning Devices - Signal Installation, Circuitry, etc.
☐ Closure	☐ Surface Improvement, Install Prefab Crossing, etc.
☐ Relocation	☐ Passive Improvement, Signs, Markings, etc.
☐ Major Modification (track removal, road widening, etc.)	☐ Grade Separation
☐ Medians / Channelization	☐ Luminaires
☐ Pedestrian Amenities	☐ Other

Source: Nevada Department of Transportation.

APPENDIX G: SAMPLE AGREEMENTS

- Railroad-Highway Master Agreement for Warning Devices
- TxDOT Diagnostic Checklist and Responsibilities

RAILROAD–HIGHWAY MASTER AGREEMENT
FOR WARNING DEVICES

This Master Agreement ("MASTER AGREEMENT") is made and entered into this _____ day of _____, 20_____, by and between the _____ Department of Transportation, hereinafter called the "DEPARTMENT," and _____ [Railroad Company], hereinafter called the "RAILROAD."

WITNESSTH:

WHEREAS, the RAILROAD owns and operates a line of railroad in and through the City/County of _____, in the State of _____.

WHEREAS, the DEPARTMENT wants to progressively upgrade the safety at railway–highway crossings by installing warning devices throughout the State of _____. In order to expedite the processing of applications for these safety improvements and processing of related agreements, it is the desire of the DEPARTMENT and the RAILROAD to enter into this MASTER AGREEMENT setting out the general terms and conditions under which the improvements shall be provided, with the understanding that supplements to this MASTER AGREEMENT will be issued and executed from time to time covering specific installations in the form marked Exhibit A, attached hereto and hereby made a part hereof (the "Supplement" or "Supplements").

WHEREAS, the RAILROAD desires to cooperate with the DEPARTMENT in the installation of these grade crossing warning devices that both parties agree to accomplish through the use of Federal Section 130 and/or State funds.

WHEREAS, the local public authority, if applicable, having jurisdiction of the highway or street crossing is referred to in this MASTER AGREEMENT and each Supplement as the "LOCAL AUTHORITY."

NOW, THEREFORE, in consideration of the mutual covenants and agreement of the parties contained herein, the receipt and sufficiency of which are hereby acknowledged, the parties agree as follows:

Section 1: Scope of Work

The RAILROAD will provide all the work, labor, material, and services to install the warning devices, hereinafter called "signals," at the locations described in the applicable Supplement.

The LOCAL AUTHORITY shall perform those services necessary to facilitate the processing of all documents required for orderly progress of the project in accordance with the policies and procedures of the State of _____ and the Federal-Aid Policy of the Federal Highway Administration.

The LOCAL AUTHORITY, where applicable, shall install without expense to the RAILROAD advance warning signs, standard pavement markings for railroad crossings, and guardrail or barriers to protect the signal from highway traffic when such protection is required.

Section 2: Notice from the Department

The DEPARTMENT will provide, at project expense, notice to the RAILROAD of the proposed project. The notice will contain a description of the site, a detailed plan showing the locations of warning devices to be installed, improvement proposed, funding sources proposed, and a request to the RAILROAD to prepare plans and estimates for the work involved.

Section 3: Railroad Obligations

A. The RAILROAD shall, at project expense, furnish all labor, material, and equipment necessary for the project, and shall install warning signals and/or crossing surface of the type and at the location described in the applicable Supplement, subject to the terms and conditions of this MASTER AGREEMENT and the applicable Supplement.
B. The RAILROAD shall also furnish, at project expense, such detailed plans, specifications, and estimates of cost that may be required in addition to those prepared by the State. The plans, specifications, and estimates shall become a part of the applicable Supplement.
C. The position of the crossing improvements shall be established jointly by representatives of the DEPARTMENT and the RAILROAD.
D. The RAILROAD shall not begin installation of the crossing improvements until authorization is received from the DEPARTMENT. The RAILROAD shall notify the DEPARTMENT at least forty-eight (48) hours prior to the commencement of the improvements. The RAILROAD shall notify the DEPARTMENT in writing of the date when all work is completed. At the completion of all work, representatives of the DEPARTMENT and the RAILROAD will conduct a joint inspection of the crossing improvements.

Section 4: Department or Local Authority Obligations

A. Unless otherwise provided in Section 4B, the DEPARTMENT, at project expense, shall (1) furnish all supervision, labor, materials, and equipment that are needed to install and thereafter maintain advance warning signs, standard

pavement markings, guardrails, or barriers to protect warning devices from highway traffic and, if applicable, shall resurface and align the crossing approaches to the alignment of the new rail crossing and (2) provide all necessary traffic control, barricades, and detour signing for crossing work.

B. If a LOCAL AUTHORITY has jurisdiction of the highway or street and will have the responsibility to perform the work described in Section 4A or any other work set forth in this MASTER AGREEMENT or shall be responsible for any other obligations under this MASTER AGREEMENT, the DEPARTMENT in a separate agreement with the LOCAL AUTHORITY shall require the LOCAL AUTHORITY to perform such work and/or be responsible for such obligations and shall require the LOCAL AUTHORITY to comply with the terms and conditions contained in this MASTER AGREEMENT and in the respective Supplement.

