METROLINX

GO Transit Signals and Communications – Signal Design Manual

RC-0506-03SIG-03

Revision 02
May 2025

Signal Design Manual
RC-0506-03SIG-03

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Preface

This is the third edition of the Signal Design Manual. This edition includes updates to reflect current signalling best practices and lessons learned from previous signalling projects. Changes of note include the addition of correlation requirements and a new section for gas distribution and snow clearing device design. It also includes requirement updates to the Centralized Traffic Control (CTC) signal system and signalling system hardware and software requirements.

The document specifies the wayside Signalling System design requirements for use by design contractors carrying out the design activities for the GO Transit Signal and Train Control system. It is intended for suitably qualified professionals familiar with the subject matter. This document is not a substitute for all applicable local codes, standards and manuals.

This document was developed by the Signals & Communications Office, Asset Management and Maintenance Division, Metrolinx.

Suggestions for revision or improvements can be sent to the Metrolinx Signals and Communications office, Attention: Director of Signals and Communications Engineering, who shall introduce the proposed changes to the Metrolinx Signals and Communications Engineering office. The Director of the Signals and Communications Engineering office ultimately authorizes the changes. Submitted suggestions should include a description of the proposed change, background of the application and any other useful rationale or justification. The submitter's name, company affiliation (if applicable), e-mail address, and phone number must also be included.

May 2025

Revision	Date	Comments
0	June 2020	Initial release
1	February 2021	Revised signal downgrade, local control panel & miscellaneous requirements
2	May 2025	Updated formatting, general updates, and signal fleeting function

CONTENTS

1. Introduction

1.1 Purpose

1.1.1 This Signal Design Manual provides the design guidelines to be applied for the Signalling System in Metrolinx Territory. The Signalling System includes a Centralized Traffic Control (CTC) Signal System, Grade Crossing Warning System (GCWS), Defect Detection System, Data Communication System and Power Supplies. CTC Signal System includes Controlled Locations, intermediate signals, cut sections and hand throw switches with or without electric lock.

1.1.2 This document is not intended as a comprehensive design specification nor a detailed instruction manual for untrained personnel. It is intended to be used by staff and contractors who are experienced in the conceptual design, preliminary design, detailed design, installation, testing and commissioning, operation and maintenance of Signalling Systems.

1.1.3 Signalling System design contractors shall follow the design guidelines herein in conjunction with the standards, rules and regulations defined in Section 2 of this manual.

1.1.4 This Signal Design Manual will be revised in the future to accommodate new technologies that become available for deployment in the Metrolinx Territory.

2. Regulations and Standards

2.1 Canadian Rail Operating Rules

2.1.1 Railway Operations are governed by the Canadian Rail Operating Rules (CROR) as contained within the Metrolinx Rail Corridors Operating Manual.

2.1.2 The System design and the functions shall not violate the Metrolinx Rail Corridors Operating Manual nor prevent train operations per the Metrolinx Rail Corridors Operating Manual.

2.2 Canadian Legislation and Transport Canada

2.2.1 Signalling System shall comply with the Canadian Legislative Acts and Regulations and Transport Canada (TC) federal regulations, to the extent applicable, including:

a) Railway Signal & Traffic Control System standards (TC E-17);

b) Liquefied Petroleum Gases Bulk Storage Regulations (No. 0-31)(C.R.C., c. 1152);

c) Wire Crossings and Proximities Regulations (No. E-ll)(C.R.C., c. 1195);

d) Canadian Rail Operating Rules;

e) Standards Respecting Pipeline Crossings Under Railways (TC E-10); and

f) Standard Respecting Railway Clearance (TC E-05).

2.2.2 These standards apply to railway companies subject to the jurisdiction of the Minister of Transport pursuant to the Railway Safety Act (RSA).

2.3 Railway Safety Act

2.3.1 Metrolinx railway systems and operations shall comply with the Railway Safety Act (RSA).

2.3.2 An overview of the RSA, as well as a detailed copy of the act, is available on the Transport Canada website: https://laws-lois.justice.gc.ca/eng/acts/R-4.2/.

2.4 American Railway Engineering & Maintenance of Way Association

2.4.1 Signalling System shall comply with the AREMA C&S Manual, unless there is a conflict with the following, which shall take precedence: federal, provincial or municipal laws and regulations.

2.5 Grade Crossing Regulations, Standards and Guides

2.5.1 Signalling System shall comply with the following regulations, standards and guides that define requirements for the design, installation, testing and maintenance of the warning devices at Grade Crossings:

a) Grade Crossing Regulations (SOR-2014-275);

b) Grade Crossing Standards;

c) Engineering Standards for Grade Crossing Warning Systems Used at Restricted Grade Crossings (TC E-52);

d) Engineering Standards for "Walk Light" Grade Crossing Warning Systems (TC E-39);

e) Minimum Railway/Road Crossing Sightline Requirements for all Grade Crossings without Automatic Warnings Devices G4-A;

f) AREMA C&S Manual Section 3 – Highway-Rail Grade Crossing Warning Systems;

g) Transport Canada Standard for LED Signal Modules at Highway/Railway Grade Crossings (TC E-14);

h) Manual of Uniform Traffic Control Devices (MUTCD) for Canada;

i) Grade Crossing Handbook;

j) Canadian Road/Railway Grade Crossing Detailed Safety Assessment Field Guide; and

k) Guideline For Inspecting and Testing Pre-emption of Interconnected Traffic Control Signals and Railway Crossing Warning Systems TP 13755 (ISBN T33-11/2001 0-662-65823-X).

2.6 GO Transit Signals & Communications Standards

2.6.1 The Signalling System shall comply with the GO Transit Signals and Communications Standards, with the latest version available at:

https://www.metrolinx.com/en/metrolinx-technical-standards

2.6.2 Where a rule or instruction conflicts with a law or regulation issued by a government body having jurisdiction, the statute or regulation will take precedence over the rule or instruction.

2.6.3 The GO Transit Signals & Communications Standards comprise the following:

a) RC-0506-03SIG-01 Codes of Practice;

b) RC-0506-03SIG-02 General Instructions;

c) RC-0506-03SIG-03 Signal Design Manual (this document);

d) RC-0506-03SIG-04 Signal Sighting Distance Design Standard;

e) Specification 34 42 01 Aluminum House Specification;

f) Specification 34 42 02 Wayside LED Signal Module Specification;

g) Specification 34 42 03 Wayside Signal Structure Specification;

h) Specification 34 42 04 Overhead Signal Structures Specification; and

i) Specification 34 42 05 Hot Air Switch Clearing Device Specification.

2.6.4 Signalling System drawings and documentation shall comply with MX-ALM-STD-004 -Metrolinx CADD/BIM Standards Manual.

2.6.5 Signalling System shall comply with the GO Transit Track Standards, RC-0506-02TRK.

2.7 Canadian Electrical Code

2.7.1 AC distribution equipment, such as power services, isolation transformers, breaker boxes, utility plugs, bungalow lights, light switches, etc., shall be provided in compliance with Canadian Electrical Code (CEC) Part I.

2.7.2 Additional guidelines to be followed are provided in the AREMA C&S Manual Section 11.1.5 Recommended Guidelines for the Application of the National Electrical Safety Code (NESC) and the National Electrical Code (NEC) to Railway Signal Facilities.

2.8 Union Station Rail Corridor

2.8.1 The USRC project has developed a Manual of Standard Signalling Principles (MSSP), which is a compilation of the high-level design concepts associated with the USRC Signalling System.

2.8.2 The MSSP contains an abstract level definition of each of the fundamentals of signalling controls, interlocks, rules, regulations, codes of practice and Good Industry Practice.

2.8.3 The MSSP shall be used as the basis of design and modification for the Signalling System deployed in the USRC.

2.9 Non-Standard Design

2.9.1 Where the Signalling System must deviate from GO Transit Signals & Communications Standards or AREMA C&S Manual, the design contractor shall follow the Procedure for Requesting Deviations to Metrolinx Standard Technical Requirements (CKH-ENG-PRC-001_Deviation).

a) Design contractor shall produce detailed requirements for any non-standard design. The requirements shall be verified and validated throughout the project life cycle, including design, installation, testing and commissioning. Any special instructions for maintenance and operations shall be clearly defined.

b) Design contractor shall follow AREMA C&S Manual, Part 17.3.1, Recommended Safety Assurance Program for Electronic/Software Based Products Used in Safety-Critical (Vital) Applications to ensure that any design used in vital applications is safe throughout the Signalling System life cycle.

3. Document Control and Drafting Requirements

3.1 Enterprise Document Record Management System (EDRMS)

3.1.1 EDRMS is a web-based system that provides an environment that Metrolinx adopts to advance projects in a consistent and efficient manner.

3.1.2 EDRMS currently supports the following activities:

a) Storage and transfer of CADD and PDF files; application software; executive software; service bulletins, manuals, etc.;

b) Storage and transfer of hardware configuration and asset information; and

c) Maintenance and distribution of all documentation.

3.1.3 Documents are managed by the Metrolinx Signals and Communications Office.

3.1.4 CADD files will be maintained by both the design contractor and Metrolinx.

3.2 File Designations

3.2.1 The design contractor shall comply with the Rail Corridors Document and Record Management System, Capital Projects group Rail Corridor Document Management – CKH –ASMT-PRC-004 (RC-0701-02), which defines the various metadata fields used in Rail Corridors' Document Register and associated file naming structures.

a) Follow the file designations defined in this section for Signalling System documentation.

3.2.2 All documentation for the Signalling System shall be named using the following format, where the naming segments are further detailed in subsequent subsections:

a) Subdivision – Mileage – Discipline – Content Type – Sub Content Type – Additional Info

3.2.3 Subdivision abbreviations shall follow Table 01 below.

Table 01: Subdivision Abbreviation

Subdivision	Abbreviation
All	ALL
Bala	BA
Belleville	BEL
Canpa	CA
Fergus	FR
Galt	GA
GO	GO
Grimsby	GR

Subdivision	Abbreviation
Guelph	GPH
Halton	HAL
Hamilton	HAM
Highbury	HB
Kingston	KN
Mactier	MT
Newmarket	NM
Oakville	OA
Pearson	PER
USRC East	USRC
USRC West	USRC
Uxbridge	UX
Weston	WN
Pearson	PE
Whitby Rail Maintenance Facility	WRMFE
Willowbrook Rail Maintenance Facility	WRMFW

3.2.4 [Mileage] shall reflect the milepost of the primary signal location to the nearest 1/100th of a mile, with 5 fixed characters. For example,at a location with a milepost of 6.10, the mileage shall be 00610.

a) For Route and Aspect charts and Track Layout plans, both of which include a range of mileage, the boundaries of the mileage range shall be defined, such as 31610-31853.

3.2.5 [SIG] is the default mnemonic, used universally for Signalling System documents.

3.2.6 The categories defined in Tables 02 through 06 shall be followed for Signalling System documents.

Table 02: Category 1

Type	Mnemonic	Remarks
Design & Calculations	DC	
Drawings	DWG	
Software	SOF	

Table 03: Category 2

Type	Mnemonic	Remarks
Centralized Traffic Control (Interlocking)	CTC	
Intermediate	INT	
Grade Crossing Warning System	XING	
Route and Aspects	R&A	
Track and Signal Layout	TL	
Cut Section	CS	
Electric Lock	EL	
Hand Throw Switch	HT	
Communication	COM	
Communication - Fibre Optics	FIB	
Communication - Radio Tower	RTR	
Power and Electrical	PWR	Including AC power supply to the S&C System
Snow Clearing Device	SCD	
Wayside Inspection System	WIS	
High Water Detection	HWD	
Ballast Integrity Systems	BIS	
Wheel Impact Load Detector	WILD	

Table 04: Category 3 (Optional)

Type	Mnemonic	Remarks
CADD Files	CADD	Applicable to design drawings
PDF Files	PDF	Applicable to design drawings
Southward or Eastward direction	SW or EW	Applicable to R&A Chart
Northward or Westward direction	NW or WW	Applicable to R&A Chart

Table 05: Category 4

Type	Mnemonic	Remarks
Page Number (3 digits)	001, 002, 003, etc.	Applicable to design drawings

Table 06: Category 5

Type	Mnemonic	Remarks
Revision (typically 1-2 digits)	R0, R1, R2, R3, …	Applicable to design drawings

3.2.7 File Designation Principles and Examples:

a) The circuit plan file name designates the line and the milepost location, to the nearest 100th of a mile. For example, using KN-31610-SIG-DW-CTC-CADD:

   i. The prefix "KN" designates the line, Kingston Subdivision;

   ii. The location is at milepost 316.10, rounded to the nearest 100th, which is 10;

   iii. "SIG" designates that the file belongs to the signal system;

   iv. “DW” designates that the file is a drawing, rather than software (SW) or Design Calculations (DC);

   v. “CTC” designates the locations as a CTC Control Point; and

   vi. “CADD” indicates that it is a CADD file. Files extensions are designated according to the type of plan.

b) All CADD files, as well as related project files, pertaining to one project and one asset shall be zipped together and uploaded to EDRMS as a single file with the same mnemonic as the PDF copy of the drawing, but with the designation “CADD” added at the end of the document number. The CADD copy will always be secured using the “confidential” feature in EDRMS.

   i. Example: KN-31610-SIG-DW-CTC-CADD, for Kingston sub, Milepost 316.10, drawing, CTC location, CADD files.

c) Individual CADD Files:

   i. Each CADD file for the location shall be given a unique name.

   ii. Example: KN-31610-SIG-DW-CTC-CADD-012-R2, for Kingston sub, Mile 316.10, CTC location, CADD file, page 12, revision 2.

d) Software:

   i. Software includes application software, programmed and compiled by the design contractor, and executive/boot software, provided by equipment suppliers. Metrolinx manages the latest version of the executive/boot software along with the supplier.

   ii. It is the responsibility of the design contractor to incorporate the Metrolinx-approved executive/boot software within the design, which shall be reflected in the Program Configuration design.

iii. Executive/boot software names shall not be changed.

iv. Application software includes vital and non-vital software, categorized into site-specific and typical applications.

v. Example: KN-31610-SIG-SW-CTC-VR2 - Kingston sub, Mile 316.10, CTC location, Application software, Vital (V), revision 2.

vi. Example: KN-31610-SIG-SW-CTC-C1VR2 - Kingston sub, Mile 316.10, CTC location, Application software, Chassis 1, Vital, revision 2.

vii. Example: KN-31610-SIG-SW-CTC-NVR2 - Kingston sub, Mile 316.10, CTC location, Application software, Non-Vital (NV), revision 2.

viii. Example: KN-31610-SIG-SW-INT-VR2 - Kingston sub, Mile 316.10, Intermediate Signal location, Application software, Vital, revision 2.

ix. Example: KN-31610-SIG-SW-INT-C2VR2 - Kingston sub, Mile 316.10, Intermediate Signal location, Application software, Vital, Chassis 2, revision 2.

e) Design contractor shall propose and submit the file designation to Metrolinx for advance review and approval, if unable to comply with the principles defined in this section.

3.3 Drafting Requirements

3.3.1 General Requirements

a) Drawings shall conform to the Metrolinx CADD/BIM Standards Manual MX-ALM-STD-004.

b) AutoCAD software shall be used to generate drawings and save them in the version format identified in the Metrolinx CADD/BIM Standards Manual MX-ALM-STD-004.

c) Symbols used to show signal infrastructure on drawings shall comply with the AREMA C&S Manual.

d) Design contractor shall provide CADD files to Metrolinx for each drawing sheet, including reference files.

e) Standard drawing size shall be printable on 11” X 17” paper.

f) All drawing content shall be legible. Design notes shall be used as necessary, but should be kept to a minimum.

g) Plans shall include the note "Field to verify" if appropriate.

h) Signalling System configurations and code system configurations shall be shown on the drawings for all equipment and programming configuration sheets prior to issuing to the field.

i) Plans and design sketches shall be oriented so that the west or north is on the left and the east or south is on the right.

j) Design drawings shall have an index page including drawing and sheet number, description, and revision & date column that shows the revision & date of each page.

k) Design drawings shall have a revision date on each page.

l) All circuits that are continued from one sheet to another shall reference the connecting sheet number and circuit nomenclature.

m) Circuits shall completely show tie-ins with foreign railroads. (e.g., do not use notes such as "shown on foreign railroad plan number XXXX" without including the appropriate foreign railroad design sheets within Metrolinx design).

n) Gauge of wires on the circuit plan shall be clearly defined.

o) Circuit plan shall show the designation of the wire to be connected, and never leave the decision to the field installation personnel.

p) In the case where updates are required for at least one sheet in an existing drawing set, the title blocks and compliance with current Metrolinx standards are required only for the sheets being updated.

