SYSTEMS ENGINEERING FUNCTIONAL REQUIREMENTS

for:

RAILROAD-HIGHWAY GRADE CROSSING

MINNESOTA DEPARTMENT OF TRANSPORTATION

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1.0 SCOPE OF APPLICATION PACKAGE

This document provides ***Functional Requirements*** (*FR*) for various types of active grade crossing protection that may apply to this project. Please see the corresponding *Minnesota Statewide Regional ITS Architecture and Systems Engineering Checklist* (*Checklist)* for the project to identify which specific types apply and other pertinent site details. Regardless of the types, all active protection grade crossings include the *FR* for the flashing-light signals (item .1). Following are the name and numbering identifiers for the various protection types:

.1 – Flashing-Light Signals (FLS, common to all forms of active protection)
.2 – Cantilever Flashing-Light Signals (CFL)
.3 – Standard Railroad Gates (SRG)
.4 – Four Quadrant Gates (FQG)
.5 – Traffic Signal Preemption (TSPr)
.6 – Other

The *FR* are categorized by the above protection types. Illustrations of these are provided in the corresponding *Concept of Operations* document.

1.1 Railroad Flashing-Light Signals (FLS)

Basic FLS consist of:

- A pole with "RAILROAD CROSSING" crossbuck sign at the top
- A pair of red flashing lights mounted in a horizontal line that flash in alternating sequence.

FLS are always included with both versions of gates (SRG and FQG) as well. They are generally post-mounted, but where improved visibility to approaching traffic is required, CFL are used. The FLS are activated by the approach of a train that closes a track circuit. With constant warning protection, the equipment is configured such that the time that the flashers are activated until the arrival of the train is fairly constant, based on calculations of train approach speed. With variable warning protection, the flasher activation time before train arrival changes as a function of the speed of the approaching train. With either mode, flashing operation continues until the train or trains fully clear the grade crossing area. Ideally the crossing protection equipment is monitored by both a rail operations center and a road MCM center for an alarm in case of a device failure.

1.2 Railroad Cantilever Flashing-Light Signals (CFL)

CFL are essentially the same functionally as FLS except that the flashing-light signals are suspended over the approach roadway to increase conspicuity. Post-mounted FLS are typically also installed. CFL may be appropriate when any of the following conditions exist:

- Multilane highways (two or more lanes in one direction).
- Highways with paved shoulders or a parking lane that would require a post-mounted light to be more than 10 feet from the edge of the travel lane.
- Roadside foliage obstructing the view of post-mounted flashing light signals.

- A line of roadside obstacles such as utility poles (when minor lateral adjustment of the poles would not solve the problem).
- Distracting backgrounds such as an excessive number of neon signs (conversely, cantilevered flashing lights should not distract from nearby highway traffic signals).
- Horizontal or vertical curves at locations where the extension of flashing lights over the traffic lane will provide sufficient visibility for the required stopping sight distance.

1.3 Standard Railroad Gates (SRG)

SRG are the common active protection devices at grade crossings in urban and suburban areas across the US. The gates include flashing red lights that are activated at the same time that the post-mounted flashing lights are activated. Sometimes a median is also constructed to prevent drivers from trying to "beat the train" by driving around lowered gates, an obviously dangerous maneuver.

1.4 Four Quadrant Railroad Gates (FQG)

FQG are the same in function as SRG but with the added protection on the departing, or exit, side of grade crossing approaches for more positively discouraging gate running by drivers. There is a need to delay the times the gates on the departing side come down to avoid trapping vehicles in the grade crossing area because of the downstream gates. Some sites use detection in the grade crossing area to control exit gate operation (dynamic exit gate operating mode). Design of FQG timing must be carefully considered to implement the best possible protection.