C. All work performed by the DEPARTMENT or the LOCAL AUTHORITY shall be in compliance with the current Manual on Uniform Traffic Control Devices.

Section 5: Maintenance by Railroad

A. Upon completion of installation, the warning devices shall be operated and maintained by and at the expense of the RAILROAD, provided, however, that the RAILROAD'S agreement herein to operate and maintain said warning devices shall not prejudice the RAILROAD from having the benefit and advantage of Federal, State, or other public funds that may become available to pay or contribute to the cost of operation and maintenance of warning devices at highway–railway grade crossings.

B. The portion of the crossing surface between the track tie ends shall be maintained by and at the expense of the RAILROAD. If, in the future, the DEPARTMENT or the LOCAL AUTHORITY elects to have the surfacing material between the track tie ends replaced with paving or some surfacing material other than timber planking, the RAILROAD, at the DEPARTMENT'S or the LOCAL AUTHORITY'S expense, shall install such replacement surfacing.

Section 6: Maintenance by Local Authority

The LOCAL AUTHORITY will maintain the advance warning signs, the standard pavement markings for railroad crossings, and protecting barriers or guardrails at the LOCAL AUTHORITY'S expense. However, in the event that any existing or future legislation makes Federal, State, or other funds available for the operation, maintenance, repair, or replacement of signals at grade crossings, the LOCAL AUTHORITY shall cooperate with the RAILROAD to secure said funds for the operation, maintenance, repair, or replacement of the signals installed pursuant hereto. This agreement may be supplemented and amended as necessary for operation and maintenance of said warning devices and their appurtenances.

Section 7: Repair or Replacement of Damaged or Obsolete Facility

In the event that said warning devices or their appurtenances installed under any Supplement are damaged, and if after a diligent effort by the RAILROAD, documented in writing, the item for damages proves uncollectible from the person or persons responsible for such damage, or in the event the RAILROAD and the DEPARTMENT agree that said warning devices cannot be maintained or by virtue of their obsolescence require replacement, then in either event cost of repair of said warning devices or cost of reinstallation of new warning devices shall be borne by the parties hereto in the same participation ratio as the cost of the original installation. The DEPARTMENT will not assume any liability for further damage or participate in any flagging or other costs on account of the warning devices being inoperative due to damage or replacement.

If the damage to said warning devices is caused by highway traffic, the DEPARTMENT or LOCAL AUTHORITY, as applicable, will cooperate with the RAILROAD in determining the location and identification of the parties responsible for such damage to the extent of making accident records available to the RAILROAD.

If the said warning devices cannot through age be maintained or require replacement because of obsolescence, then the cost of replacing the said warning devices shall be negotiated by the LOCAL AUTHORITY and the RAILROAD as specified in the participation Exhibit A, with such State, Federal, or other public funds as may be available at the time that such replacement becomes necessary.

Section 8: Disposition of Signal No Longer Required

A. In the event that said warning devices are no longer required at the grade crossing and the RAILROAD and the DEPARTMENT/LOCAL AUTHORITY agree that they are not obsolete, the DEPARTMENT will take ownership and arrange to have them relocated to some other grade crossing. The division of costs of said relocation shall be agreed upon between the RAILROAD and DEPARTMENT/LOCAL AUTHORITY, as applicable, prior to such removal.

B. If for any reason the warning devices shall no longer be required at the grade crossing and in the opinion of the RAILROAD and DEPARTMENT/LOCAL AUTHORITY, as applicable, the warning devices are obsolete, the RAILROAD may remove the said warning devices and credit the DEPARTMENT/LOCAL AUTHORITY, as applicable, the value of salvage recovered less cost of removal.

Section 9: Working on Railroad Property

A. The DEPARTMENT, when working on any RAILROAD property, will comply with the terms and conditions set forth in Exhibit E, attached hereto and hereby made a part hereof, and will also require, in its separate contract with the LOCAL AUTHORITY and/or the DEPARTMENT'S Contractor (as such term is defined in Paragraph B below), that the LOCAL AUTHORITY and/or Contractor also comply with the terms and conditions contained in Exhibit E.
B. The term "Contractor" as used in this MASTER AGREEMENT or in any Supplement shall mean the contractor or contractors hired by the DEPARTMENT or the LOCAL AUTHORITY to perform any work on the RAILROAD'S property and shall also include the Contractor's subcontractors and the Contractor's and subcontractor's respective employees, officers, and agents and others acting under its or their authority.