3.3.2 Drawing Markings

a) All markings on drawings shall clearly depict the changes to be made in the field.

b) When circuits or equipment are removed from one page and redrawn on another, a note indicating the page number of the relocated equipment or circuit shall be added to the original page.

c) If there is a question as to the correlation of the content of a drawing with respect to field conditions, then the note “FIELD TO VERIFY” may be used.

d) Marked drawings shall be made from and compared to the record copy to ensure that the marked drawing correctly depicts what is shown on the record copy.

3.3.3 Drawing Colour Convention

a) Colours selected for layers or objects may appear differently between the AutoCAD screen and the printed copy due to various plot style tables (.ctb file extension) and printer characteristics. The plot style tables provided in this manual indicate the correct colour for the printed copy.

b) Changes shall denote changes to be made in the field. If coloured copies are required, Red=In and Blue=Out shall be used; Orange=In and Green=Out shall be used as the 2nd phase if there are two phases, on a new page, noted and numbered accordingly, for example, an existing page 021 would have a 021P page to show the next phase. There shall be no more than two colours on a plan.

c) Design contractor shall follow the colour code defined in Table 07: Colour Table for drafting.

d) In the case of drafting a new drawing, the entire contents of the drawing can be drawn in black with the stamp "ALL NEW" in the bottom right corner in red (AutoCAD colour 10).

Table 07: Colour Table

Description	Colour Name	AutoCAD Colour Code	Example
Additions, prior to commissioning	Red	10	
Removals, prior to commissioning	Blue	130	
Temporary additions prior to commissioning, or 2nd project phase	Orange	30	
Temporary removals prior to commissioning, or 2nd project phase, or future work	Green	90	
Existing or Commissioned work	Black	7	

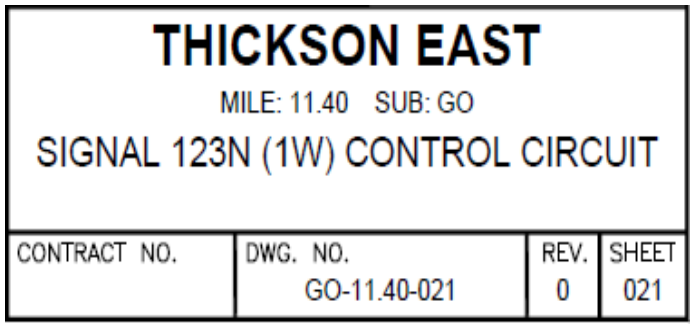
3.3.4 Sample Title Block

a) A description of the circuits shown on individual sheets shall be included within the title block (i.e., "Signal 123N(1W) Control Circuit").

b) Generic descriptions such as "Equipment at…" or "Circuits at…" shall not be used.

c) Follow the format of "DWG. NO.", "REV." and "SHEET" in the sample. Fill the "CONTRACT NO." based on the contract number.

Figure 01: A Sample of the "Title Block"



3.3.5 Sample Reference Drawings

a) Reference drawings referred by the design package shall be listed in the Reference Drawings column.

i. Note the column of Reference Drawings is not commonly used in Signalling System design.

Figure 02: A Sample of the "Reference Drawings"

REFERENCE DRAWINGS	
XX-XX.XX-XX	DESCRIPTION OF THE DRAWING
DWG NO.	TITLE

3.3.6 Sample Issue Column

a) Any formal issuance from a design contractor shall be recorded in the Issue column. The issuance stage may include Issued for Review, Issued for Tender, Issued for Construction, As-Installed, etc.

Figure 03: A sample of the "Issue"

ISSUE		
1	20/10/20	ISSUED FOR CONSTRUCTION
0	20/10/16	ISSUED FOR REVIEW
NO.	DATE	ISSUED FOR

3.3.7 Sample Revisions

a) The reason for the revision shall be recorded in the Revisions column, with the associated Revision Number, and when applicable, the Metrolinx project number shall also be recorded.

Figure 04: A sample of the "Revisions"

REVISIONS		
1	30/03/24	LSE POLE LINE ELIMINATION PROJ NO. 123456
REV.	DATE	

3.3.8 Cell Library

a) Design Contractor shall use the cell library defined in the Metrolinx CADD/BIM Standards Manual MX-ALM-STD-004.

3.3.9 As-Installed Plan

a) As-Installed Plan includes the Marked Up As-Installed Plan and the Final As-Installed Plan.

b) The Marked Up As-Installed Plan is the set of Issued for Construction plans used by field personnel, which documents the current field configurations/changes. Marked Up As-Installed plans, together with associated testing records, shall be returned to the Engineer of Record (EOR) with a transmittal sheet that is signed and dated following any change to equipment, circuitry, or software by the field personnel.

c) Production of the Final As-Installed Plan is the final stage in the deployment of signalling equipment. The record drawings/documentation provide up-to-date configurations essential for maintaining a reliable and safe Signalling System.

d) The Final As-Installed Plan includes track and cable layout plan, route and aspect charts, signal layout, circuit drawings, application software, program configurations, hardware configurations, etc.

i. EOR shall seal and submit the Final As-Installed Plan to Metrolinx (software does not need to be sealed).

ii. If any existing design errors are found during the preparation of the Final As-Installed Plan, they need to be immediately brought to the attention of Metrolinx and immediately corrected.

e) EOR shall review test records, including Factory Acceptance Testing results, Site Acceptance Testing results, and Commissioning Test results, and review any other documentation received from field personnel for compliance with GO Transit Signals and Communications standards to ensure the commissioned Signalling System is safe and reliable for operations.

i. EOR shall submit a sealed letter (on company letterhead) acknowledging the completed review and listing all documents submitted as part of the Final As-Installed Plan and testing records organized by location of work (mileage and subdivision) and system commissioned (e.g., crossing warning system, Control Point, intermediate, defect detection system, etc.).

f) EOR shall provide the Final As-Installed Plan along with the sealed letter to Metrolinx within 30 days after the changes are placed into service.

g) Refer to GO Transit Signals & Communications Standards GI – 301 (f) Conditions of Plans for more details.

3.4 Design Process

3.4.1 Design contractor shall implement internal design processes and assign competent personnel to perform any design work for Metrolinx to ensure the quality of the design and, ultimately, the reliability, availability, maintainability, and safety of the Signalling System placed in service.

3.4.2 Design contractor shall provide a plan describing its internal design process and shall support audits by Metrolinx at Metrolinx's discretion.

3.4.3 Design contractors shall only assign design work to staff approved in advance by Metrolinx.

3.4.4 Understanding of the Work

a) Prior to the commencement of design revisions, the design contractor shall:

i. Review all available Final As-Installed plans and equipment configurations. These documents should be requested from Metrolinx for revision control purposes.

ii. Be familiar with the current field configuration. If the information available is questionable or known to be inaccurate and could affect the safety of design, the design contractor shall identify, in writing, the discrepancies to Metrolinx and propose a plan to correlate the design. This includes all aspects of the signal design, such as software or hardware configurations, wiring or circuits, routes and aspects, etc.

iii. Identify the core hardware to be used and provide the list to Metrolinx for approval prior to detailed design, including VMIS, crossing predictor/controller, switch machine, snow clearing device, power off light, vital relay, non-vital relay, charger, battery, ethernet switch, local control panel, cell modem, recording device, gate mechanism, communication device, etc.

iv. Discuss with Metrolinx any questions concerning work to be performed and/or scheduling.

b) Design contractor shall notify Metrolinx of any conflicts with the current Final As-Installed plans that are being used as the design baseline and develop a plan jointly with Metrolinx to resolve the conflicts.

c) Metrolinx will ensure the Final As-Installed plans can be revised without conflict with other concurrent/outstanding projects.

i. If a conflict is found, the records of other concurrent/outstanding projects can be requested by the design contractor.

ii. Metrolinx will coordinate with design contractors to resolve the conflict. This may require discussing specific sequencing between the projects and using different colours to denote the different project works.

3.4.5 Checking

a) The design contractor shall provide a qualified person, other than the primary person performing the design, to thoroughly check all revised and/or new designs.

i. This person shall have a working knowledge of Signalling Systems and all phases of Signalling System projects.

ii. This person shall be familiar with the requirements of Transport Canada, AREMA C&S manual, and the GO Transit Signals and Communications Standards.

3.4.6 Approval

a) The design contractor shall provide a qualified person, other than the person performing the initial design or checking, to approve all revised and/or new designs by the design contractor.

i. This person shall have extensive knowledge of Signalling Systems and all phases of the Signalling System project.

ii. This person shall be familiar with the requirements of Transport Canada, AREMA C&S manual, and GO Transit Signals and Communications Standards.

3.4.7 Sealed Drawings

a) The design contractor shall provide a licensed Professional Engineer (P. Eng.) in the province of Ontario to review and seal all revised and/or new design Issued for Construction (IFC) drawings and documentation. This person may be the same as the checker and/or approver.

3.4.8 Field Engineer

a) Implementation contractor shall provide a Field Engineer who is a licensed Professional Engineer (P. Eng.) in the province of Ontario, to support site Engineering after the IFC phase of the project.

i. Field Engineer shall review and modify the IFC design when discrepancies are found in the field and agreed upon by Metrolinx prior to implementation.

ii. Field Engineer may or may not be the original design contractor staff.

iii. Field Engineer may also be the EOR for the construction phase.

iv. Field Engineer is subject to all design requirements in this design manual.

b) If the implementation contractor is the same entity as the design contractor, then the functions of the Field Engineer shall be conducted by the originator of the design to the fullest extent possible.

3.4.9 Engineer of Record (EOR)

a) EOR shall be a licensed Professional Engineer (P. Eng.) in the province of Ontario who will review the construction test records and Marked Up As-Installed Plans and seal the records as Final As-Installed Plans.

b) EOR shall be familiar with the requirements of Transport Canada, AREMA C&S manual, and GO Transit Signals and Communications Standards.

3.4.10 Plan Revisions

a) The design contractor, Field Engineer and EOR shall follow the design, check, and approval process and principles defined in this document for any revisions to the original plans.

i. The title block of the revised drawings shall reflect the personnel who revised the design and date in the fields of “designed by/checked by/approved by.”

ii. The original title block on the revised drawings shall be replaced with the new title block, if the original title block format is different than the title block format defined in this design manual.

b) Revisions can be caused for numerous reasons, including scope changes initiated by Metrolinx, design errors, and changes initiated by the installation/testing/commissioning personnel.

c) Refer to GO Transit Signals & Communications Standards GI – 301 (a) – Working with Approved Plans for more details.

4. General Signalling Design Principles

4.1 General Requirements

4.1.1 The Signalling System shall be designed using fail-safe principles. System safety design shall ensure that any single independent component or subsystem failure will result in a safe condition. Failures that are not independent (those failures that, in turn, may cause others) shall be considered in combination as a single failure and shall not cause an unsafe condition.

4.1.2 Signals shall be provided to govern train movements into and through a particular Interlocking and between the limits of adjacent Interlockings. The Signalling System shall be arranged so that failure of any part of the Signalling System shall cause affected signals to revert to the most restrictive indications associated with current conditions.

4.1.3 Signalling System circuits shall ensure that the following types of component failures have a restrictive effect on equipment and signal aspects:

a) Two-terminal devices: open, short, partial open, or partial short.

b) Devices with more than two terminals: a combination of opens, shorts, partial opens and/or partial shorts.

4.1.4 Signalling System circuits and application software shall comply with the examples and principles included in AREMA C&S Manual Section 16.

a) If a particular application is not covered in AREMA C&S Manual Section 16, relevant examples of circuitry that are known to be tested and in service may be used as a guide, and shall be submitted to Metrolinx for approval.

4.1.5 The Signalling System shall be fully tested by qualified personnel independent from the design team per AREMA C&S Manual Section 2.4.1 and GO Transit Signals and Communications Standards.

4.2 Closed-Loop Circuit Principles

4.2.1 The closed-loop circuit principle shall be applied for Signalling System designs, which affect the safety of train operation.

4.2.2 The closed-loop principle requires any permissive state or action to be verified before the permissive state or action can be formally output by the circuit.

a) Furthermore, the requisite conditions shall be verified to be continuously present to maintain the permissive state or action.

4.2.3 The failure to perform a logical operation (including decisions) or the absence of a logical input or output, shall not cause an unsafe condition.

4.3 Double Break Circuits

4.3.1 Circuits not confined within a single Equipment House that affect system safety shall be interrupted by relay contacts in both the positive and negative energy feed ("double break").

4.4 Diodes

4.4.1 Diodes shall not be used to separate vital circuits where their failure (opening or shorting) may cause an unsafe condition. Instead, separate relay contacts shall be used in each circuit.

4.5 External Devices

4.5.1 External devices such as resistors, capacitors or diodes shall not be used to lengthen the release time of a relay if the failure of such external device could cause an unsafe condition.

4.6 Non-Vital Relays

4.6.1 Contacts of non-vital relays shall not be used in vital circuits.

4.7 Track Circuits

4.7.1 The occupancy of a track circuit by a train, locomotive or car shall cause the track circuit relay or equivalent to be de-energized.

4.7.2 The following design principles shall be applied for vital track circuits:

a) Track circuits shall function in a fail-safe manner, such that no failure of any component of the track circuit will result in a hazardous condition or state;

b) The minimum length of a track circuit shall be 120 feet, and shall not be shorter than the minimum track circuit length recommended by the equipment supplier;

c) The track circuit system shall detect any shunt with resistance less than or equal to 0.06Ω located at any point within the track circuit and within the fouling section of turnouts, where applicable;

d) The length of dead sections of the track (i.e., those sections within which a shunt is not detected) shall comply with AREMA C&S Manual and GO Transit Signals and Communications Standards. Dead sections are to be kept to a minimum to the greatest possible extent;

e) Bonding of track circuits shall conform to the AREMA C&S Manual and GO Transit Signals & Communications Standards;

f) DC and DC-coded track circuits shall be insulated from all adjoining track circuits and from all non-signalled track;

g) Polarity staggering:

i. When insulated joints are used with polarity-sensitive track circuits, polarity staggering shall be maintained at the insulated joints for track circuits of the same or similar types.

ii. For audio frequency track circuits, train detection carrier frequency and modulation rate separation shall be maintained per the equipment supplier's recommendations.

h) When different types of track circuits are used in proximity to one another, the design shall account for any operational and/or performance differences;

i) Track circuits shall be wired and configured to prevent unintended runaround paths between the source of the detection signal and the receiving end of the track circuit. The only viable path between the transmit and receive ends of the track circuit shall be the running rails and associated bonding wires;

j) Track circuits shall detect broken rail conditions for both running rails;

k) Track circuits shall compensate for ballast leakage and shall be designed for 2 ohm ballast, unless otherwise approved by Metrolinx;

l) Where track circuits are combined using repeaters to aggregate a block, the status of the last repeater track circuit shall be used in the signal control circuit to interpret the occupancy of the block;

m) Regular-release biased-neutral track relays shall be used with DC track circuits. Track relays and repeaters are to be mounted at eye level whenever possible for convenience of testing; and

n) Multiple-relay fouling circuits shall be used for Over Switch (OS) track circuits on turnouts with power-operated switches per GO Transit Signals & Communications Standards SCP 11 – Bonding and Fouling Turnouts.

4.8 Signal Control

4.8.1 Signals shall be interconnected such that proceed aspects cannot be displayed simultaneously for conflicting movements, except that opposing signals may display an aspect indicating "proceed at restricted speed" at the same time on a track dedicated for switching movements by a single train.

4.8.2 Signalling System circuits shall be designed such that each signal governing train movements into a block will display its most restrictive aspect when any of the following conditions are present in the block:

a) Occupancy by a train, locomotive or car (unless for the following: move, return to train or switching operations);

b) Switch points are not locked in the correct position as specified for the route;

c) An independently operated fouling-point derail equipped with a switch circuit controller is not in the derailing state;

d) Any track relay associated with the signal is in the de-energized position, or a device which functions as a track relay is in its most restrictive state; or

e) When the associated signal control circuit is de-energized.

4.8.3 Signals at adjacent Control Point shall be interconnected such that aspects to proceed on the signalled track cannot be displayed simultaneously for opposing movements.