1.5 Traffic Signal Preemption (TSPr)

When railroad-highway grade crossings are in near proximity to traffic signals, the two systems are directly connected so that the highest possible level of grade crossing protection is provided. The application scope here is heavy rail, i.e., operations in which the train can not be expected to stop in time to avoid a collision with an object on the grade crossing. The approach of a train near a TSPr signal thus always preempts normal signal operation to clear the crossing and avoid a collision.

The operational mode as described in Section 1.1 critically affects traffic signal clearance timing. With constant warning time, traffic signal clearance timing must be related to the specific warning time for activating crossing protection. In the mode with non-constant warning time, the variable detection time of the train relative to when it reaches the crossing must be factored into site design and subsequent signal timing. Control logic must clear vehicles, bicyclists, and pedestrians off the railroad tracks by special pre-emption phasing and timing. Signal operation with preemption may also include turning signals further downstream of a crossing to green to allow queued vehicles to leave the crossing area.

1.6 Other

[Reserved for new grade crossing features and their characteristics. Please consult with appropriate Mn/DOT, FHWA, or local staff to develop needed scope description.]

2.0 REFERENCE DOCUMENTS

See *ConOps* Section 2. To that list add:
National ITS Architecture, V 6.1, http://www.iteris.com/itsarch/index.htm

3.0 FUNCATIONAL REQUIREMENTS AND VERIFICATION METHOD

Table 1 lists the pertinent Functional Requirements including Verification Method. Table 2 maps the ITS Needs and Services that were identified in the companion *ConOps* document for each feature (Table 2 of that document) to the *FRs* identified here, for traceability from the *ConOps* to the *FRs*.

4.0 SUPPORTING DOCUMENTATION

See associated *Checklist* for additional support documents.

Table 1 Functional Requirements for Grade Crossing Protection

ID	Functional Requirement	Verification Method*	Comments
GCP-FLS	*Railroad Flashing-Light Signals*		
GCP-FLS-1	The field element shall close the railroad-highway grade crossing when a train is approaching with enough time for travelers to safely clear the crossing using post-mounted flashing-light signals at a minimum, plus other devices as specified in the plans.	I, D	
GCP-FLS-2	The activation of the flashing-light signals shall be coordinated with the approaching train message from the track circuit to provide adequate warning in advance of train arrival at the crossing.	I, D	
GCP-FLS-3	The activation timing shall provide either constant warning time or variable warning time in accordance with the plans.		
GCP-FLS-4	Active grade crossing protection shall be in effect until the train(s) leave the grade crossing area.	I, D	
GCP-FLS-5	To the maximum extent possible, active grade crossing protection shall use fail-safe design and operations principles.	I, D	
GCP-FLS-6	The field element shall monitor the status of the railroad-highway grade crossing equipment, including the current state, mode of operation, equipment condition, and failure alarms. This information shall be forwarded to the rail wayside equipment.	I, D	

* D - Demonstration
T - Test
A - Analysis
I - Inspection

Table 1 Functional Requirements for Grade Crossing Protection (continued)

ID	Functional Requirement	Verification Method*	Comments
Railroad Flashing-Light Signals (cont.)			
GCP-FLS-7	When specified in the plans, the field element shall transmit current state, mode of operation, equipment condition, and failure alarms to the rail operations center. This may include the current status of the tracks, whether a train is approaching, and how long the crossing will be closed.	I, D	
GCP-FLS-8	When specified in the plans, the field element shall transmit current state, mode of operation, equipment condition, and failure alarms to the traffic management center. This may include the current status of the tracks, whether a train is approaching, and how long the crossing will be closed.	I, D	
GCP-FLS-9	When specified in the plans, the field element shall control dynamic message signs (DMS) and other traveler information devices in the vicinity of the railroad-highway grade crossing to advise drivers, bicyclists, and pedestrians of approaching trains.	I, D	
GCP-FLS-10	When specified in the plans, the field element shall determine whether the railroad-highway grade crossing is blocked by traffic in the roadway or by some other obstruction, then notify the traffic management center and/or the rail operations center.	I, D	
GCP-FLS-11	When specified in the plans, the traffic management center and/or the rail operations center shall archive status data received on railroad-highway grade crossing equipment, including state, mode of operation, equipment condition, and failure alarms.	I, D	