Section 10: Funding and Audit

A. The project will be funded in conformity with Federal Highway Administration regulations adopted for safety improvement projects authorized in the Transportation Equity Act for the 21st Century, its revisions, or amendments. All bills rendered by the RAILROAD and paid by the DEPARTMENT/LOCAL AUTHORITY will be subject to audit and approval by the Federal Highway Administration ("FHWA"). Reimbursement shall be in accordance with provisions of the Federal-Aid Policy Guide, provided, however, that the use of said Federal-Aid Policy Guide as a guideline for reimbursement between the parties hereto shall not be construed as a condition precedent to the DEPARTMENT'S obligation to pay the RAILROAD for work performed by it. If the DEPARTMENT desires to secure reimbursement from the FHWA for all phases of the work performed by the RAILROAD, it is the responsibility of the DEPARTMENT to ensure that the interpretation of the Federal-Aid Policy Guide will permit Federal participation in the cost and expense of work that, pursuant to each Supplemental, is to be performed by the RAILROAD at the expense of the DEPARTMENT.
B. If the DEPARTMENT requires the services of a consultant, the DEPARTMENT shall be responsible for audit of the consultant's records to determine eligible federal aid costs on the project. The report of said audit shall be in the DEPARTMENT'S files and made available to the State or Federal government. An audit shall be conducted by the DEPARTMENT'S internal Audit office in accordance with generally accepted auditing standards as issued by the U.S. Government Accountability Office.
C. All project records in support of all costs incurred and expenditures shall be open to inspection by the DEPARTMENT and the FHWA at the RAILROAD'S offices, during normal business hours, and shall be retained and made available by the RAILROAD for such inspection for a period of not less than three (3) years from the date of final billing from the RAILROAD.

   Any overpayment of federal money in ineligible items of cost found as a result of the audit will be reimbursed by the RAILROAD to the DEPARTMENT or LOCAL AUTHORITY, as applicable, for the amount of such overpayment. All such excess funds will be reimbursed to the FHWA.

Section 11: Billing and Payments

A. The RAILROAD will submit progressive itemized invoices detailing the actual cost incurred by the RAILROAD in carrying out work to be performed under this MASTER AGREEMENT and each Supplement to the LOCAL AUTHORITY or DEPARTMENT, as applicable. Work shall include cost of labor, materials, and other services as shown in the estimate of cost furnished by the RAILROAD and accepted by the LOCAL AUTHORITY or DEPARTMENT, as applicable. The LOCAL AUTHORITY or DEPARTMENT, as applicable, shall pay all undisputed parts of said progressive invoices within thirty (30) days and no later than one hundred twenty (120) days of receipt of invoices. The DEPARTMENT will promptly notify the RAILROAD of all disputed billings.
B. A final and complete billing of all actual incurred costs and expenses, ascertained in accordance with the provisions of 23 CFR, Chapter I, Subchapter B, Part 140, Subpart I, as supplemented and amended, which by this reference is incorporated in this MASTER AGREEMENT, shall be made within one (1) year of completion of project by the RAILROAD. The DEPARTMENT/LOCAL AUTHORITY agrees to make final payment of eligible costs listed in the final invoice within ninety (90) days of receipt of said final invoice.

Section 12: Preliminary Engineering Costs

The DEPARTMENT and the RAILROAD acknowledge that the cost of preliminary engineering incurred prior to approval of the specific project by the FHWA is ineligible for reimbursement with Federal funds and will therefore be reimbursed with State funds if incurred after the DEPARTMENT'S request for preparation of estimates.

Section 13: Separate Agreement with the Local Authority

If a grade crossing improvement project is to be undertaken at a crossing at which the highway or street is subject to the jurisdiction of the LOCAL AUTHORITY instead of the DEPARTMENT, the DEPARTMENT shall enter into a separate agreement with the LOCAL AUTHORITY whereby the LOCAL AUTHORITY shall assume responsibility for the obligations set forth herein as applicable to the LOCAL AUTHORITY with jurisdiction over the highway or street.

Section 14: Nondiscrimination Provision

If the RAILROAD enters into contract or agreement with a contractor to perform any of the work under this MASTER AGREEMENT or Supplement, the provisions of the Civil Rights Act of 1964 will apply and become a part of the Supplement for the project by reference.

Section 15: Successors or Assigns

This MASTER AGREEMENT and each Supplement shall be binding on and inure to the benefit of the parties hereto, their successors, and assigns.

Section 16: Indemnification

Nothing in this MASTER AGREEMENT is intended to be construed as a requirement for an indemnification against the sole negligence of the RAILROAD, its officers, employees, or agents. Moreover, for any work performed in the State of _____, the DEPARTMENT will require its contractor to indemnify the RAILROAD and any other railroad company occupying or using the RAILROAD'S right-of-way or line of railroad against all loss, liability, and damages, including environmental damages, hazardous materials damages, penalties, or fines that may be assessed for, caused by, or the result of the contractor's negligence; provided, however, that if such loss, liability, damages, penalties, or fines are caused by or result from the concurrent negligence of (a) the RAILROAD or the RAILROAD'S officers, employees, or agents and (b) the DEPARTMENT'S contractor or the contractor's employees, agents, or subcontractors, such indemnity shall be valid and enforceable only to the extent of the negligence of the DEPARTMENT'S contractor or the contractor's employees, agents, or subcontractors. Likewise, if such loss, liability, damages, penalties, or fines are caused by or result from the concurrent negligence of (a) the RAILROAD or the RAILROAD'S officers, employees, or agents and (b) the DEPARTMENT'S officers, employees, or agents, such indemnity shall be valid and enforceable only to the extent of the negligence of the DEPARTMENT'S officers, employees, or agents.

IN WITNESS WHEREOF, the parties hereto have caused this MASTER AGREEMENT to be executed in duplicate by their proper officers thereunto duly authorized, as of the day and year first herein written.