4.8.4 The signal control network (also known as the home network) shall provide the primary circuits for controlling signal aspects, which shall include a check of the following critical functions required to display permissive signal aspects:

a) Track switch points are lined and locked in the proper position for the route. This includes all switches in a route and any switches that are not directly in a route but may affect or be affected by other conditions, such as maintaining parallel routes or precluding conflicting routes.

b) The opposing route check is not initiated or established, and opposing route locking (if route locking is employed) is not in effect.

c) Time locking is not active (time is not running) on opposing signals.

d) Track circuits in the route are not de-energized, except where Call-on, Return to Train or switching operations allow Restricting aspects to be displayed into occupied tracks.

e) Track circuits that foul the route are not occupied, unless switch conditions (such switch shall be locked by the route) prevent the fouled track circuits from affecting the route.

f) The conditions at the exiting end of the route (the block beyond the last opposing signal or up to the next signal in the same direction) are valid (route locking is effective in the direction of travel, and block conditions ahead are favourable), and field track (exit) blocking is not established.

g) For tracks signalled for bi-directional travel (tumbledown has been initiated and/or traffic is set for the direction of travel), the direction of traffic shall be set, and traffic locking shall be applied for the exiting end of the route up to the next adjacent controlled location.

4.9 Vital Circuit Power Supply Isolation

4.9.1 The power source or operating battery bank for vital circuits shall be electrically isolated from power sources for non-vital circuits.

4.9.2 Vital circuits shall be designed using fail-safe principles, utilizing equipment, including printed circuit boards (PCBs), terminals, insulated wires, and wiring methods specifically designed for vital applications.

4.9.3 The dielectric strength of equipment shall comply with AREMA C&S Manual Section 11.5.1.

4.9.4 The following two methods are acceptable to separate vital and non-vital power supplies:

a) The Isolation method preferred by Metrolinx for new installations or modifications to existing Signalling System equipment is:

i. A DC/DC converter with an input-to-output, input-to-ground, and output-to-ground isolation rating of either 2000 Vrms for electronic circuits or 3000 Vrms for relay logic circuit applications, per AREMA C&S Manual Part 11.5.1.

b) An alternative method that may be retained for existing non-vital circuits at an existing location, but shall not be introduced for a new location or a location to be re-signalled, is the use of independent battery banks and chargers.

4.10 Power Buss and Connections

4.10.1 Power to relay contacts and equipment shall be connected directly to the power buss. Daisy chains, battery or power loop connections are prohibited for new designs. Where daisy chains, battery or power loops are part of the existing installation, only removal of contacts or equipment is permitted within the loop.

4.10.2 Power busses shall be designed to have 10% spare connection points for future purposes.

4.11 Switch Machine Placement

4.11.1 Switch machines shall be installed outside of the tracks wherever practicable.

4.12 Hand Throw Switches

4.12.1 Hand Throw Switches (also known as Hand Operated Switches), with or without Electric Locks, shall not be installed within interlocking limits or Controlled locations.

4.13 Clearance Point

4.13.1 The Clearance Point is defined in SCP 1 – "Location of Insulated Joints" at the point where there is 13' 6" between track centers.

4.13.2 The effective insulated joint shall be a minimum of 16' (car overhang) beyond the Clearance Point.

a) For locations deployed with sectional release function, sometimes it is necessary to install the insulated joint fouling the turnout, and the following requirements shall be followed.

b) Electric locking shall be so designed that occupancy of any track circuit fouling the turnout must electrically lock the switch until such track circuits and the over-switch track circuit are vacant, and route locking/traffic locking are released.

c) IJ fouling the turnout shall be drawn with a half circle at the direction fouling the turnout in both R&A and track and signal plan. For example, if the insulated joint fouls turnout on the right side, a half circle shall be drawn on the right side of an insulated joint, with an arrow pointing to the right side. If the insulated joint fouls turnouts on both sides, a full circle shall be drawn around the insulated joint, with the arrow pointing to both sides. Fouling conditions shall be clearly noted on the plan.

4.13.3 Tables 08 through 13 are provided for guidance while determining the clearance point distance on No. 10, No. 12 and No. 20 turnouts.

4.13.4 Design contractor shall calculate the actual distance based on the track and switch design for the specific project, along with any other project-specific requirements.

a) Refer to the associated drawings in the GO Transit Track Standards for details of the calculations.

b) Table heading meanings are as follows:

i. Lead means the distance between the Point of Switch (PS) and ½" Point of Frog (PF);

ii. X means the distance between ½" PF and the Beginning of Curve (BC);

iii. BC to EC means the distance between BC and the End of Curve (EC); and

iv. PS to EC means the distance between PS and EC.

Table 08: No.10 Turnout with Fixed Frog

Track Center	Lead	X	BC to EC	PS to EC
13′ 0″	81′ 6 ½″	42′ 3 1/8″	80′ 3 3/8″	204′ 1.0″
13′ 6″	81′ 6 ½″	47′ 2 7/8″	80′ 3 3/8″	209′ ¾″
14′ 0″	81′ 6 ½″	52′ 2 ¾″	80′ 3 3/8″	214′ 5/8″
14′ 6″	81′ 6 ½″	57′ 2 5/8″	80′ 3 3/8″	219′ ½″
15′ 0″	81′ 6 ½″	62′ 2 ½″	80′ 3 3/8″	224′ 3/8″
16′ 0″	81′ 6 ½″	72′ 2 1/8″	80′ 3 3/8″	234′ 0.0″

Table 09: No.12 Turnout with Fixed Frog

Track Center	Lead	X	BC to EC	PS to EC
13′ 0″	98′ 1.0″	49′ 3 3/8″	99′ 3.0″	246′ 7 3/8″
13′ 6″	98′ 1.0″	55′ 3 ¼″	99′ 3.0″	252′ 7 ¼″
14′ 0″	98′ 1.0″	61′ 3 1/8″	99′ 3.0″	258′ 7 1/8″
14′ 6″	98′ 1.0″	67′ 3.0″	99′ 3.0″	264′ 7.0″
15′ 0″	98′ 1.0″	73′ 2 7/8″	99′ 3.0″	270′ 6 7/8″
16′ 0″	98′ 1.0″	85′ 2 5/8″	99′ 3.0″	282′ 6 5/6″

Table 10: No.20 Turnout with Fixed Frog

Track Center	Lead	X	BC to EC	PS to EC
13′ 0″	156′ ½″	79′ 10 ¼″	170′ 2 ¼″	406′ 1.0″
13′ 6″	156′ ½″	89′ 10 ¼″	170′ 2 ¼″	416′ 1.0″
14′ 0″	156′ ½″	99′ 10 1/8″	170′ 2 ¼″	426′ 7/8″
14′ 6″	156′ ½″	109′ 10 1/8″	170′ 2 ¼″	436′ 7/8″
15′ 0″	156′ ½″	119′ 10.0″	170′ 2 ¼″	446′ ¾″
16′ 0″	156′ ½″	139′ 9 7/8″	170′ 2 ¼″	466′ 5/8″

Table 11: No.10 Crossover with Moveable Frog

Track Center	Lead	Between ½″ Frog Points	PS to EC
13′ 0″	81′ 6 ½″	34′ 8 1/8″	197′ 9 1/8″
13′ 6″	81′ 6 ½″	39′ 8″	202′ 9″
14′ 0″	81′ 6 ½″	44′ 7 7/8″	207′ 8 7/8″
14′ 6″	81′ 6 ½″	49′ 7 5/8″	212′ 8 5/8″
15′ 0″	81′ 6 ½″	54′ 7 ½″	217′ 8 ½″
16′ 0″	81′ 6 ½″	64′ 7 ¼″	227′ 8 ¼″

Table 12: No.12 Crossover with Moveable Frog

Track Center	Lead	Between ½″ Frog Points	PS to EC
13′ 0″	98′ 1.0″	41′ 8 ¾″	237′ 10 ¾″
13′ 6″	98′ 1.0″	47′ 8 5/8″	243′ 10 5/8″
14′ 0″	98′ 1.0″	53′ 8 ½″	249′ 10 ½″
14′ 6″	98′ 1.0″	59′ 8 3/8″	255′ 10 3/8″
15′ 0″	98′ 1.0″	65′ 8 ¼″	261′ 10 ¼″
16′ 0″	98′ 1.0″	77′ 8″	273′ 10″

Table 13: No.20 Crossover with Moveable Frog

Track Center	Lead	Between ½″ Frog Points	PS to EC
13′ 0″	156′ ½″	69′ 10″	381′ 11″
13′ 6″	156′ ½″	79′ 10″	391′ 11″
14′ 0″	156′ ½″	89′ 9 7/8″	401′ 10 7/8″
14′ 6″	156′ ½″	99′ 9 7/8″	411′ 10 7/8″
15′ 0″	156′ ½″	109′ 9 ¾″	421′ 10 ¾″
16′ 0″	156′ ½″	129′ 9 5/8″	441′ 10 5/8″

5. CTC Signal System

5.1 Block Design

5.1.1 General Requirements

a) This section defines the block design principles.

b) Design contractor shall refer to the contract requirements for the definition of roles and responsibilities relating to block design.

c) Signal block design subdivides a territory into blocks, the occupancy or vacancy of which is used by Interlocking Controllers and Intermediate Signal Controllers to activate Fixed Signals to ensure safe train separation and to protect movements over powered track switches and derails.

d) Signal spacing and/or signal aspects shall be based on the appropriate braking curves information for the applicable:

   i. Worst-case train consist;

   ii. Highest train speed; and

   iii. Smallest (including largest negative) track gradient in the vicinity of the signal.

e) In case of longer distances to the next interlocking and/or long block distances, Intermediate Signals, controlled by Intermediate Signal Controllers, may be introduced to subdivide large blocks, as required to improve the headway.

   i. Where two-block braking is not feasible due to physical limitations, approach signals shall be placed at the worst-case braking distance from the home signals.

   ii. This will allow movements into the block between Control Points at speed, but will still allow trains to come to a stop or reduce the speed for diverging movement safely at the home signal without introducing a permanent slow order.

f) To maximize train throughput, back-to-back Intermediate Signals may be provided, spaced at the braking distance for bi-directional operation and following moves in the block.

g) Train movement/operation simulations shall be conducted to evaluate the effectiveness of the proposed block layout.

5.1.2 Sightline Distance

a) Signal locations shall be selected to provide adequate sight distance for the Operating crew of a train approaching the signal to clearly see and interpret the aspect displayed before they have to safely react to it.

b) Signal locations shall comply with GO Transit Signals and Communications Standards – Signal Sighting Standard, RC-0506-03SIG-04.

5.1.3 Signal Spacing

a) Signals shall be spaced per the Maximum Authorized Speed and any Permanent Slow Orders (PSOs) specified in the Timetable, Special Instructions and Bulletins.

   i. Recent and imminent changes in the Maximum Authorized Speed and PSOs must be identified and considered when determining signal spacing.

b) Temporary Slow Orders (TSOs) are not to be used in calculating stopping distance and signal spacing, due to their transient nature.

c) Each signal shall be located sufficiently in advance of the next signal or signals which control train movements in the same direction to enable an Operating crew of a train to comply with a more restrictive signal through brake application, other than an emergency application, initiated at such signal.

d) Each PSO shall be reviewed for possible elimination or adjustment. The adjustment of speed restrictions should consider the following:

   i. A preference for uniform speeds;

   ii. Typical actual train speeds due to grades, curves, operating patterns, equipment restrictions; and

   iii. Grade crossing locations and warning system approach distances and times.

e) In cases where an approach aspect is not repeated, signals shall be spaced with constraints as follows:

   i. Double-block braking is preferred in the block design.

   ii. Advanced Clear to Stop aspect shall be designed regardless of whether a single block has sufficient braking distance or not.

   iii. Aspects indicating speed reductions shall be designed in progression of Advanced Clear to Limited / Medium / Slow.

5.1.4 Braking Distance

a) Trains of various braking characteristics operate at various speeds in Metrolinx Territory.

b) Braking characteristics of all train types shall be considered when locating signals and determining aspects to be used.

c) The following types of trains shall be considered to provide a worst-case scenario for stopping distances and speed reduction distances:

   i. GO Transit Passenger Trains;

   ii. Union-Pearson Express (UPE) Trains;

iii. VIA Passenger Trains;

iv. Other Passenger (i.e., Amtrak) Trains; and

v. CN and CP freight Trains (Refer to Time Table for freight train categories).

d) The following speeds are used as the basis for determining stopping and speed reduction profiles:

i. Clear Speed = Track Speed.

ii. Diverging Speed = a speed not exceeding 25 MPH.

iii. Limited Speed = a speed not exceeding 45 MPH.

iv. Medium Speed = a speed not exceeding 30 MPH.

v. Slow Speed = a speed not exceeding 15 MPH.

vi. Restricting Speed = a speed not exceeding 15 MPH.

vii. Stop.

5.1.5 Maximum speeds for divergent moves of different train types:

a) #20 Turnout = 45 MPH for all train types.

b) #16 Turnout = 30 MPH for all train types.

c) #12 Special Turnout (all welded) = 25 MPH for all train types.

d) #12 Regular Turnout and any turnout size below #12 = 15 MPH for all train types.

e) Double Slip Switch at USRC = 30 MPH for GO Transit trains; 25 MPH for VIA and other non-GO Transit passenger trains (timetable speed); 15 MPH for freight trains.

5.1.6 The stopping profiles used to calculate block length at a given location vary based on authorized block entry speed ("Clear Speed," 45MPH, 30MPH, 25MPH and 15MPH) to a Stop.

5.1.7 The speed reduction profiles used to calculate block length at a given location vary based on authorized block entry and exit speed combinations as follows:

a) Clear Speed to 45MPH.

b) Clear Speed to 30MPH.

c) Clear Speed to 25MPH.

d) Clear Speed to 15MPH.

e) 45MPH to 30MPH.

f) 45MPH to 25MPH.

g) 45MPH to 15MPH.

h) 30MPH to 15MPH.

5.1.8 Average Grade

a) The braking distance calculations for each type of freight or passenger train shall be evaluated over computed average gradients to determine the actual "worst-case" braking distance to be used for speed reductions.

b) Average gradients are determined by calculating the following three scenarios and selecting the worst case (lowest positive gradient or steepest negative gradient):

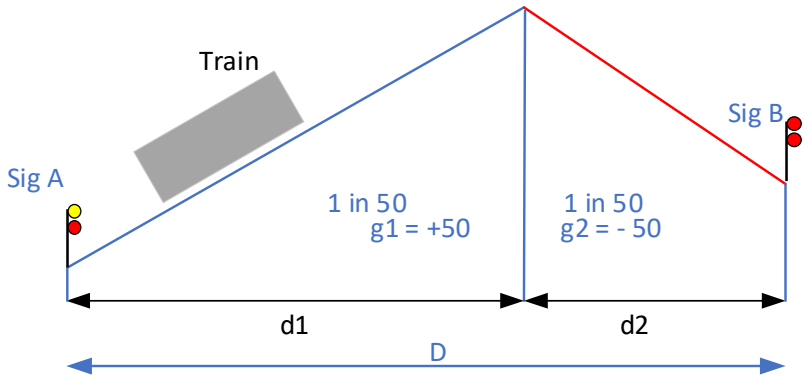
i. Gradient A: Signal to Signal in the block of interest;

ii. Gradient B: Signal to Signal + SHORT train length (1000 feet for passenger trains; 6000 feet for freight trains); and

iii. Gradient C: Signal to Signal + LONG train length (2000 feet for passenger trains; 12,000 feet for freight trains).

c) Calculation for average gradient – basic equation:

i. The average gradient is calculated by taking the arithmetic mean of individual grade elements over the region being evaluated, as shown in the example below (example drawing is not to scale);



$$\frac{G_{average}Gradient}{D} = 1/(\frac{d1}{g1} + \frac{d2}{g2})$$

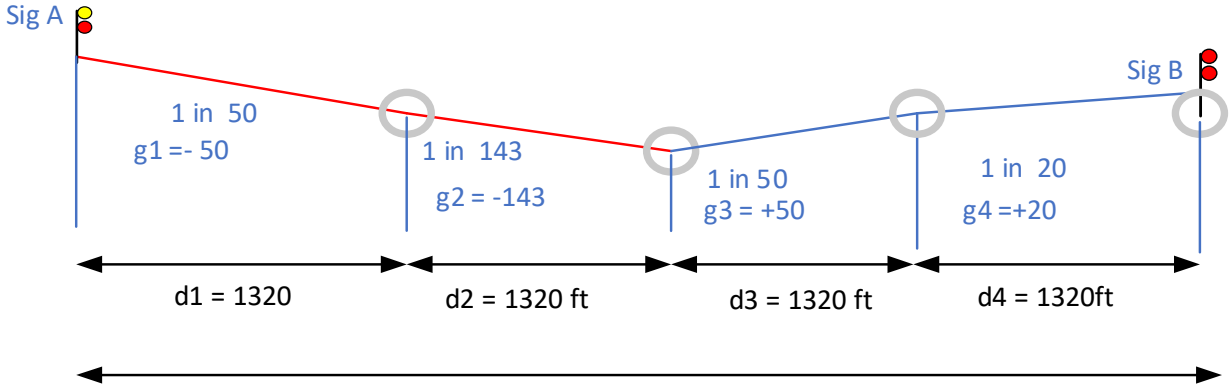
$$G_{average}Gradient = D/(\frac{d1}{g1} + \frac{d2}{g2})$$

ii. Where Gradient is the average gradient, and D is the total distance over the region being evaluated.

d) Calculation for average gradient – sample:

i. Assuming the following parameters for a sample calculation using the above equation to compute average gradient: signal-to-signal block length of 5280 feet; segment gradients of 1 in 50 feet, 1 in 143 feet, 1 in 50 feet and 1 in 20 feet; train lengths of 6000 and 12000 feet (freight trains).

ii. Gradient A – Signal to Signal. Drawing below is not to scale.