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Table 1 Functional Requirements for Grade Crossing Protection (continued)

ID	Functional Requirement	Verification Method*	Comments
Railroad Flashing-Light Signals (cont.)			
GCP-FLS-12	When specified in the plans, the field element shall collect pedestrian images and pedestrian sensor data, and respond to pedestrian crossing requests via display, audio signal, or other manner.	I, D	
GCP-CFL	*Railroad Cantilever Flashing-Light Signals*		
GCP-CFL-1	When specified in the plans, the field element shall close the railroad-highway grade crossing when a train is approaching with enough time for travelers to safely clear the crossing using cantilever-mounted flashing-light signals. Post-mounted flashing-light signals shall also be provided when also specified in the plans.	I, D	
GCP-SRG	*Standard Railroad Gates*		
GCP-SRG-1	When gates are specified in the plans, the field element shall close the railroad-highway grade crossing when a train is approaching with enough time for travelers to safely clear the crossing using approach side gates in addition to flashing-light signals.	I, D	
GCP-SRG-2	When specified in the plans, pedestrian gates shall be included in addition to vehicle gates.	I, D	
GCP-SRG-3	The lowering of the gates shall be coordinated with, and follow, the initiation of flashing-light signal activation.	I, D	

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Table 1 Functional Requirements for Grade Crossing Protection (continued)

ID	Functional Requirement	Verification Method*	Comments
GCP-FQG	*Four Quadrant Railroad Gates*		
GCP-FQG-1	When four quadrant gates are specified in the plans, the field element shall close the railroad-highway grade crossing when a train is approaching with enough time for travelers to safely clear the crossing using approach side and exit side gates, in addition to flashing-light signals.	I, D	
GCP-FQG-2	The lowering of the exit side gates shall lag the lowering of the approach side gates to allow vehicles to safely clear the grade crossing area.	I, D	
GCP-TSPr	*Traffic Signal Preemption*		
GCP-TSPr-1	When Traffic Signal Preemption is shown in the plans, the field element shall close the railroad-highway grade crossing when a train is approaching with enough time for travelers to safely clear the crossing by preempting adjacent traffic signals with prescribed sequencing and timing.	I, D	
GCP-TSPr-2	Preemption shall be in addition to other active grade crossing protection.	I, D	
GCP-TSPr-3	When specified in the plans, the field element shall support the integrated control of adjacent traffic signals to clear an area in advance of an approaching train and to manage traffic around the grade crossing.	I, D	
TS-Oth	*Other*		
TS-Oth-1	*[Develop as appropriate]*		

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Table 2 Mapping of Grade Crossing Protection Needs/Services to Functional Requirements

Feature	Needs/Services		ITS Functional Requirements
Railroad Flashing-Light Signals	TM28	Provide railroad flashing light signals and gates	GCP-FLS-1 thru -5, -9 thru -12
	TM38	Provide health monitoring of rail crossings	GCP-FLS-6 thru -8
Railroad Cantilever Flashing-Light Signals	TM28	Provide railroad flashing light signals and gates	GCP-CFL-1
Standard Railroad Gates	TM28	Provide railroad flashing light signals and gates	GCP-SRG-1 thru -3
Four Quadrant Railroad Gates	TM28	Provide railroad flashing light signals and gates	GCP-FQG-1, -2
Traffic Signal Preemption	TM28	Provide railroad flashing light signals and gates	GCP-TSPr-1 thru -3
Other		*[Develop as appropriate.]*	

Needs/Services per *Minnesota Statewide Regional ITS Architecture* (March 2009)

Needs/Services Key:
TM - Traffic Management

See Table 1 for Functional Requirements content.