RAILROAD	DEPARTMENT
(Federal Tax ID #_____)	By: _____
By: _____	Title: _____
Title: _____	Date: _____
Date: _____	

EXHIBIT A

SUPPLEMENT TO RAILROAD–HIGHWAY MASTER AGREEMENT BETWEEN
_____ TRANSPORTATION DEPARTMENT
AND
_____ RAILROAD
FOR GRADE CROSSING WARNING DEVICES
INVOLVING FEDERAL SECTION 130 FEDERAL AID FUNDS

Project Name: _____

Project No.: _____ (the "Project") DOT No.: _____

Railroad Subdivision: _____ Railroad Milepost: _____

Hwy, Road, or Street: _____ (the "Crossing")

City: _____ County: _____

A. _____Transportation Department ("DEPARTMENT") and _____ Railroad Company ("RAILROAD") entered into a RAILROAD–HIGHWAY MASTER AGREEMENT ("MASTER AGREEMENT") dated _____.
B. As provided in the MASTER AGREEMENT, the DEPARTMENT and the RAILROAD are to enter into supplements to the MASTER AGREEMENT covering each Section 130 project.
C. This supplement to the MASTER AGREEMENT ("Supplement") is being executed by the DEPARTMENT and the RAILROAD [*add if applicable:* City of _____, County of _____ (the "LOCAL AUTHORITY")] to provide for the Project improvements described in this Supplement that are to be completed at the crossing described above pursuant to the terms and conditions of the MASTER AGREEMENT.
D. Listed below are the proposed improvements with cost estimates. The RAILROAD'S force account estimate(s) is attached as Exhibit B, and wiring diagram (if required) is attached as Exhibit D, and are hereby made a part of this Supplement. All work and the financing thereof shall be subject to the terms and provisions of the MASTER AGREEMENT.
E. Description of Improvement: _____

_____

Estimated Total Cost	Federal Funds	State Funds	Local Funds	Railroad Funds
$	$	$	$	$

F. The [DEPARTMENT] [LOCAL AUTHORITY] shall be responsible for reimbursing the RAILROAD for railroad flagging costs relating to any work performed by the State, LOCAL AUTHORITY, or Contractor.

RAILROAD

(Federal Tax ID # _____)

By: _____

Title: _____

Date: _____

LOCAL AUTHORITY [*add if applicable*]

By: _____

Title: _____

Date: _____

DEPARTMENT

By: _____

Title: _____

Date: _____

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EXHIBIT B

RAILROAD

DETAILED FORCE
ACCOUNT COST ESTIMATE

Type of Work	**Labor**	**Non-Labor**	**Total**
1. Install Warning Devices (Type)			
a. Freight Material Handling			
b. Equipment Rental			
c. Expenses			
d. Salvage			
e. Other			
2. Engineering and Accounting			
3. Liability Insurance			
4. Labor Surcharge			
5. Other Work by Railroad			
☐ Yes ☐ No **EXHIBIT C** attached hereto			
6. **Total Project Costs**			

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EXHIBIT C

RAILROAD

OTHER WORK [IF REQUIRED]
COST ESTIMATE

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EXHIBIT D

RAILROAD

DETAILED WIRING DIAGRAM [IF REQUIRED]