D= Signal to Signal 5280 ft = 1 mile

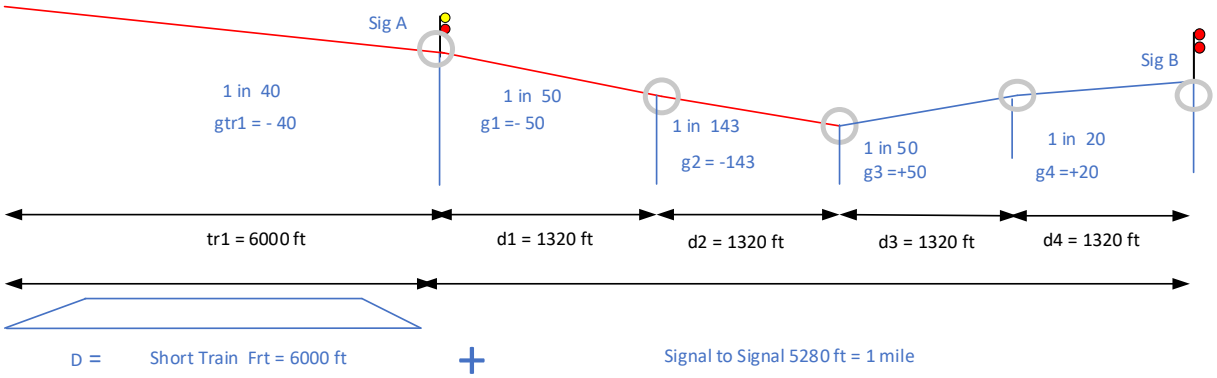
$$G_{average}Gradient\_1 = D/(\frac{d1}{g1} + \frac{d2}{g2} + \frac{d3}{g3} + \frac{d4}{g4})$$

$$G_{average}Gradient\_1 = 5280/(-\frac{1320}{50} - \frac{1320}{143} + \frac{1320}{50} + \frac{1320}{20})$$

= +93.01 or 1% grade, or 1 foot of vertical change for every 93.01 feet of horizontal distance.

$G_{average}Gradient_1\%$ = + (1/93.01) x 100 = +1.075%

iii. Gradient B – Signal to Signal and Short Train. Drawing below is not to scale.



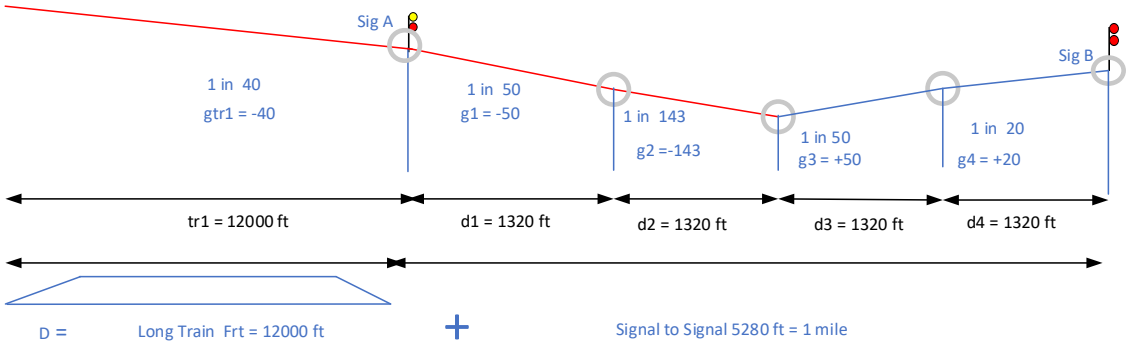
$$G_{average}Gradient\_2 = D/(\frac{d1}{g1} + \frac{d2}{g2} + \frac{d3}{g3} + \frac{d4}{g4} + \frac{tr1}{gtr1})$$

$$G_{average}Gradient\_2 = (5280 + 6000)/(-\frac{1320}{50} - \frac{1320}{143} + \frac{1320}{50} + \frac{1320}{20} - \frac{6000}{40})$$

= - 120.93, or 1 feet of vertical change for every 120.93 feet of horizontal distance.

$G_{average}Gradient_2\% = -(1/120.93) \times 100 = -0.82\%$

iv. Gradient C – Signal to Signal and Long Train. Drawing below is not to scale.



$$G_{average}Gradient\_3 = D/(\frac{d1}{g1} + \frac{d2}{g2} + \frac{d3}{g3} + \frac{d4}{g4} + \frac{tr1}{gtr1})$$

$$G_{average}Gradient\_3 =$$

$$(5280 + 12000)/(-\frac{1320}{50} - \frac{1320}{143} + \frac{1320}{50} + \frac{1320}{20} - \frac{12000}{40})$$

= - 71.04 or 1 feet of vertical change for every 71.04 feet of horizontal distance.

$G_{average}Gradient_3\% = -(1/71.04) \times 100 = -1.4\%$

v. Determine worst case average gradient by taking the lowest value of the gradients obtained in the above three examples.

$$Gradient\%_{worstcase} = Lowest\ Value\ (G_{average}Gradient_1\%, G_{average}Gradient_2\%, G_{average}Gradient_3\%)$$

$$Gradient_{\%worstcase} = Lowest\ Value\ (+1.075\%, -0.82\%, -1.4\%)$$

$$Gradient_{\%worstcase} = -1.4\%$$

5.1.9 To further increase the margin of safety, the following additional margin factor shall be added to the overall stopping distance curves when performing signal block design:

a) Some stopping curves referenced in this document incorporate the 20% margin factor, while others do not;

b) For those identified as not having a margin factor built into the stopping curves, an additional margin of 20% shall be added when braking distance curves are referenced;

c) Metrolinx GO Train braking curves incorporate the margin factor of 20% of the calculated stopping distance;

d) CN "Freight and Passenger Braking Curves" do NOT include the 20% margin factor, so they must have the margin added;

e) CN "Development of GO Transit Passenger Train Stopping Distances" includes a variable margin factor PLUS an added fixed length and does not need additional distance added to the stopping distances derived from the graphs; and

f) VIA "Braking Stopping Distance Look Up Tables" do NOT include the 20% margin factor, so they must have the margin added.

5.1.10 Freight trains and non-GO Transit passenger trains that require longer braking distances than GO Transit trains are required to operate at lower speeds, which are determined during the simulation process and included in the applicable subdivision timetable.

5.2 Direction Naming Convention

5.2.1 The direction naming convention shall utilize the following:

a) West for Northward or Westward movements; and

b) East for Southward or Eastward movements.

5.3 Track Circuit Naming

5.3.1 For OS track circuits within an interlocking or Control Point, the track circuit name shall relate to the designation number of the track associated with the track circuit followed by the letter "T"; for example:

a) The north or east track is designated as Track 1 (single track is designated as Track 1);

b) The west or south track is designated as Track 2;

c) For more than 2 tracks, use the corresponding track number, such as Track 3, etc.

5.3.2 Subsequent track circuits on a track shall be designated with a consecutive letter starting with "A" before the "T," for example:

a) The next track circuit within the interlocking is designated "1AT";

b) The next subsequent track circuit is designated "1BT", etc.;

c) At an end-of-siding location OS track circuit is designated "OST".

5.3.3 For the bidirectional track circuit between 2 intermediate signals in Coded Track Circuit territory, the name shall relate to the track name and what directional side of the insulated joints the circuit is on, followed by the letter "T," for example:

a) For Track 1, west side of the insulated joints, the name is 1WT.

5.3.4 For a Coded Track Circuit adjacent to the Control Point, the same naming convention is applied, such as 1WT, for the Coded Track Circuit, on the west side of the insulated joints for signal 1E.

5.3.5 For a Coded Track Circuit at an end-of-siding location:

a) FPT shall be used for the track circuit at the facing point side;

b) For the track circuit on a straight track at the trailing point side, TPMT shall be used; and

c) For the track circuit on the diverging track at the trailing point side, TPST shall be used.

5.3.6 For the Island track circuit at a Grade Crossing, the track circuit name shall relate to the designated number of the track associated with the track circuit and an "X" with a "T" suffix, for example:

a) North track or east track, which is Track 1, shall be designated 1XT;

b) West or south track, which is Track 2, shall be designated 2XT;

c) For more than 2 tracks, use the corresponding track number, such as Track 3XT, etc.;

d) For a single track, it is acceptable to use XT.

5.3.7 For signal blocks with multiple track circuits in a relay-based system, the track circuit name shall relate to the number of the southbound or eastbound signal entering the block with the track circuit name followed by the letter "T," for example:

a) The first track circuit related to Signal 3168N shall be "3168NT";

b) Subsequent track circuits shall have a consecutive letter starting with the letter "A" before the "T";

c) The next track circuit after 3168NT will be called "3168NAT", the next subsequent track circuit "3168NBT", and so on.

5.4 Signal Naming

5.4.1 Signals shall be designated by their associated track mileage to approximately the nearest tenth of a mile. Southbound or eastbound signals shall be designated using even numbers, and northbound or westbound signals shall be designated using odd numbers. The number shall be a minimum of 3 digits and prefixed with "0" if the mileage is less than 10.

a) Intermediate signal numbering shall be consistent through a subdivision. If the southbound or eastbound signals are numbered higher than the northbound or westbound signals on a subdivision, this numbering convention shall be used for new locations to ensure consistency.

b) On multi-track (more than 2 tracks), the designated track name shall be suffixed to the signal number (i.e., 331T1, 331T2, etc.).

c) On the double track, the track orientation shall be suffixed to the signal number (i.e., 331N, 331S).

d) On a single track for a signal located on the trailing point at an end-of-siding location, "S" or "N" shall be suffixed to the signal number (i.e., 331S for a signal located on the south track).

e) Low mast ("dwarf") signals shall be suffixed with "D" (i.e., 331D).

5.4.2 Signal names shall be consistent usage among Local Control Panels, design sketches, circuit nomenclature, house wire tagging, software nomenclature, and Route and Aspect charts.

5.4.3 To simplify and standardize the application software, the signal nomenclature shall be designated by track number and direction shown in parentheses. This will allow for standard wiring, tagging procedures and simplifying software production.

a) For example, for 331T1(1W). 1W shall be used in application software.

i. In a double-track situation, "1" shall be associated with the north track, and "2" shall be associated with the south track (i.e., 331S(2W)).

ii. In a single-track situation for back-to-back controlled signals, "1" shall be associated with the direction of "W" or "E" (i.e., 331(1W)).

b) At an end-of-siding location:

i. FP shall be used for the facing point signal (i.e., 331(FP)) for signal located on the facing point side,

ii. TPM shall be used for signal located on a straight track at the trailing point side (i.e., 332S(TPM)).

iii. TPS shall be used for signal located on a diverging track at the trailing point side (i.e., 331N(TPS)).

5.5 Switch Naming

5.5.1 The convention for naming switches shall be:

a) Power Switches shall be assigned an odd number (even numbers are not used) starting from one and increasing from the west or north (i.e., 1, 3, 5, etc.). Crossover Switches shall be assigned the same number suffixed with the letter's "A" and "B" (i.e., 1A, 1B, etc.), where A is the west or north end of such crossover, and B is the east or south end.

b) Hand Operated Switches shall be labelled either EL (Electric Lock) or HOS (Hand Operated Switch) depending on whether electric locks or switch circuit controllers are applied. The label shall be suffixed with the mileage of the switch points.

5.5.2 Switch names shall be consistent in usage among Local Control Panels, design sketches, circuit nomenclature, house wire tagging, software nomenclature, and R&A Charts.

5.6 Route & Aspect Charts

5.6.1 General Requirements

a) Route & Aspect (R&A) charts shall be furnished for all new designs and modifications to existing designs.

b) R&A charts shall indicate the aspects for all possible routes and associated signals.

c) Each route shall be carried back to the first Clear aspect, including routes to and from foreign railway connections.

d) The R&A charts contain information that is the basis of the design of the Signalling System.

5.6.2 R&A charts shall contain the following:

a) Single line track configuration (not to scale) on a standard drawing frame, complete with signals identified by name and including any aspect modifier plates per the CROR;

b) All track circuits, power switches, electric locks, hand-operated switches, signals, size of turnouts, code repeaters and crossings (if the crossing location is interfaced with the CTC system);

c) Signal aspects for each location in all directions consistent with safe operation;

d) Coded track codes as applicable;

e) Signal aspects (generally speed signalling type) in accordance with the CROR or special aspects contained in the applicable railway operating timetable;

f) A graphical depiction of routes for each aspect displayed (i.e., aspects for straight moves to be connected with straight lines, aspects for diverging routes to be connected with diverging lines for turnouts);

g) Call on, return to train, stick circuits, and any other feature necessary to supplement operation;

h) Potential maintenance code (Code M) associated with a device (i.e., signal or code repeater);

i) Block indication (Code 5) for 3 or more block applications; and

j) Any additional notes required to clarify special situations or requirements, such as sectional switch releasing clearances at insulated joints.

5.6.3 The R&A chart for the affected controlled block shall be updated whenever the wayside signal system is altered, and aspect is affected. A controlled block is a block in CTC between consecutive controlled locations or points. Agreement is needed with Metrolinx for areas where changes are made by overlapping projects, but otherwise, the R&A chart should be issued as one complete file, including the entire subdivision and areas with or without the changes.

5.7 Track Code Assignments

5.7.1 Track codes carry track, block, and signal aspect information between two wayside locations.

5.7.2 As shown in Table 14, ten-track codes communicate this information, six of which represent vital information while the other four represent non-vital information.

Table 14: Code Definition

CODE	DEFINITION
1	Non-vital reference code, begins each message transmission Usually followed by other vital and non-vital codes Verify track integrity when no other codes are being transmitted
2, 3, 4, 7, 8, 9	Vital code carrying aspect information
5	Non-vital code, indicates block occupancy
6	Non-vital code, as a tumbledown code to set opposing signals to stop
M	Non-vital code, indicates power off and light out alarms for intermediate signals Programmed for specific site requirements

5.7.3 Tables 15 and 16 define the code assignments recommended to be used for major resignalling projects, such as resignalling an entire subdivision.

a) Terminology conventions used in these tables are as follows:

i. / = "Over",

ii. Y = Yellow,

iii. FY = Flashing Yellow,

iv. G = Green,

v. FG = Flashing Green, and

vi. R = Red.

b) For modifications to existing locations, or the limited addition of locations within an existing subdivision, the code assignments are allowed to follow the existing rules in the subdivision, to ensure consistency between new (or modified) and existing locations.

Table 15: Code Assignment for 2 Block Braking

Code Received	Sample Aspect	CROR Description	Code transmitted	Sample Aspect	CROR Description
Not Applicable	R/R – Rule 439 R/Y – Rule 436	Rule 439 - STOP Rule 436 - Restricting (Controlled Signal) Rule 436 – Restricting, Proceed at Restricting Speed (R/R With "R" Plate on Signal With Directional Stick Established)	8	Y/R	Rule 411 - Proceed, preparing to STOP at next signal
8	Y/R	Rule 411 - Proceed, preparing to Stop at next signal	4	FY/R	Rule 415 - Advanced Clear to Stop
Varies	R/R/G	Rule 431 – Slow to Clear	9	Y/Y	Rule 409 – Clear to Slow
Varies	R/G/R	Rule 422 – Medium to Clear	2	Y/G	Rule 407 - Clear to Medium
Varies	R/FG/R	Rule 416 – Limited to Clear	3	Y/FG	Rule 406 - Clear to Limited
2	FY/G/R	Rule 413 - Advanced Clear to Medium	7	G/R	Rule 405 – Clear
3	FY/FG/R	Rule 412 - Advanced Clear to Limited	7	G/R	Rule 405 – Clear
4	FY/R	Rule 415 - Advanced Clear to Stop	7	G/R	Rule 405 – Clear
7	G/R	Rule 405 – Clear, PROCEED	7	G/R	Rule 405 – Clear

Table 16: Code Assignment for 4 Block Braking

Code Received	Sample Aspect	CROR Description	Code transmitted	Sample Aspect	CROR Description
Not Applicable	R/R – Rule 439 R/Y – Rule 436	Rule 439 - Stop Rule 436 - Restricting (Controlled Signal) Rule 436 – Restricting, Proceed at Restricting Speed (R/R With "R" Plate on Signal With Directional Stick Established)	8	Y/R	Rule 411 - Proceed, preparing to Stop at next signal
8	Y/R	Rule 411 – Clear to Stop	4	FY/R	Rule 415 - Advanced Clear to Stop
4	FY/R	Rule 415 - Advanced Clear to Stop	2	Y/FG	Rule 406 - Clear to Limited
Varies	R/FG/R, R/FG/FG, R/FY/R	Rule 416 – Limited to Clear Rule 417 – Limited to Limited Rule 421 – Limited to Stop			
2	Y/FG	Rule 406 - Clear to Limited	3	FY/FG	Rule 412 - Advanced Clear to Limited
3	FY/FG/R FY/FG	Rule 412 - Advanced Clear to Limited	7	G/R	Rule 405 – Clear
7	G/R	Rule 405 – Clear	7	G/R	Rule 405 – Clear

5.8 Track Occupancy Configuration

5.8.1 Whenever practical, the status of each track section shall be communicated separately to the GO Transit Train Control System (GTCS).

5.8.2 All track indications shall indicate to the GTCS as a 1 (or true) when occupied.

5.8.3 OS track indications shall be provided according to the following:

a) The loss of shunt shall simultaneously remove the OS track indication and switch locking indications;

b) There shall be an indication for each OS track section;

c) Stuck searchlight mechanism conditions shall operate independently from OS indications and shall be indicated separately.

5.8.4 Block indications (BK) shall be designed per the principles defined below unless otherwise approved by Metrolinx.

a) BK indications shall include hand throw switches located in a block that is outside the OS track circuits. BK indications shall indicate as a 1 when the block(s) is de-energized or when a hand-throw switch is not in the normal position. Block indications shall also indicate hazard detectors (i.e., WIS, BIS, High Water Detector, etc.) if they are not able to indicate separately, or as directed by Metrolinx. The following examples show Code 1 or Code 5 used for block indication to GTCS.

i. BK shall be configurable using vital configuration setting per track. If this indication is not currently employed at the location, it shall be disabled by vital configuration settings.

b) Maintenance Code M will indicate either Remote Light Out (RLOK) or Remote Power Off (RPOK) from the Intermediate signals, and code repeaters, towards the next appropriate Control Point. These indications shall indicate to the GTCS as a 1 when displayed. RPOK shall always feed towards the Control Point in the North or West direction, and RLOK shall always feed toward the Control Point in the South or East direction.

i. RLOK shall include light-out and other alarms associated with the VMIS (Vital Microprocessor Interlocking System) healthy for all intermediate signals within the block. RLOK shall begin from the furthest North or West intermediate signal in the block.

ii. RPOK shall include power-off and other alarms associated with the low battery alarm, charger healthy, and ground fault for all intermediate signal and code repeater sites within the block. RPOK may begin at a code repeater site if located further South or East of the last intermediate signal location within the block.

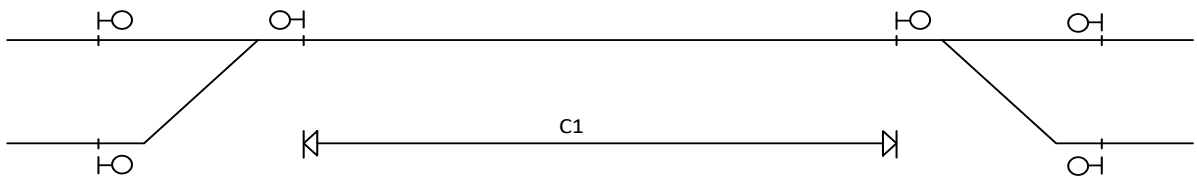
iii. In some limited applications, it may be required to combine both the RPOK and RLOK to feed in one direction, such as interfacing coded track with line circuits within a block.

c) One-Block Track Indication (reference Figure 05):

i. Code 1 shall be used for block indication; and

ii. Code M and Code 5 are not used for this application, unless code repeaters are present in the block, in which RPOK is applicable.

Figure 05: One-Block Track Indication



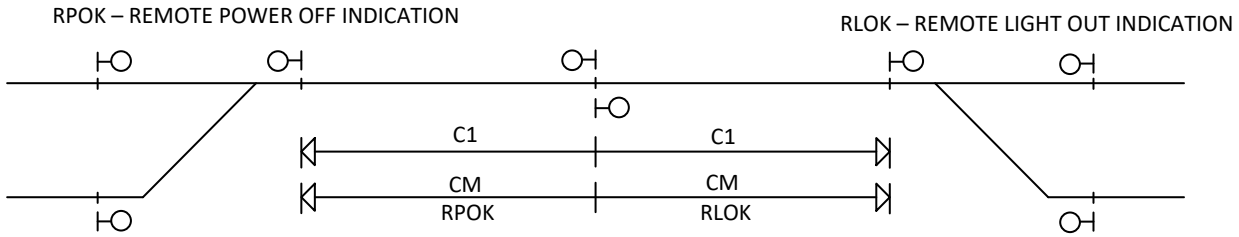
d) Two-Block Track Indication (reference Figure 06):

i. Code 1 is used for block indication;

ii. Code M indicates RPOK or RLOK; and

iii. Code 5 is not used for this application.

Figure 06: Two-Block Track Indication

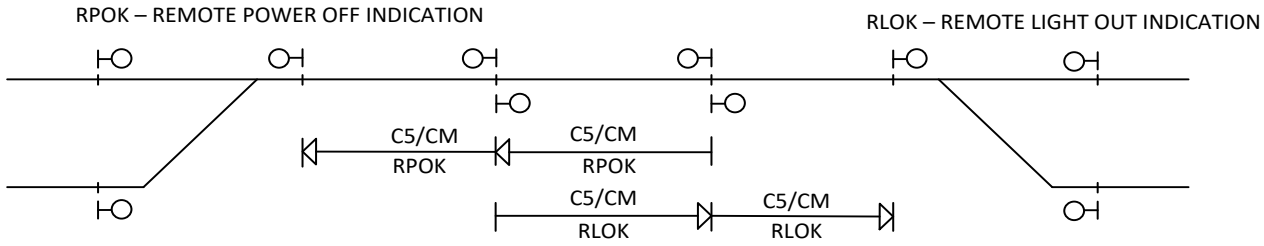


e) Three-Block Track Indication (reference Figure 07):

i. Code 5 is used for block indication, which provides a repetition of the middle block; and

ii. Code M is used to indicate RPOK or RLOK.

Figure 07: Three-Block Track Indication

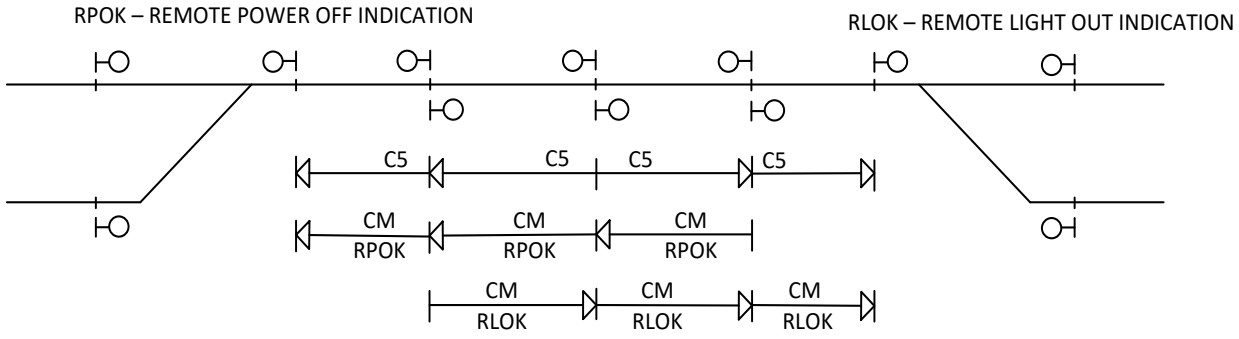


f) Four Blocks Track Indication (reference Figure 08):

i. Code 5 is used for block indication without overlapping; and

ii. Code M is used to indicate RPOK or RLOK.

Figure 08: Four-Block Track Indication



5.9 AC Power Off Indication

5.9.1 The AC Power Off Indication shall be provided from the Control Point to both LCP and GTCS when an AC Power Off condition has occurred, the battery is unhealthy, or the charger is unhealthy.

5.9.2 Remote AC Power Off Indication from the Intermediate signal locations via Maintenance Code M shall be provided to both the Local Control Panel (LCP) and GTCS at the respective Control Point.

5.9.3 The AC Power Off Indication shall be parallel contacts for multiple tracks such that if any one track loses the Maintenance Code M, then the Indication shall activate for both LCP and GTCS. If this indication is not currently used at the location, it shall be disabled by vital configuration settings.

5.10 Light Out Detection

5.10.1 Light-out detection is a method of verifying if a signal is operable by monitoring the signal lighting circuit to ensure the circuit is complete (no break).

5.10.2 Signalling System shall downgrade the upstream signal to the appropriate signal aspect as described in section 5.11 wherever a light-out condition is detected.

5.10.3 Light-out indication shall be provided from the Control Point to both GTCS and LCP to advise when a signal light-out condition has been detected.

5.10.4 Remote Light Out Indication from the Intermediate signal locations via Maintenance Code M shall be provided to both GTCS and LCP at the Control Point.

5.10.5 The Remote Light Out Indication shall be parallel contacts for multiple tracks such that if any one track loses the Maintenance Code M, then the Indication shall activate for both LCP and GTCS. If this indication is not currently used at the location, it shall be disabled by vital configuration settings.

5.11 Signal Downgrade Due to Light Out Conditions

5.11.1 In conjunction with CROR Rule 27, signal downgrade tables in this section shall be utilized for any locations outside of USRC.

5.11.2 The failure of a signal lamp in a signal shall not cause the display of a less restrictive aspect than intended per AREMA C&S Manual Part 2.1.1.

5.11.3 The principles of downgrading the signal aspects of a signal that has light-out conditions are intended to be used for Colour Light Signals.

5.11.4 The signal aspect downgrades defined in Table 17 and Table 18 can only be achieved if the downgrade aspect is available under normal operations and is itself not suffering from a Light Out condition. For example, if a Green LED is detected as out, the Yellow is detected as working, and the Green aspect could be downgraded to Flashing Yellow.

a) If the downgraded aspect is a valid signal aspect and is an aspect that the signal is able to display under normal operations, the principles defined for the downgraded aspect shall be followed. As an example, if G/R is downgraded to FY/R, the principles defined for FY/R shall be applied if there is light out detected on either Yellow or Red or both.

b) If the downgraded aspect is not an aspect that the signal is able to display under normal operations, for example, if G/R is downgraded to FY/R, however, FY/R is not an aspect defined in the Route and Aspect chart for the signal, then G/R shall be downgraded to Y/R, if Y/R is a valid aspect defined in the Route and Aspect chart. The contractor shall propose the solution and submit to Metrolinx for agreement and approval.

5.11.5 Unless otherwise indicated in the tables, the aspect (including the aspect defined in the "Aspect" column for initial downgrade, the aspect defined in the "Downgraded Aspect" column for further downgrade, and the aspect defined in the "Light Out" column without further downgrade) resulting from a light out condition shall be altered to display STOP (all signal heads to Red or Dark if Red is not available), applicable to controlled signal) or Restricting (all signal heads to be Red or Dark if Red is not available, applicable to intermediate signal), and the previous (upstream) signal will display XXX to Stop (such as Clear to Stop).

5.11.6 Colour designations, R=Red, Y=Yellow, G=Green, FY= Flashing Yellow, FG=Flashing Green, D= Dark.

5.11.7 NA = Not applicable, meaning that the signal aspect is not further downgraded.

5.11.8 Aspect (D) = low mast signal. Default aspect represents the high mast signal.

5.11.9 Code (Line Circuit) Out = Downgrade – corresponds to the aspect in the "Downgraded Aspect" column; Stop – corresponds to the Stop (controlled signal) or Restricting (intermediate signal); NC – corresponds to the aspect in the "Aspect column."

Table 17: Controlled Signal Aspect Downgrade Table

Rule	Aspect	Light Out	Downgraded Aspect	Code (Line Circuit) Out
405 – Clear	G/R/R	D/R/R	FY/R/R	Downgrade
		G/D/R, G/R/D, G/D/D	NA	Stop
	G/R	D/R	FY/R	Downgrade
		G/D	NA	Stop
406 – Clear To Limited	Y/FG/R	Y/FG/D	NA	Stop
		D/FG/R	R/R/Y (w/o DV plate)	Stop
		Y/D/R	Y/R/R	Downgrade
	Y/FG	D/FG	R/Y (w/o DV plate)	Stop
		Y/D	Y/R	Downgrade
407-Clear to Medium	Y/G/R	Y/G/D	NA	Stop
		D/G/R	R/R/Y (w/o DV plate)	Stop
		Y/D/R	Y/R/R	Downgrade
	Y/G	D/G	R/Y (w/o DV plate)	Stop
		Y/D	Y/R	Downgrade
408 – Clear to Diverging 409- Clear to Slow	Y/Y/R	Y/Y/D	NA	Stop
		D/Y/R	R/R/Y (w/o DV plate)	Stop
		Y/D/R	Y/R/R	Downgrade
	Y/Y	Y/D	Y/R	Downgrade
		D/Y		Stop
411- Clear to Stop	Y/R/R	Y/D/R, Y/R/D, Y/D/D	NA	Stop
		D/R/R	R/R/Y (w/o DV plate)	Stop
	Y/R	Y/D	NA	Stop
		D/R	R/Y (w/o DV plate)	Stop
412- Advanced Clear to Limited	FY/FG/R	FY/FG/D	NA	Stop
		D/FG/R	R/R/Y (w/o DV plate)	Stop
		FY/D/R	FY/R/R	Downgrade
	FY/FG	D/FG	R/Y (w/o DV plate)	Stop
		FY/D	FY/R	Downgrade
413- Advanced Clear to Medium	FY/G/R	FY/D/R	FY/R/R	Downgrade
		D/G/R	R/R/Y (w/o DV plate)	Stop
		FY/G/D	NA	Stop
	FY/G	FY/D	FY/R	Downgrade

Rule	Aspect	Light Out	Downgraded Aspect	Code (Line Circuit) Out	
			D/G	R/Y (w/o DV plate)	Stop
414- Advanced Clear to Slow 414a – Advanced Clear to Diverging	FY/Y/R	FY/Y/D	NA	Stop	
		D/Y/R	R/R/Y (w/o DV plate)	Stop	
		FY/D/R	FY/R/R	Downgrade	
	FY/Y	FY/D	FY/R	Downgrade	
		D/Y	R/Y (w/o DV plate)	Stop	
415- Advanced Clear to Stop	FY/R/R	FY/D/R, FY/R/D, FY/D/D	NA	Stop	
		D/R/R	R/R/Y (w/o DV plate)	Stop	
	FY/R	FY/D	NA	Stop	
		D/R	R/Y (w/o DV plate)	Stop	
416- Limited to Clear	R/FG/R	R/D/R	R/FY/R	NC	
		D/FG/R	D/R/Y	Stop	
		R/FG/D	NA	Stop	
	FG/R(D)	D/R	FY/R	NC	
		FG/D	NA	Stop	
417- Limited to Limited	R/FG/FG	R/FG/D	R/FY/R	NC	
		D/FG/FG	D/R/Y	Stop	
		R/D/FG	R/FY/R	NC	
418 – Limited to Medium	R/FG/G	R/FG/D	R/FY/R	NC	
		D/FG/G	D/R/Y	Stop	
		R/D/G	R/FY/R	NC	
419 - Limited to Slow 419a – Limited to Diverging	R/FG/FY	R/FG/D	R/FY/R	NC	
		D/FG/FY	D/R/Y	Stop	
		R/D/FY	R/FY/R	NC	
	FG/FY(D)	FG/D, D/FY	FY/R	NC	
421- Limited to Stop	R/FY/R	R/FY/D	NA	Stop	
		D/FY/R	D/R/Y	Stop	
		R/D/R	R/R/Y (w/o DV plate)	Stop	
	FY/R(D)	D/R	R/Y (w/o DV plate)	Stop	
		FY/D	NA	Stop	
422- Medium to Clear	R/G/R	R/D/R	R/Y/R	NC	
		D/G/R	D/R/Y	Stop	
		R/G/D	NA	Stop	
	G/R(D)	D/R	Y/R	NC	
		G/D	NA	Stop	
423 - Medium to Limited	R/G/FG	R/G/D	R/Y/R	NC	
		D/G/FG	D/R/Y	Stop	
		R/D/FG	R/Y/R	NC	

Rule	Aspect	Light Out	Downgraded Aspect	Code (Line Circuit) Out
	G/FG(D)	D/FG, G/D	Y/R	NC
424- Medium to Medium	R/G/G	R/G/D	R/Y/R	NC
		D/G/G	D/R/Y	Stop
		R/D/G	R/Y/R	NC
425- Medium to Slow 425a – Medium to Diverging	R/G/FY	R/G/D	R/Y/R	NC
		D/G/FY	D/R/Y	Stop
		R/D/FY	R/Y/R	NC
	G/FY(D)	D/FY, G/D	Y/R	NC
427- Medium to Stop	R/Y/R	R/Y/D	NA	Stop
		D/Y/R	D/R/Y	Stop
		R/D/R	R/R/Y (w/o DV plate)	Stop
	Y/R(D)	D/R	R/Y (w/o DV plate)	Stop
		Y/D	NA	Stop
428 – Diverging to Clear 431- Slow to Clear	R/R/G	R/R/D	R/R/FY	NC
		D/R/G, R/D/G	NA	Stop
	R/G	R/D	R/FY	NC
	G(D)	D	FY	NC
	R/G(D)	D/G	NA	Stop
		R/D	R/FY	NC
432- Slow to Limited 432a – Diverging to Limited	R/FY/FG	R/FY/D	R/R/FY	NC
		D/FY/FG	D/R/FY	Stop
		R/D/FG	R/R/FY	NC
433- Slow to Medium 433a – Diverging to Medium	R/FY/G	R/FY/D	R/R/FY	NC
		D/FY/G	D/R/FY	Stop
		R/D/G	R/R/FY	NC
434- Slow to Slow 434a – Diverging to Diverging	R/FY/FY	R/FY/D	NA	Stop
		R/D/FY	R/R/FY	NC
		D/FY/FY	D/R/FY	Stop
429 – Diverging to Stop 435– Slow to Stop	R/R/FY	D/R/FY, R/D/FY	NA	Stop
	R/FY(D)	D/FY	NA	Stop
430- Diverging 436 – Restricting	R/R/Y	D/R/Y, R/D/Y	NA	Stop
	R/Y(D)	D/Y	NA	Stop
Note: Electronic DV plate shall be considered “w/o DV plate” while using this table.				