EXHIBIT E

TERMS AND CONDITIONS RELATING TO
WORKING ON THE RAILROAD'S PROPERTY

1. The RAILROAD, at its determination, may provide inspection, security, flagging, or other protective services as necessary for the protection of the RAILROAD'S property or operations whenever there are DEPARTMENT, LOCAL AUTHORITY, or Contractor activities or work on the RAILROAD'S property.
2. All work to be done by the DEPARTMENT, LOCAL AUTHORITY, and any Contractor on RAILROAD property shall be done in a manner satisfactory to the RAILROAD. The work shall be performed diligently and completed within a reasonable time or within such period of time as may be specified in writing by the RAILROAD. The authorized representative of the RAILROAD shall have final authority in all matters affecting safe and timely train operations.
3. No Project work on any RAILROAD property shall commence until the DEPARTMENT, LOCAL AUTHORITY, or Contractor has provided fifteen (15) days' advance notice to the RAILROAD representative and at least fifteen (15) days' advance notice for any work to be performed within twenty-five (25) feet of any railway track, or where such work, personnel, or equipment will be near enough to any track that an equipment extension (such as, but not limited to, a crane boom) will reach to within twenty-five (25) feet of any track. No work of any kind shall be performed, and no person, equipment, temporary structures, machinery, tools, materials, or vehicles shall be located, operated, placed, or stored within twenty-five (25) feet of any railway track at any time, for any reason, unless and until the RAILROAD has given approval of such use and a RAILROAD flagger is available at the job site to provide flagging protection. When it becomes necessary for the RAILROAD to bulletin and assign an employee to a flagging position in compliance with union collective bargaining agreements, the DEPARTMENT, LOCAL AUTHORITY, or Contractor must provide the RAILROAD a minimum of five (5) days' notice prior to the cessation of the need for a flagman. If five (5) days' notice of cessation is not given, the DEPARTMENT or the LOCAL AUTHORITY will be required to pay flagging charges for the five (5)-day notice period required by union agreement to be given to the employee, even though flagging is not required for that period. An additional fifteen (15) days' notice must then be given to the RAILROAD if flagging services are needed again after such five (5)-day cessation notice has been given to the RAILROAD.
4. The work performed by the DEPARTMENT, LOCAL AUTHORITY, or Contractor shall be done at such time and in such manner as not to damage any railway tracks or interfere with (1) the timely and safe movement of the RAILROAD'S trains and on-track maintenance equipment or (2) the installations or operations of the RAILROAD'S tenants, unless mutually agreed upon prior to any such work activity.
5. The RAILROAD reserves the right to stop, by an oral directive followed by a written notice, any DEPARTMENT, LOCAL AUTHORITY, or Contractor activities or operations on RAILROAD property that, at the RAILROAD'S determination, could or is creating an imminent hazard to RAILROAD property or operations. After stopping any activity or operation, the RAILROAD is to notify the DEPARTMENT, LOCAL AUTHORITY, and Contractor in writing of the required modification to activities or operations, along with recommended protective services that will be provided by the RAILROAD to allow Project construction to continue.
6. Work on the job site shall not cease without the RAILROAD'S written consent and subject to such reasonable conditions as the RAILROAD may specify. It is understood that the RAILROAD'S tracks at and in the vicinity of the work will be in use during progress of the work and that movement or stoppage of rail traffic, including track maintenance equipment, may cause delays in the work of the Project. The DEPARTMENT and/or LOCAL AUTHORITY hereby assume the risk of any such delays and agree that no claims for damage on account of any delay shall be made against the RAILROAD.
7. The DEPARTMENT or LOCAL AUTHORITY, at its own expense, shall adequately police and supervise all work to be performed by the Contractor. The responsibility of the DEPARTMENT or LOCAL AUTHORITY for safe conduct and adequate policing and supervision of the Project shall not be lessened or otherwise affected by the RAILROAD'S collaboration in performance of any work, or by the presence at the job site of the RAILROAD'S representatives, or by compliance by the DEPARTMENT or LOCAL AUTHORITY with any requests or recommendations made by such representatives.
8. All Project work shall be performed in compliance with all applicable Federal, DEPARTMENT, and local laws and regulations affecting the Project work, including, without limitation, all applicable Federal Railroad Administration regulations.
9. The DEPARTMENT, LOCAL AUTHORITY, or Contractor shall telephone the RAILROAD during normal business hours (_____, except holidays) at _____ [also include a 24-hour, 7-day number for emergency calls] to determine if fiber optic cable is located within the job site area on RAILROAD property. If there are fiber optic cables on such property, the Contractor will telephone the telecommunications company(ies) involved, arrange for a cable locater, and make arrangements for relocation or other protection of the fiber optics, at Project expense, prior to beginning any work on RAILROAD property.
10. The DEPARTMENT, LOCAL AUTHORITY, and Contractor, at no expense to the RAILROAD, shall provide and maintain suitable facilities for draining the highway and its appurtenances, and shall not suffer or permit drainage

water therefore to flow or collect on property of the RAILROAD. The DEPARTMENT and LOCAL AUTHORITY shall provide adequate passageway for the waters of any streams, bodies of water, and drainage facilities (either natural or artificial, including water from the RAILROAD'S culvert and drainage facilities), so that said waters may not, because of any facilities or work of the Contractor, be impeded, obstructed, diverted, or caused to back up, overflow, or damage the property of the RAILROAD or any part thereof, or the property of others. The Contractor shall not obstruct or interfere with existing ditches or drainage facilities.

11. Upon completion of work, the DEPARTMENT, LOCAL AUTHORITY, and Contractor shall remove from RAILROAD property all machinery, equipment, surplus materials, and rubbish and leave such property in a condition satisfactory to the RAILROAD.
12. The DEPARTMENT, LOCAL AUTHORITY, and Contractor shall remedy any damage to the RAILROAD property and the RAILROAD'S tenants' property caused by itself during Project activities or the failure to perform activities, and in the event the Contractor or its insurance carrier(s) fail to repair or restore the same.
13. Safety of personnel, property, rail operations, and the public is of paramount importance in the prosecution of the work performed by DEPARTMENT, LOCAL AUTHORITY, or Contractor. The DEPARTMENT, LOCAL AUTHORITY, or Contractor shall be responsible for initiating, maintaining, and supervising all safety, operations, and programs in connection with its work on RAILROAD property.
14. The DEPARTMENT and LOCAL AUTHORITY shall protect and hold harmless the RAILROAD and the RAILROAD'S tenants from and against all loss, liability, and damage arising from activities of the DEPARTMENT or LOCAL AUTHORITY on RAILROAD property during and after Project work.
15. The DEPARTMENT and LOCAL AUTHORITY shall provide, without expense to the RAILROAD and the RAILROAD'S tenants, a minimum of $500,000 of liability insurance for bodily or personal injury, death, or property damage or loss as a result of any one occurrence or accident, regardless of the number of persons injured or the number of claimants during Project work.
16. The DEPARTMENT'S or LOCAL AUTHORITY'S contract with the Contractor shall require the Contractor to indemnify, defend, and hold harmless the RAILROAD, its officers, agents, and employees from and against any loss, damages, claims, actions, penalties, fines, costs, and expenses, including, without limitation, court costs and reasonable attorney's fees, which may result from (1) injury to or death of any person, including the RAILROAD'S and Contractor's officers, agents, and employees, as well as any other person, and/or (2) damage to or loss or destruction of property whatsoever, including the RAILROAD'S and the Contractor's property or property in their care or custody or any other property (hereinafter collectively "Loss") when the Loss is due to or arises from the Contractor's work or other acts or omissions on RAILROAD property, except to the extent that the Loss is caused by the sole negligence of the RAILROAD. The RAILROAD shall have the right to file a lawsuit or claim directly against the Contractor in connection with the provisions of this Section.
17. The DEPARTMENT'S or LOCAL AUTHORITY'S Contractor shall not store material or park equipment and vehicles on RAILROAD property when not in use in the Project.
18. The DEPARTMENT or LOCAL AUTHORITY shall ensure that the payment bond(s) it obtains from the Contractor for the Project includes the payment of any mechanic's or materialmen's liens filed by the Contractor against any property of the RAILROAD. If such bonds are not sufficient for such liens to be released, the DEPARTMENT or LOCAL AUTHORITY shall immediately pay off such liens so that such liens are released and not enforced.
19. Any utility lines constructed on RAILROAD property by or under authority of the DEPARTMENT or LOCAL AUTHORITY for the purpose of conveying electric power or communications incidental to the DEPARTMENT'S or LOCAL AUTHORITY'S use of RAILROAD property for highway purposes shall be constructed in accordance with specifications and requirements of the RAILROAD, and in such manner as to not adversely affect any communication or signal lines of the RAILROAD or its licenses now or hereafter located on the property.
20. Before commencing any work on any RAILROAD property, the Contractor will provide the RAILROAD and the DEPARTMENT or LOCAL AUTHORITY with the insurance binders, policies, certificates, and/or endorsements set forth in Exhibit F of this AGREEMENT. All insurance correspondence, binders, policies, certificates, and/or endorsements shall be sent to:

RAILROAD	DEPARTMENT [OR LOCAL AUTHORITY]
Attention: _____	Attention: _____
Address: _____	Address: _____
_____	_____
City: _____ State: _____	City: _____ State: _____

EXHIBIT F

INSURANCE REQUIREMENTS FOR CONTRACTOR
AS SPECIFIED BY RAILROAD

The Contractor shall, at its sole cost and expense, procure and maintain until Project completion the following insurance coverage:

A. **Commercial General Liability** insurance. Commercial general liability (CGL) with a limit of not less than $5,000,000 each occurrence and an aggregate limit of not less than $6,000,000. CGL insurance must be written on ISO occurrence form CG 00 01 12 04 (or a substitute form providing equivalent coverage).
B. **Business Automobile Coverage** insurance. Business auto coverage written on ISO form CA 00 01 (or a substitute form providing equivalent liability coverage), with a limit of not less than $1,000,000 per occurrence.
C. **Workers' Compensation and Employers' Liability** insurance. Coverage must include but not be limited to:
   ☐ Contractor's statutory liability under the workers' compensation laws of the Department of _____ of the State of _____.
   ☐ Employers' Liability (Part B) with limits of at least $500,000 each accident, $500,000 disease policy with a limit of $500,000 per employee.

   If the Contractor is self-insured, evidence of state approval and excess workers' compensation coverage must be provided. Coverage must include liability arising out of the U.S. Longshoremen's and Harbor Workers' Act, the Jones Act, and the Outer Continental Shelf Land Act, if applicable.
D. **Railroad Protective Liability** insurance. The Contractor must maintain Railroad Protective Liability insurance written on ISO occurrence form CG 00 35 12 04 (or a substitute form providing equivalent coverage) on behalf of the RAILROAD as named insured, with a limit of not less than $2,000,000 per occurrence and an aggregate of $6,000,000. This information must be submitted to the RAILROAD before the work may be commenced.
E. **Umbrella or Excess** insurance. If the Contractor utilizes umbrella or excess policies, these policies must "follow form" and afford no less coverage than the primary policy.
F. **Pollution Liability** insurance. Pollution Liability coverage must be included when the scope of the work as defined in the AGREEMENT includes installation, temporary storage, or disposal of any "hazardous" material that is injurious in or upon land, the atmosphere, or any watercourses, or may cause bodily injury at any time.

   Pollution Liability coverage must be written on ISO form Pollution Liability Coverage Form Designated Sites CG 00 39 12 04 (or a substitute form providing equivalent liability coverage), with limits of at least $5,000,000 per occurrence and an aggregate limit of $10,000,000.

   If the scope of work as defined in this AGREEMENT includes the disposal of any hazardous or nonhazardous materials from the job site, the Contractor must furnish to the RAILROAD evidence of pollution legal liability insurance maintained by the disposal site operator for losses arising from the insured facility accepting the materials, with coverage in minimum amounts of $1,000,000 per loss, and an annual aggregate of $2,000,000.

Other Requirements

G. All policy(ies) required above (except workers' compensation and employers' liability) must include the RAILROAD as "Additional Insured" using ISO Additional Insured Endorsements CG 20 26 and CA 20 48 (or substitute forms providing equivalent coverage). The coverage provided to the RAILROAD as additional insured shall, to the extent provided under ISO Additional Insured Endorsements CG 20 26 and CA 20 48, provide coverage for the RAILROAD'S negligence whether sole or partial, active or passive, and shall not be limited by the Contractor's liability under any indemnity provisions under which the Contractor is to indemnify the RAILROAD under this Project.