Table 18: Intermediate Signal Aspect Downgrade Table

Rule	Aspect	Light Out	Downgraded Aspect	Code (Line Circuit) Out
405- CLEAR	G/R	D/R	FY/R	Downgrade
		G/D	NA	Stop
	G	D	FY	Downgrade
406- Clear to Limited	Y/FG	Y/D	Y/R	Downgrade
407- Clear to Medium	Y/G	Y/D	Y/R	Downgrade
408 – Clear to Diverging 409- Clear to Slow	Y/Y	Y/D	Y/R	Downgrade
411- Clear to Stop	Y/R	Y/D	NA	Stop
412- Advanced Clear to Limited	FY/FG	FY/D	FY/R	Downgrade
413- Advanced Clear to Medium	FY/G	FY/D	FY/R	Downgrade
414- Advanced Clear to Slow	FY/Y	FY/D	FY/R	Downgrade
415- Advanced Clear to Stop	FY/R	FY/D	NA	Stop

5.12 Electric Locking

5.12.1 Signalling System shall incorporate electric locking functions in compliance with AREMA C&S Manual Section 2 – Railroad Signal System, and Section 16 – Vital Circuit and Software Design.

5.12.2 Route Locking

a) All signal routes shall be provided with route locking to prevent the movement of any switch, movable point frog, or derail underneath or in advance of a Train within an established route.

b) The route locking shall vitally prevent any opposing or conflicting train movements within interlocking and Control Point.

c) The sectional release function shall be provided to release the route, locking in sections behind a train moving through a route where possible and applicable without compromising train operation safety.

5.12.3 Time Locking

a) All controlled signals shall be provided with time locking. The time-locking function shall be activated before a signal can be cleared. Once route locking is established, it shall not be released until the time locking function is released.

b) No failure, such as track circuit failure, power failure or VMIS failure, shall release the time locking.

c) Time locking timing shall come into effect when:

i. Approach locking is employed, and the approach section is occupied; or

ii. Approach locking is not employed, and the signal returns to its most restrictive aspect through cancellation by any means other than normal train operation.

d) Time-locking settings shall be computed per AREMA C&S Manual Part 2.4.20.

   i. The predetermined time-locking setting shall be shown on the Program Configuration design in the design package and be documented on the vital software description document.

e) Where an inoperative approach signal or no approach signal is present:

   i. The minimum timer value shall be 60 seconds when the maximum authorized speed does not exceed 15 mph. The vital timer value shall be adjustable from 60 seconds to 1200 seconds.

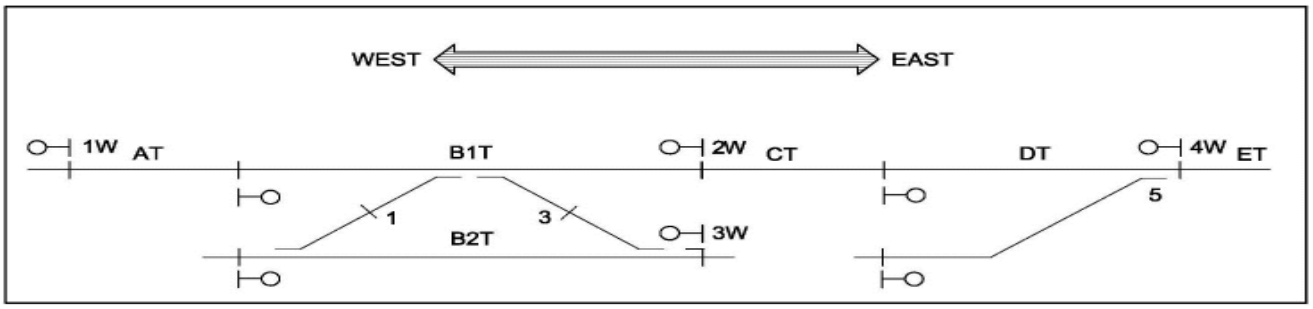
   ii. The minimum timer value shall be 180 seconds when the authorized speed exceeds 15 mph. The vital timer value shall be adjustable from 180 seconds to 1200 seconds.

f) The minimum timer value shall be 180 seconds for all other configurations. The vital timer value shall be adjustable from 180 seconds to 1200 seconds.

g) When a common timer is used for multiple signals, the greatest time calculated shall be used.

h) Refer to Figure 9 for a time-locking scenario. After signal 3W is cleared for a train movement towards signal 1W, time locking shall be in effect as there is no track circuit to the east of signal 3W.

Figure 9: Approach / Time Locking Layout



5.12.4 Indication Locking

a) For Metrolinx application, indication locking applies to the switches interlocked with the Signalling System. If a switch on a route is not established in the desired position, the signal shall not be cleared. After a signal is cleared, and the switch on the cleared route loses correspondence, the cleared signal shall be reverted to its most restrictive aspect.

5.12.5 Detector Locking

a) Detector locking shall be initiated when there is a lack of positive indication of a track circuit vacancy, or when any of the following conditions exist:

   i. Track circuit is occupied within which there is a power-operated switch, movable point frog or a derail;

   ii. A cleared signal has been downgraded to STOP or the most restrictive aspect if any track circuit in the route is occupied or failed;

   iii. For paired powered switch machines, either of the switches has track circuit occupancy.

b) As detector locking is a vital function, no failure of a track circuit or VMIS shall release the detector locking.

c) Once the track circuit indicates that an occupancy no longer exists, detector locking shall be released after the prescribed loss of shunt timing.

5.12.6 Traffic Locking

a) The traffic locking function shall prevent opposing signals to clear routes into the same track section.

b) For sections of track where traffic locking is applicable, the traffic locking shall lock the direction of the traffic whenever:

   i. Any track circuit within that section becomes occupied;

   ii. An interlocking route is requested into that section; or

   iii. Time or approach locking on a route set into the section is in effect.

c) The traffic locking shall prevent a signal clearing a route into a section until the direction of the traffic has been established and locked in the intended direction.

d) No failure, such as power loss or VMIS failure, shall release the established traffic locking.

e) Wherever possible, fibre optic cables shall be designed between adjacent Control Points to transfer the electric locking conditions, fulfilling the traffic locking function.

   i. Electric locking conditions, including route requests, routing locking and signal clearing, shall be transmitted from a Control Point to an adjacent Control Point such that opposing signals at the adjacent Control Point are prevented from clearing.

f) If fibre optic cables are not available, the traffic locking conditions shall be transferred via a coded track circuit to the adjacent Control Point, in which the following transmission delay factors shall be taken into account:

i. The signal delay clearing timer shall be calculated and designed based on the actual field configurations;

ii. 3 seconds shall be considered for each coded track circuit;

iii. 2 seconds shall be considered as the processing time for the adjacent Control Points;

iv. If the above calculation is greater than 12 seconds, consult Metrolinx; and

v. The signal delay clearing timer shall be adjustable from 0 to a value that is 3 seconds multiplied by the number of coded track circuits for that signal seconds.

g) Signal clearing shall not be delayed for Call-On, Return to Train or Switching operations.

h) Cleared signal shall not be affected by any opposing signal request.

5.12.7 Approach Locking

a) Approach locking function shall be provided for all controlled signals, unless otherwise directed by Metrolinx. If approach locking is not currently used at the location, it shall be disabled by vital configuration settings and application ID.

b) No failure, such as track circuit or VMIS, shall release the approach locking.

c) Improper track occupancy of the release tracks shall not release approach locking.

d) Local reset of time locking shall be incorporated into the design for maintenance and testing purposes. This function shall only be implemented during the Local Control Mode. A two-step resetting procedure shall be provided, where the first step is to apply the AS Reset Jumper, and the second is to toggle the ASR reset pushbutton with the signal pushbutton on the Local Control Panel.

e) Intermediate signal locations shall incorporate approach-locking vital outputs. If approach locking is not currently used at the location, it shall be disabled by vital configuration settings and application ID.

5.12.8 Switch Locking

a) Switch locking shall ensure that all the power switches, derails, and movable point frogs are electrically locked while a signal is cleared or the train is moving within the route governed by the cleared signal.

b) The switch locking function shall remain effective during time locking/approach locking/detector locking/route locking/switch blocking/flank protection functions. Track blocking shall not inhibit a switch movement but shall only inhibit a signal route through the blocked track circuit.

c) No failure of a track circuit or VMIS shall release the switch locking.

5.12.9 Sectional Release

a) Signalling System shall incorporate a sectional release function wherever practicable, through which route locking is released in sections behind a train moving through that route.

b) The sectional release function shall release switches, derails, movable point frog and movable bridges in the route as track circuits are sequentially shunted and re-energized through the route, freeing them for other routes.

c) The design of sectional release points in the circuits shall consider the following:

   i. Fouling by equipment that is standing or moving on adjacent or intersecting tracks;

   ii. Movement of switches or establishing another route creating a possibility for equipment fouling; and

   iii. Slack action resulting in the reverse movement of the tail end of the train.

d) Where fouling does not permit immediate sectional release, both the fouling track circuit and the track circuit on the route shall be unoccupied before release can occur.

e) The sectional release points shall be indicated in the specific location, route and aspect and track and signal layout plans. A combination of two of the following notations above the insulated joint where a sectional release point is present will indicate the function and direction available:

   i. "*" shall indicate sectional release is not available in the direction travelled;

   ii. ">" shall indicate sectional release is available for movements travelling in right-bound movement over the insulated joints;

   iii. "<" shall indicate sectional release is available for movements travelling in left-bound movement over the insulated joints.

f) For example, "< >" over an insulated joint indicates sectional release is available in both directions and "* >" over an insulated joint indicates sectional release is only available for right-bound movements.

5.12.10 Loss of Shunt

a) A Loss of Shunt function shall be provided per AREMA C&S Manual Section 16 "Vital Circuit and Software Design Part 16.4.8, Section 2.2.10, Section 2.2.15, Section 2.4.1, Section 2.4.5, Section 2.4.10" to prevent the track circuit from energizing due to the momentary loss of shunt.

   i. For track circuits within a controlled location, the vital timer shall be set to 10 seconds for each track. This timer shall not be made settable to a lesser or greater time in the application program configuration.

ii. For large controlled locations consisting of many track circuits within a route, a jumper input may be provided for software testing purposes to temporarily decrease the OS track vital Loss of Shunt timers to 4 seconds for a duration of 60 minutes. After 60 minutes elapse, the jumper must be removed and reapplied to reset the Loss of Shunt test timers.

5.13 Field Blocking

5.13.1 General Requirements

a) Design contractor shall follow the contract requirements and Metrolinx's directions with respect to the type of the field blocking and locations to be deployed.

5.13.2 Signal Blocking

a) Signal blocking shall be a vital function that has two forms:

i. Entrance blocking; and/or

ii. Exit blocking.

b) The state of signal blocking shall be maintained by the vital logic.

c) Entrance blocking shall ensure no route can be established from the blocked entrance signal.

d) Entrance blocking shall be established only when the signal is not requested, cleared, or fleeted, and Time Locking is not in effect for that signal.

e) Exit blocking shall ensure the selected signal cannot be used as an exit point for any routes, including those that use that signal as part of a through route.

f) Exit blocking shall be applied only when the signal is not part of a cleared route.

g) A request to establish signal blocking on a signal against items d) and f) shall be rejected, an alarm shall be generated, and the route request, established route, and time locking shall not be adversely affected.

h) Initiation and Cancellation

i. Individual signal-blocking initiation and cancellation requests shall only be available from GTCS.

ii. Signal-blocking status indication shall be available on both GTCS and LCP displays.

iii. The blocking request shall be sent to the Signalling System wayside non-vital logic that passes the blocking request on to the vital logic.

iv. The vital logic shall determine whether to place the blocking into effect or not.

i) Failure Mode Performance

i. No failure of a track circuit or VMIS shall release signal blocking that had been previously set.

ii. When applied in a VMIS with or without redundancy, upon total failure and reboot of either the single or both normal and backup VMISs, signal blocks shall be in effect upon VMIS power-up.

iii. If communications between the Control Point and GTCS are intact, the GTCS will initiate a synchronization of the blocking process such that commands initiated at the GTCS while the VMIS was not available will be cancelled.

iv. In a redundant VMIS architecture, if the offline VMIS reboots, all field blocks shall be in effect upon power-up, but the states of the signal blocks shall be read from the online VMIS to synchronize the field block states between the two redundant systems.

v. In a redundant architecture, if the online VMIS is the unit that has rebooted, signal-blocking state synchronization will be done by the GTCS such that commands initiated at the GTCS while the VMIS was unavailable will be cancelled.

5.13.3 Track Blocking

a) Track blocking shall be a vital function.

b) The state of track blocking shall be maintained by the vital logic.

c) Track blocking shall ensure no route, including Call-On, can be established to traverse or enter a blocked track circuit or if the blocked track circuit would be fouling to the route.

i. To accommodate the application of CROR rules 567.2, 567.3, and 618.1 (clear signal into blocked track after Protection Against Restriction has been issued to a movement), the signal shall be cleared into the blocked track circuit if a request is received from the GTCS.

ii. Route shall be cancelled after the route is consumed by the train, and the same procedures will be required if the signal needs to be cleared again.

d) Track blocking shall be designed as a separate function for each individual OS track circuit and exit block.

e) Track blocking shall not affect the ability to move switches located in a blocked track.

f) Track blocking shall be able to be established regardless of the track circuit occupancy status.

g) Track blocking design shall follow recommended design guidelines within AREMA C&S Manual Part 16.4.40.

h) A request to establish a track block for a track circuit that is either part of, or fouling, a cleared, requested, or fleeted route shall be rejected, an alarm shall be generated, and the established route or route request shall not be adversely affected.

i) Initiation and Cancellation

i. Individual track-blocking initiation and cancellation requests shall only be available from GTCS.

ii. Track blocking status indication shall be available on both GTCS and LCP displays.

iii. The blocking request shall be sent to the Signalling System wayside non-vital logic that passes the blocking request on to the vital logic.

iv. The vital logic shall determine whether to place the blocking into effect or not.

v. Track-blocking cancellation requests shall have no restriction, i.e., can be made at any time.

j) Failure Mode Performance

i. No failure of the track circuit or VMIS shall release track blocking that had been previously set.

ii. When applied in a VMIS with or without redundancy, upon total failure and reboot of either the single or both normal and backup VMISs, track blocks shall be in effect upon VMIS power-up. If communications between the Control Point and GTCS are intact, the GTCS will initiate a synchronization such that commands initiated at the GTCS while the VMIS is unavailable will be cancelled.

iii. In a redundant VMIS architecture, if the offline VMIS within a subzone reboots, all track blocks shall be in effect upon power-up, but the states of the track blocks shall be read from the online VMIS to synchronize the track block states between the two redundant systems.

iv. In a redundant VMIS architecture, if the online VMIS is the unit that has rebooted, track-blocking state synchronization will be done by the GTCS such that commands initiated at the GTCS while the VMIS is unavailable will be cancelled.

5.13.4 Switch Blocking

a) Switch blocking shall be a vital function.

b) The state of switch blocking shall be maintained by the vital logic.

c) Switch blocking shall inhibit a specific switch from moving from the blocked position.

d) Switch blocking shall be designed as a separate function for each individual single switch and crossover.

e) Switch blocking shall be able to be established in either normal or reverse position, as long as the switch is in correspondence at the time the switch block request was received.

f) While switch blocking is in effect, the associated switch lock shall be in effect, i.e. the switch shall be locked. This will prevent the switch from moving out of the position in which it was blocked for as long as the switch-blocking function is in effect.

g) Switch blocking shall allow routes over the blocked switch if the position in which the switch is blocked is appropriate for the route.

h) If a switch block request is received from the GTCS for a switch that is out of correspondence, the request shall be rejected, and an alarm shall be generated.

i) The setting of a switch block shall not affect any established routes or any ongoing train movements.

j) Initiation and Cancellation

   i. Individual switch-blocking initiation and cancellation requests shall only be available from the GTCS.

   ii. Switch-blocking status indication shall be available on both the GTCS and LCP displays.

   iii. The blocking request shall be sent to the Signalling System wayside non-vital logic that passes the blocking request on to the vital logic.

   iv. The vital logic shall determine whether to place the blocking into effect or not.

   v. Switch-blocking cancellation requests shall have no restriction (i.e. the request can be made at any time).

k) Failure Mode Performance

   i. No failure of the track circuit or VMIS shall release switch blocking that had been previously set.

   ii. When applied in a VMIS with or without redundancy, upon total failure and reboot of either the single or both normal and backup VMIS, switch blocks shall be in effect upon VMIS power-up. If communications between the Control Point and GTCS are intact, the GTCS shall initiate a synchronization such that commands initiated at the GTCS while the VMIS was unavailable shall be cancelled.

   iii. In a redundant VMIS architecture, if the offline VMIS within a subzone reboots, all switch blocks shall be in effect upon power-up, but the states of the switch blocks shall be read from the online VMIS to synchronize the switch block states between the two redundant systems.

   iv. In a redundant VMIS architecture, if the online VMIS is the unit that has rebooted, switch-blocking state synchronization will be done by the GTCS such that commands initiated at the GTCS while the VMIS was unavailable will be cancelled.

5.14 Special Operations Requirements

5.14.1 Call-On (Following Move Operation)

a) Call-On shall be a vital function that receives non-vital requests from either the GTCS or LCP.

b) Call-On shall be requested by operation of the Call-On control from either GTCS or LCPs.

c) The state of the Call-On shall be maintained by the vital logic.

d) Call-On shall only be cleared to a restricting aspect.

e) Call-On route shall be available to be set when all conditions are favourable for the signal to clear except for the route beyond the exit point (i.e., exit block is down).

i. Call-On shall only be set if there is no track occupancy between the entrance signal and the exit point (all OS track circuits on the route shall be energized).

f) Call-On shall be vitally inhibited if any fouling track to the route indicates occupancy.

g) Whenever a Call-On route is set, inhibit shall be provided to opposing traffic until the route is cancelled or the train movement is completed.

i. Call-On function shall be provided for controlled signals capable of displaying a more permissive aspect than restricting. The restricting aspect for these signals shall be initiated by requesting a "Call-On" regardless of the application requiring that aspect.

ii. The restricting aspect shall change to Stop once the OS track circuit in advance of the signal is occupied.

iii. Call-On function shall be vitally inhibited if the signal blocking or any track blocking is active, regardless of whether the track is inside the route or fouling the route.

iv. Call-On shall be cancelled automatically after the train movement is complete or manually from either GTCS or LCP by cancelling the same signal request.

v. Call-On function shall be disabled when the fleeting function is active for the same signal.

h) Call-On availability status indications shall be provided to both GTCS and LCP.

5.14.2 Return to Train (RTT) Operation

a) For a train coming to a controlled signal and leaving its cars on the approach track to this signal, an RTT function shall be provided to permit the locomotive to return to those cars. The provision of the RTT function shall enable a locomotive to return to the occupied track by the signal clearing the restricting aspect.

b) RTT shall be a vital function that receives non-vital requests from either the GTCS or LCPs.

c) RTT shall use the same request as the Call-On request.

d) The state of RTT shall be maintained by the vital logic.

e) RTT functional design shall comply with the AREMA C&S Manual, Part 16.4.21 recommendations.

f) After an RTT route request is received, the signal logic protecting that route shall clear a restricting aspect only if all conditions are favourable for the signal to clear except for the route beyond the exit point (e.g., the exit block is occupied).

g) RTT route availability status indications shall be provided to the GTCS and LCP.

5.14.3 Switching Operation

a) Under normal circumstances, no route shall be established for a signal where the track sections protected by the signal are occupied, nor shall opposing routes be requested simultaneously. Therefore, a locomotive cannot normally perform switching operations between any opposing signals.

b) However, a switching function shall be provided to permit the opposing routes to be set regardless of the track occupancy status between these opposing signals so that a locomotive can perform switching operations.

c) At some locations, where the need is required, a switching function can be used to relieve the RTC from clearing a signal numerous times.

d) Switching shall be a vital function that receives non-vital requests from either the GTCS or LCP:

i. The state of switching shall be maintained by the vital logic;

ii. Switching function shall permit two opposing routes to be set, with the opposing signals displaying restricting aspects regardless of the track circuit occupancy status between these two opposing signals;

iii. Switching routes and their restricting aspects shall not be cancelled by the train movements;

iv. Switching function shall be allowed only when the switches are locked by the route locking and their correspondences are aligned between these two opposing signals;

v. When traffic circuits are involved, the design shall follow the recommendations from the AREMA C&S Manual, Part 16.4.3, item 3.c;

vi. Where hand-throw switches and/or grade crossings are involved, the design shall follow the recommendations from the AREMA C&S Manual, Parts 16.5.2 and 16.30.9;

vii. Switching function shall comply with switching associated rules specified in CROR;

viii. Either the GTCS or LCP shall be able to request a switching route via switching request and signal request;

ix. Once the switching route is established, Call-On requests to any of the signals involved in the switching route shall be inhibited;

x. Switching status indication shall be available on both the GTCS and LCP displays; and

xi. Switching cancellation shall be possible from either the GTCS or LCP, via the cancellation of the signal.

5.14.4 Fleeting

a) Fleeting shall be a non-vital function used to minimize the number of operator actions required when multiple trains are moving consecutively through the same route.

b) Once set, fleeting shall automatically request a signal to clear for a following move on the same route previously established once a given train has passed beyond the entering track circuit of the interlocking that returned the signal to red (slots off the signal).

c) The fleeting function shall operate by maintaining the entrance selected function in the energized state.

d) The fleeting function shall maintain locking and inhibit sectional release since the signal request is maintained with fleeting.

e) Fleeting shall disable the Call-On and require the block to clear before the signal can become permissive.

f) The fleeting function shall not be available for dwarf signals in yard areas unless otherwise directed by Metrolinx.

g) Fleeting shall be requested by the operation of the fleeting control associated with an individual signal from either GTCS or LCPs.

h) The fleeting request shall be sent to the Signalling System non-vital logic, where checks are made to confirm that a route is established, and the signal has cleared.

i) Fleeting shall be able to be cancelled:

i. With a separate control, with no effect on the signal which has been cleared or requested, from either GTCS or LCP;

ii. If the cleared or requested signal is cancelled, from either GTCS or LCP.

j) The Fleeting status of each signal shall be clearly displayed on both GTCS and LCP.

5.15 Remote, Local, and Field Control

5.15.1 General Requirements

a) This section defines the design requirements for control modes and how to transfer from one mode to another.

b) Signalling System shall have three control modes:

i. Remote Control from GTCS;

ii. Local Control from LCP; and

iii. Field Control from the switch machine.

c) Transfer of control, whether controlled by GTCS or LCP, shall not affect the vitality of the Signalling System nor disrupt or alter any established routes or other controls in effect at the time of the transfer.

d) GTCS shall have all the controls and indications required to control and supervise train operations on the Metrolinx territory. When a field location is in GTCS control, it is referred to as Remote Control Mode. Most of the time, a field location is in Remote Control Mode.

e) LCPs shall be provided at each Control Point. LCPs enable the local control of train operations when required and facilitate maintenance, including troubleshooting and maintenance testing when needed. When LCP controls a Control Point, it is referred to as Local Control Mode.

f) Field Control (FC) is for maintenance testing to control individual switch machines in the field. FC is established from LCP. Proper verbal communications between RTC and field operators are required to ensure that protection is in place.

i. After FC is established from LCP, all switches controlled by the same LCP shall be placed into FC mode. No route can be selected, nor can any switches be thrown at the Control Point by either remote or local controls.

g) The Signalling System shall incorporate measures to prevent any control of the Signalling System, including switches, signals and SCDs from more than one control mode at any given time.

5.15.2 Remote Control Mode

a) Remote control mode shall be the control mode and be available at the Control Point having an intact communication link to the GTCS where the remote control is selected on LCP.

b) The remote control mode shall ensure a field location accepts controls only from GTCS to provide safe and efficient Signalling System control within and around that location.

c) The Signalling System indications and alarms shall be transmitted to GTCS even if the field location is not in the remote control mode.

d) Remote control mode shall allow LCP to issue alarm acknowledgements if and where applicable.

e) The control mode transfer between remote and local shall be seamless, and any set routes or other data shall not be lost or altered during the transfer.

5.15.3 Local Control Mode

a) Local control mode shall be the operation control mode for each field location when an authorized user selects the local control on the LCP and the LCP is healthy.

b) When in local control mode, the Control Point shall only accept controls from the LCP to provide safe and efficient train operations and maintenance within and around that location.

c) The Signalling System indications and alarms shall be available to display on LCP regardless of whether the Control Point is in local control mode.

d) When in local control mode, the transfer to the remote control mode shall be available as soon as the authorized user selects remote control on the LCP, except for the following:

i. If field blocking is designed for the location, the vital input for local global cancellation of the field blockings shall be removed before the control mode can be transferred from Local Control to Remote Control.

5.15.4 Field Control Mode (FCM)

a) FCM shall enable an authorized user to control the switch machine or crossover at the switch for maintenance and testing purposes.

b) FCM shall be the control mode when field control is selected on the LCP and:

i. No routes within the Control Point are established or run time;

ii. LCP is healthy; and

iii. All originally cleared signals shall be cancelled.

c) In FCM, control of the switch machine shall only be possible locally at the machine.

d) When a switch is in FCM, its correspondence status shall be provided to GTCS and LCP.

5.16 Flank Protection

5.16.1 Flank Protection is a means of protecting the movement of a train across junctions by the setting and locking of switches not on the route (either manually or automatically, with automatically being preferred) to prevent being fouled by the movement of any other train.

5.16.2 Flank Protection shall be provided when the following two criteria are met:

a) Two turnouts forming a crossover are both set for parallel routes; and

b) The forcing of the switch or switches will not adversely affect train movements on other legitimate routes.

5.17 Remote Controls and Indications

5.17.1 The Signalling System shall receive remote control from GTCS, and provide indications to GTCS.

5.17.2 Typical Control and Indications

a) Table 19 below defines the typical remote controls and indications for Control Points. The application will vary depending on the configurations of the Control Point to be designed.

Table 19: Typical Controls and Indications

Section	Equipment Type	Controls	Indications
1	Signals	1. Signal Request 2. Signal Cancel 3. Signal Fleeting 4. Signal Fleeting Cancel 5. Signal Call-On 6. Signal Switching 7. Signal Blocking	1. Signal Cleared 2. Signal Fleeted 3. Signal Call-On (exit track) 4. Signal Return to Train (exit track) 5. Signal Switching 6. Signal Light Out (1 per signal) 7. Remote Signal Light Out 8. Signal Route Locked 9. Signal Blocked
2	Switches	1. Switch Normal 2. Switch Reverse 3. Switch Blocking	1. Switch Normal 2. Switch Reverse 3. Switch Locked 4. Switch Overload 5. Switch in Hand Throw 6. Switch Blocked
3	Track	1. Track Blocking	1. Block Track Circuit Occupancy 2. Approach Track Circuit Occupancy 3. Over Switch Track Circuit Occupancy 4. Track Blocked
4	Power		1. AC Power Off / Charger Failed 2. Remote AC Power Off 3. Ground Fault Detected 4. High / Low Battery Alarm 5. Foreign Energy (GEO Location Only) Alarm
5	Switch Clearing Device (SCD)	1. SCD On 2. SCD Off 3. SCD Force-Off On 4. SCD Force-Off Off	1. SCD On / OFF 2. SCD Alarm

Section	Equipment Type	Controls	Indications
6	Miscellaneous Indications		1. Local Control 2. Field Control 3. Code Fail 4. Communication Fail Between VMIS 5. VMIS Health Alarm 6. LCP Health Alarm 7. Bungalow Door Alarm 8. High-Temperature Alarm 9. Low-Temperature Alarm

5.18 Local Controls and Indications

5.18.1 Signalling System shall incorporate local control and indications via LCP. Always consult Metrolinx, the LCP to be designed for the location, prior to the design.

5.18.2 The local control functions shall include the capability to clear or cancel signal requests and position switches for routes, remove field blocking, and control SCD and other miscellaneous functions.

5.18.3 Table 20 below defines the typical local controls, indications, hardware and configuration for Control Point, using Quest LCP as a baseline. The application will vary depending on the configurations of the Control Point to be designed.

Table 20: Typical Local Controls and Indications

Control	Panel Hardware and Configuration	Indication	Panel Hardware and Configuration
Signal	Signal Request pushbutton, 1 per signal; Signal Cancel pushbutton, 1 per signal. Note: For large plants, to save space, it is allowed to combine request / cancel pushbuttons for signals which will never be able to be cleared at the same time.	1. Signal Cleared 2. Signal at STOP 3. Signal Light Out 4. Remote Signal Light Out	1. 1 Red LED, above Signal Request pushbutton, normally dark, solid when the pushbutton is pushed, or request is established in VMIS, extinguished after the pushbutton is released and a signal request is cancelled manually or by train route; flashing when the signal is fleeted. 1 per signal. 2. 1 Red LED, above Signal Cancel pushbutton, normally dark, solid when pushbutton is pushed, extinguished after pushbutton is released. 1 per signal. 3. 1 Green LED on track map representing signal, normally dark, flashing while signal is requested and pending, solid when signal is cleared. 1 per signal. 4. 1 Red LED on track map representing signal, solid when signal is at Stop, normally lit, 1 per signal. Flashing when AS Timer is running. 5. 1 Red LED, on LCP under tracks, normally dark, solid when Signal Light Out (LO) is detected. 1 per signal. 6. 1 Red LED, on LCP under tracks, normally dark, solid when Remote Signal Light Out (RLO) is detected, 1 per track.
Call-On / Return To Train	General Call-On/Return to Train request pushbutton, 1 per location. Work in conjunction with Signal Request pushbutton.	Call-On / Return to Train Conditions are established	1. 1 Red LED, above Call-On/Return to Train Request pushbutton, normally dark, solid when Call-On/Return to Train pushbutton is pushed and extinguished after the pushbutton is released. 1 per location. 2. 1 Amber LED, on exit track, normally dark, solid if Call-on conditions are established, flashing if Return to Train conditions are established. 1 Per exit block. 3. After restricting aspect is granted, the Green LED representing signal on track map shall be lit solid.