   The Contractor shall not assign or subcontract its contract with the DEPARTMENT or LOCAL AUTHORITY for this Project, or any interest therein, without the written consent of the DEPARTMENT or LOCAL AUTHORITY. The Contractor shall be responsible for the acts and omissions of all subcontractors. Before the Contractor commences any work, the Contractor shall, except to the extent prohibited by law: (1) require each of its subcontractors to include the Contractor as "Additional Insured" in the subcontractor's Commercial General Liability and Business Automobile policies with respect to all liabilities arising out of the subcontractor's performance of work on behalf of the Contractor by endorsing these policies with ISO Additional Insured Endorsements CG 20 26 and CA 20 48 (or substitute forms providing equivalent coverage); (2) require each of its subcontractors to endorse the subcontractor's Commercial General Liability Policy with Contractual Liability—Railroads, ISO form CG 24 17 10 01 (or a substitute form providing equivalent coverage), for the job site; and (3) require each of its subcontractors to endorse the subcontractor's Business Automobile Policy with Coverage for Certain Operations in Connection with Railroads, ISO form CA 20 70 10 01 (or a substitute form providing equivalent coverage), for the job site.
H. Punitive damages exclusion, if any, must be deleted (and the deletion indicated on the certificate of insurance), unless (1) insurance coverage may not lawfully be obtained for any punitive damages that may arise under this agreement or (2) all punitive damages are prohibited by all states in which this agreement will be performed.

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I. The Contractor waives all rights against the RAILROAD and its agents, officers, directors, and employees for recovery of damages to the extent these damages are covered by the workers' compensation and employers' liability or commercial umbrella or excess liability insurance obtained by the Contractor as required by this AGREEMENT.

J. Prior to commencing the work, the Contractor shall furnish the RAILROAD with a certificate(s) of insurance, executed by a duly authorized representative of each insurer, showing compliance with the insurance requirements in this AGREEMENT.

K. All insurance policies must be written by a reputable insurance company acceptable to the RAILROAD or with a current Best's Insurance Guide Rating of A- and Class VII or better, and authorized to do business in the State of _____.

L. The fact that insurance is obtained by the Contractor will not be deemed to release or diminish the liability of the Contractor, including, without limitation, liability under the indemnity provisions of this MASTER AGREEMENT. Damages recoverable by the RAILROAD from the Contractor or any third party will not be limited by the amount of the required coverage.

M. Nothing in this AGREEMENT is intended to be construed as a requirement for an indemnification against the sole negligence of the RAILROAD, its officers, employees, or agents. Moreover, for any work performed in the State of _____, the DEPARTMENT will require its contractor to indemnify the RAILROAD and any other railroad company occupying or using the RAILROAD'S right-of-way or line of railroad against all loss, liability, and damages, including environmental damages, hazardous materials damages, penalties, or fines that may be assessed for, caused by, or the result of the contractor's negligence; provided, however, that if such loss, liability, damage, penalties, or fines are caused by or result from the concurrent negligence of (a) the RAILROAD or the RAILROAD'S officers, employees, or agents and (b) the DEPARTMENT'S contractor or the contractor's employees, agents, or subcontractors, such indemnity shall be valid and enforceable only to the extent of the negligence of the DEPARTMENT'S contractor or the contractor's employees, agents, or subcontractors. Likewise, if such loss, liability, damage, penalties, or fines are caused by or result from the concurrent negligence of (a) the RAILROAD or the RAILROAD'S officers, employees, or agents and (b) the DEPARTMENT officers, employees, or agents, such indemnity shall be valid and enforceable only to the extent of the negligence of the DEPARTMENT'S officers, employees, or agents.

PRELIMINARY DOCUMENT
NOT FOR RELEASE PURSUANT TO 23 U.S.C. SECTION 409

OFFICE USE ONLY

MINIMUM WARNING TIME
20 seconds Minimum Time (MT)
seconds Clearance Time (CT)
seconds Minimum Warning Time (MWT)
seconds Buffer Time (BT)
seconds Equipment Response Time (ERT)
seconds Advance Traffic Signal Preemption Time (APT)
seconds TOTAL APPROACH TIME

_____ Average Daily Traffic (ADT)
_____ Special Vehicle moves
_____ MPH

_____ through trains at _____ mph per day
_____ switch moves at _____ mph per day

Salvaged equipment: ☐ **YES** ☐ **NO**

Total estimated cubic yards of fill material:

☐ This project is actual cost for reimbursement of payment to the Railroad Company as agreed to by:
☐ This project is lump sum cost for reimbursement of payment to the Railroad Company as agreed to by:

TxDOT: _____ Railroad Company: _____

☐ Existing cross bucks meet TMUTCD guidelines
☐ Existing cross bucks do not meet TMUTCD guidelines and need to be ☐ replaced ☐ repaired. If replacement or repair is needed the railroad company or its contractor will make necessary arrangements, within 30 days of diagnostic
Notify TRF/RR when discrepancies are correct

☐ RxR pavement markings are to be installed, per the guidelines in the TMUTCD
☐ No RxR pavement markings are to be installed because
☐ Stop bars are to be installed, per the guidelines in the TMUTCD
☐ No stop bars are to be installed because

☐ Side lights are to be installed at this location. (Crossing is 50 feet or less from the parallel roadway)
☐ No side lights will be installed at this location. (Crossing is greater than 50 feet from the parallel roadway)

☐ AC power service is available at this location
☐ AC power service is not available at this location

☐ A signalized intersection is located _____ ft from crossing. Distance measured from the warning device to the edge of road/shoulder.
Attach copy of the preemption form
☐ No signalized intersection at this location

☐ Letter to proceed with project development was given to the Railroad Company
☐ No letter to proceed with project development was given to the Railroad Company because

☐ No yield or stop signs are to be installed by the State because
☐ Yield signs were recommended by the diagnostic team on an interim basis, per the guidelines in the TMUTCD. The local road authority ☐was notified at Diagnostic . ☐ will be notified in writing. Yield signs to be installed within 30 days of diagnostic.
Notify TRF/RR when signs are installed

☐ Stop signs were recommended by the diagnostic team on an interim basis, per the guidelines in the TMUTCD. The local road authority ☐was notified at Diagnostic. ☐ will be notified in writing. Stop signs to be installed within 30 days of diagnostic.
Notify TRF/RR when signs are installed

☐ Memo to install signs given to the district

DIAGNOSTIC TEAM

PROJECT INFORMATION

COUNTY: _____
DOT No.: _____
CONTROL: _____
PROJECT: _____
LOCATION: _____

RAILROAD: _____
MILEPOST: _____

Date of Inspection: _____
Date Layout Due: _____

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PRELIMINARY DOCUMENT
NOT FOR RELEASE PURSUANT TO 23 U.S.C. SECTION 409

GENERAL NOTES

1. Signal circuits are designed to give 20 seconds Minimum Warning Time prior to the arrival of the fastest train at this crossing. Refer to signal circuit layout for total approach time.
2. ☐ **Constant warning** ☐ **Phase motion** ☐ **C Style /AC-DC**_____ circuits are to be used at this location. Upgrades required; _____ for circuit compatibility.
3. Conduit, fill dirt and crushed cover rock to be furnished in place by the Railroad Company or its Contractor at state's expense.
4. The Railroad Company or its Contractor will remove the existing ☐ **cross bucks** ☐ **mast flashers** ☐ **cantilevers** and dispose of the foundations.
5. The State or its Contractor will furnish and install or replace the appropriate pavement markings as outlined on the attached layout and standard sheet and in accordance with the guidelines in the Texas Manual on Uniform Traffic Control Devices.
6. The State or its Contractor will furnish and install or replace the following signs in accordance with the guidelines in the Texas Manual on Uniform Traffic Control Devices (TMUTCD) and the Standard Highway Sign Designs Manual for Texas(SHSD):_____ea.(**W10-1**),_____ea.(**W10-2**),_____ea.(**W10-3**),_____ea.(**W10-4**),_____ea.(**R15-4**). Additional signs to be added._____
7. The ☐ **State** ☐ **County** ☐ **City** agrees to maintain the pavement markings and advance warning signs placed along the roadways under their jurisdiction in accordance with the guidelines in the Texas Manual on Uniform Traffic Control Devices and as shown on the layout and standard sheets as acknowledged on the Title Sheet.
8. The Railroad Company or its Contractor shall furnish, install and maintain sign mounting brackets for the report sign (R15-4) at the States expense.
9. The Railroad Company or its Contractor shall stencil the DOT-AAR numbers on the signal masts facing the adjacent roadway in 2" black lettering.
10. The ☐ **State** ☐ **County** ☐ **City** agrees to trim and maintain trees and vegetation for adequate visibility of the crossing signals and advance warning signs as acknowledged on the Title Sheet.
11. The Railroad Company or its Contractor will provide traffic control in accordance with the guidelines in the Texas Manual on Uniform Traffic Control Devices.
12. The ☐**State** ☐**Railroad Company** or its Contractor will install metal beam guard fence as shown on the layout, at the ☐ **State's** ☐ **Railroads** expense.
13. The ☐ **State** ☐ **Railroad Company** or its Contractor will install retaining wall as shown on the layout, at the ☐ **State's** ☐ **Railroads expense**.
14. The Railroad or its Contractor will furnish and install a relay to provide ☐ **simultaneous** ☐ **advance preemption** to ☐ **existing traffic signal** ☐ **proposed traffic signal** ☐ **advance flasher**. Normally a closed circuit is required between the control relay of the grade crossing warning device and the traffic signal controller or flasher as stated in the Texas Manual on Uniform Traffic Control Devices.

W10-1


W10-2


W10-3


W10-4


R15-4

R15-2

R8-8

ADDITIONAL NOTES

DESCRIPTION OF PROJECT

_____ Complete gate assemblies with _____ gate arm
_____ Complete cantilever assemblies with _____ foot arm
_____ Ea. R15-2, (_____ Tracks)

12" lamp housing shall be used and equipped with LED's (light emitting diodes), operated at not less than 8.5 volts under normal operating conditions.

Source: Texas Department of Transportation.

For More Information:

Visit http://safety.fhwa.dot.gov

FHWA, Office of Safety

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FHWA-SA-12-020