Control	Panel Hardware and Configuration	Indication	Panel Hardware and Configuration
Fleeting	Fleeting Request pushbutton, 1 per location; Fleeting Cancel pushbutton, 1 per location. Work in conjunction with Signal Request pushbutton.	1. Fleeting Request 2. Fleeting Cancel 3. Fleeting Cancelled by Signal Cancel	1. 1 Red LED, above Fleeting Request pushbutton, normally dark, solid when Fleeting is requested and extinguished after the pushbutton is released. 1 per location. 2. Same Red LED above the Signal Request pushbutton, flashing after signal is fleeted. 1 per signal. 3. Same Red LED above the Signal is solid when fleeting is cancelled, and signal is not cancelled; is out when signal is cancelled.
Switching	General Switching Signal Request pushbutton, 1 per switching route. Work in conjunction with Signal Request pushbutton.	1. Switching Request 2. Switching Cancelled by Signal Cancel	1. 1 Red LED, above the Switching Request pushbutton, normally dark, solid when switching is requested or switching route is established. 1 per switching route. 2. Same LED above is out when switching route is cancelled.
Approach Stick Reset (ASR)	General ASR pushbutton, 1 per location. Work in conjunction with Signal Cancel pushbutton.	1. ASR On 2. ASR Off	1. 1 Red LED, above ASR reset pushbutton, normally dark, solid when AS Reset activated, flashing 50 minutes after activated, and out after 60 minutes timer expired. 1 per location. 2. Same Red LED above out when ASR is Off

Control	Panel Hardware and Configuration	Indication	Panel Hardware and Configuration
Switch Machine Operation	Normal Switch request pushbutton, 1 per single switch (or crossover); Reverse switch request pushbutton, 1 per single switch (or crossover).	1. Normal Position 2. Reverse Position 3. Switch Locked 4. Switch Overload	1. 1 Red LED, for Normal switch position, flashing when switch is requested normal and out of correspondence, solid when switch is in Normal Correspondence, 1 LED per single switch (or crossover) 2. 1 Red LED, for Reverse switch position, flashing when switch is requested reverse and out of correspondence, solid when switch is in Reverse Correspondence, 1 LED per single switch (or crossover) 3. 1 Red LED, solid when switch is locked, 1 LED per single switch (or crossover) 4. 1 Red LED below the normal switch request pushbutton, solid when pushbutton is pushed, or normal request is established in VMIS, and extinguished after pushbutton is released and normal request becomes false in VMIS, flashing if normal side overloaded. 1 LED per single switch (or crossover) 5. 1 Red LED below the reverse switch request pushbutton, solid when pushbutton is pushed, or reverse request is established in VMIS, and extinguished after pushbutton is released and reverse request becomes false in VMIS, flashing if reverse side is overloaded, 1 LED per signal switch (or crossover).
Switch Clearing Device (SCD) Normal Function	SCD On pushbutton; 1 per location SCD Off pushbutton; 1 per location	1. SCD ON 2. SCD OFF 3. SCD Alarm	1. 1 Red LED above the SCD On pushbutton, solid when SCD On pushbutton is pushed, extinguished after pushbutton is released. 2. 1 Red LED above the SCD Off pushbutton, solid when SCD Off pushbutton is pushed, extinguished after pushbutton is released. 3. 1 Red LED adjacent to SCD On/Off LEDs, solid when all SCD's at the location are on and running, flashing when SCD alarm is detected, 1 per location.

Control	Panel Hardware and Configuration	Indication	Panel Hardware and Configuration
Switch Clearing Device (SCD) Force Off Function	SCD Force Off pushbutton, 1 per location; SCD Force Off Cancel pushbutton, 1 per location.	1. SCD Force Off Request 2. SCD Force Off Cancel	1. 1 Red LED above the SCD Force Off Request pushbutton, solid when SCD Force Off pushbutton is pushed, and extinguished after the pushbutton is released; 2. 1 Red LED above the SCD Force Off Cancel pushbutton, solid when SCD Force Off cancel pushbutton is pushed, and extinguished after pushbutton is released.
Track Occupancy	Indications Only	1. Approach Block (TK) Indication 2. Over Switch (OS) Track Indication	1. 1 Red LED, normally dark, solid when Track is occupied (Code 1 or 5 not received), 1 per exit block 2. 1 Red LED, normally dark, solid when Over Switch track circuit is occupied, 1 per OS track circuit
Power and Temp.	Indications Only	1. Power Off 2. Remote Power Off 3. Ground Fault 4. Low / High Battery 5. Foreign Energy 6. *Generator Running 7. *High Temperature 8. *Low Temperature	1. 1 Red LED, normally dark, solid when Power Off is detected, 1 per location. 2. 1 Red LED, normally dark, solid when Remote Power Off is detected, 1 per location. 3. 1 Red LED, normally dark, solid when a Ground Fault is detected, 1 per location. 4. 1 Red LED, normally dark, solid when a Low or high Battery condition is detected, 1 per location. 5. 1 Red LED, normally dark, solid when a Foreign Energy condition is detected at this location, 1 per location. 6. 1 Red LED, normally dark, solid when the Local Generator is running, 1 per location. 7. 1 Red LED, normally dark, solid when a High Temperature Alarm is detected, 1 per location. 8. Same LED as above, solid when a Low-Temperature Alarm is detected.

Control	Panel Hardware and Configuration	Indication	Panel Hardware and Configuration
Local Control Panel (LCP) Operation Control	3-Way Keyed Selector Switch, 1 Per Location Remote Control Local Control Field Control	1. Local Control 2. Field Control 3. Remote Control	1. 1 Green LED placed in reference to Remote Control key position, solid when location is under Remote Control and out when the key is in any other position, 1 per location 2. 1 Amber LED placed in reference to the Local Control key position, solid when location is under Local Control and out when the key is in any other position, 1 per location 3. 1 Red LED placed in reference to the Field Control key position, solid when location is under Field Control and out when the key is in any other position, 1 per location
Local Control Panel (LCP) Lighting	3 Way Toggle Switch, 1 Per Location Up – LCP Lights On Middle – LCP Lights Off Down – LCP Lights Test	1. LCP Panel Lights On 2. LCP Panel Lights Off 3. LCP Panel Lights Test	1. LCP Panel will light the appropriate LED's on the panel 2. LCP Panel lights will extinguish on the panel 3. Test lighting of all LED's on the LCP.
Local Control Panel (LCP) Equipment Health Indications	To Provide Indications Only	1. Code Fail 2. Comms Fail 3. VMIS Health Alarm 4. LCP Health Alarm 5. Door Alarm	1. 1 Red LED, normally dark, solid when Code Fail is detected, 1 per location. 2. 1 Red LED, normally dark, solid when communication between VMISs failed, 1 per location. 3. 1 Red LED, normally dark, solid if VMIS is unhealthy, 1 per location. 4. 1 Red LED, normally dark, solid if LCP is unhealthy, 1 per location. 5. 1 Red LED, normally dark, solid when any bungalow door opened, 1 per location.
Globally Remove Block	3-Way Momentary Toggle Switch, 1 Per Location Up – Remove Block Request Middle – Not Used Down – Remove Block Request	NA	NA

Control	Panel Hardware and Configuration	Indication	Panel Hardware and Configuration
Block Indication	NA	NA	1. Blue LED above switch on track map, normally dark, solid after the switch is blocked, and flashing when VMIS is powered up or reset. 1 per switch/crossover. 2. Blue LED above the OS track on the tack map, normally dark, solid after the track is blocked, and flashing when VMIS is powered up or reset. 1 per OS track circuit and per exit block.
Notes: 1) "*" is reserved for future, or defined in the contract requirements. 2) Foreign Energy indication only applicable to GEO.			

5.19 Typical Control and Indication bits used in application software

5.19.1 Table 21 - Typical Controls and Table 22 - Typical Indications define the typical controls and indications that shall be incorporated into the LCP and the interface with GTCS, in conjunction with the nomenclatures applied in the application software. Controls shall end with "Z," and indications shall end with "K."

a) The design contractor shall ensure no timing issues with the GTCS system caused by the field equipment, such as execution order problems.

Table 21: Typical Controls

Nomenclature	Sample Nomenclature in Application Software		
	LCP Control	RTC Control	Description
NWZ	L1NWZ (F1NWZ – Field Control)	C1NWZ	Switch 1 Normal Request
RWZ	L1RWZ (F1RWZ – Field Control)	C1RWZ	Switch 1 Reverse Request
GZ	L1WGZ	C1WGZ	Signal 1W Clear Request
STOPZ	L1WSTOPZ	C1WSTOPZ	Signal 1W Stop Request
FLSTOPZ	LFLSTOPZ (1 Per Location)	C1WFLSTOPZ	Signal 1W Fleeting Stop Request
COZ	LCOZ (1 Per Location)	C1WCOZ	Signal 1W Call-On Request
FLZ	LFLZ (1 Per Location)	C1WFLZ	Signal 1W Fleeting Request
SWGZ	LSWGZ	CSWGZ	Signal Switching Request (1 Per Switching Route)
SMZ	LSMZ (1 Per Location)	C1SMZ	SCD On Request
SMOFFZ	LSMOFFZ (1 Per Location)	C1SMOFFZ	SCD Off Request
SMFOZ	LSMFOZ	CSMFOZ	SCD Force Off Request (1 Per Location)

Nomenclature	Sample Nomenclature in Application Software		
	LCP Control	RTC Control	Description
SMFOSTOPZ	LSMFOSTOPZ	CSMFOSTOPZ	SCD Force Off Cancel (1 Per Location)
WBZON	NA	C5WBZON	Switch (crossover) # 5 switch block request on
WBZOFF	NA	C5WBZOFF	Switch (crossover) # 5 switch block request off
OSBZON	NA	C1AOSBZON	OS track circuit 1AT track block request on
OSBZOFF	NA	C1AOSBZOFF	OS track circuit 1AT track block request off
TBZON	NA	C1ETBZON	1ET (exit block) track block request on
TBZOFF	NA	C1ETBZOFF	1ET (exit block) track block request off
Note: Signal blocking (both entrance and exit blocking) are not illustrated here. Design contractor shall submit proposed bit assignment to Metrolinx for approval, if signal blocking (entrance blocking, exit blocking or both) is directed by Metrolinx.			

Table 22: Typical Indications

Indication	Sample Nomenclature in Application Software			Indication Logic to GTCS	
	LCP	GTCS	Description	True (or "1")	False (or "0")
NWK	L1NWK	1NWK	Switch 1 normal	Switch in normal correspondence	Switch not in normal correspondence
RWK	L1RWK	1RWK	Switch 1 reverse	Switch in reverse correspondence	Switch not in reverse correspondence
LK	L1LK	1LK	Switch 1 locked	Switch locked	Switch not locked
NJPK	L1NJPK	1NJPK	Switch 1 in the hand position	Dual control switch in hand position	Dual control switch in power position
OLK	L1OLK	1OLK	Switch 1 overload	Switch overloaded	Switch not overloaded
GK	L1WGK	1WGK	1W signal cleared	Signal Cleared (RGPR False)	Signal not Cleared (RGPR True)
COK	L1WCOK	1WCOK	1W call on stick	Following move stick established	Following move stick not established
RTTK	L1WRTTK	1WRTTK	1WT Return to Train stick	RTT stick established	RTT stick not established
FLK	L1WFLK	1WFLK	1W fleeting established	Signal fleeting established	Signal fleeting not established
SWGK	LSWGK	SWGK	Switching signal cleared (1 Per Route)	Signal in switching mode	Signal not in switching mode
ASK	L1WASK	1WASK	1W signal route locked	Route locked (AS False)	Route not locked (AS True)

Indication	Sample Nomenclature in Application Software			Indication Logic to GTCS	
	LCP	GTCS	Description	True (or "1")	False (or "0")
LOK	L1WLOK	1WLOK	1W signal light out	Signal light out detected	Signal light out not detected
RLOK	LRLOK (1 Per Location)	T1RLOK	Remote light out (remote location on Track 1)	Remote signal light out detected	Remote Signal light out not detected
POK	LPOK	POK	Local AC power off / charger failure	AC power off / charger failure	AC power on / charger healthy
RPOK	LRPOK	T1RPOK	Remote power off (remote location on Track 1)	Remote power off detected	Remote power off not detected
SMK	LSMK (1 Per Location)	SMK	SCD operating	SCD operating	SCD not operating
SMALK	LSMALK (1 Per Location)	SMALK	SCD in alarm	SCD in alarm	SCD not in alarm
TK	L1TK	1TK	1T OS occupancy	Track occupied	Track not occupied
TK	L1WTK	1WTK	1WT occupancy	Track occupied	Track not occupied
BK	L1WBK	1WBK	Track 1 west block(s) occupancy	Block(s) occupied	Block(s) not occupied
LOCALK	LLOCALK	LOCALK	Site in local control	Local control	Not local control
FIELDK	LFIELDK	FIELDK	Site in field control	Field control	Not field control
ASRESETK	LASRESETK	Not Applicable	AS timer reset (LCP function only)	AS reset	AS not reset
LCPHTHK	LLCPHTHK	LCPHTHK	Local control panel health	LCP healthy	LCP not healthy
VMISHTHK	LVMISHTHK	VMISHTHK	VMIS health status	VMIS healthy	VMIS not healthy
DOORK	LDOORK	DOORK	Bungalow door	Door open	Door closed
*GENK	*LGENK	*GENK	Generator running	Generator running	Generator not running
*HITEMPK	*LHITEMPK	*HITEMPK	High Temperature alarm	High temperature detected	High temperature not detected
*LOWTEMPK	*LLOWTEMPK	*LOWTEMPK	Low-Temperature alarm	Low temperature detected	Low temperature not detected
HGHBATTK	LHGHBATTK	HGHBATTK	High battery	High battery voltage detected	High battery voltage not detected

Indication	Sample Nomenclature in Application Software			Indication Logic to GTCS	
	LCP	GTCS	Description	True (or "1")	False (or "0")
LOWBATTK	LLOWBATTK	LOWBATTK	Low Battery	Low battery voltage detected	Low battery voltage not detected
FEK[2]	LFEK	FEK	Foreign Energy (GEO only)	Foreign energy detected	Foreign energy not detected
GFK	LGFK	GFK	Ground Fault	Ground fault detected	Ground fault not detected
CODEFAILK	LCODEFAILK	CODEFAILK	Code Failure	Code failure detected	Code failure not detected
COMMK	LCOMMK	COMMK	Communications failure between VMIS	Communication failure detected	Communication failure not detected
WBLKON[3]	L1WBLKON	1WBLKON	Switch (crossover) 1 blocking on	Switch (crossover) 1 blocking on	NA
WBLKOFF[3]	L1WBLKOFF	1WBLKOFF	Switch (crossover) 1 blocking off	Switch (crossover) 1 blocking off	NA
OSBLKON[3]	L1AOSBKON	1AOSBKON	1AT blocking on	1AT blocking on	NA
OSBLKOFF[3]	L1AOSBKOFF	1AOSBKOFF	1AT blocking off	1AT blocking off	NA
TBLKON[3]	L1WTBKON	1WTBKON	1WT block blocking on	1WT blocking on	NA
TBLKOFF[3]	L1WTBKOFF	1WTBKOFF	1WT block blocking off	1WT blocking off	NA

Notes
[1] "*" is reserved for future, or defined in the contract requirements.
[2] FEK is only available at GEO locations, and only reset is required.
[3] Signal blocking (both entrance and exit blocking) are not illustrated here. Design contractor shall submit proposed bit assignment to Metrolinx for approval, if signal blocking (entrance blocking, exit blocking or both) is directed by Metrolinx.

5.20 Track and Cable Plan

5.20.1 The Track and Cable Plan for the affected controlled block shall be updated whenever the wayside signal system and crossing warning system is altered. An agreement is needed with Metrolinx for areas where changes are made by overlapping projects, but otherwise, the Track and Cable Plan should be issued as one complete file, including the entire subdivision and areas with or without the changes.

6. Grade Crossing Warning System

6.1 General

6.1.1 Grade Crossing Warning System (GCWS) devices on public crossings shall include flashers, bell(s), and gates. Gates shall include both entrance (and exit, if required) gates, to block road traffic, and pedestrian gates if there is a sidewalk.

a) The pedestrian gates shall operate in unison with the entrance gates.

b) Flashers shall operate in unison.

6.1.2 The design and placement of the warning devices shall comply with the following:

a) Transport Canada Grade Crossings Standards, Grade Crossing Regulations, and Grade Crossings Handbook;

b) AREMA C&S Manual Section 3 "Highway-Rail Grade Crossing Warning System"; and

c) The following GO Transit Signal & Communications Standards - Codes of Practice:

i. SCP-702 - Preferred Locations for S&C Housings at Highway Crossings;

ii. SCP-703 - Cantilever Type Signal Structures and Flashing Light Signal Requirements at Road Crossing Warning Systems;

iii. SCP-704 - Location and Clearance of Highway Crossing;

iv. SCP-705 - RCWS Safety Assurance Process;

v. SCP-706 - Road Crossing Device Light Unit Alignment Procedures; and

vi. SCP-709 - Procedures to be followed by S&C Employees in the Deactivation of Road Crossing Warning Systems.

6.1.3 The placement of the warning devices shall consider sightlines determined per the Grade Crossing Standards, Section 7.

6.2 Grade Crossing Safety Assessment

6.2.1 Design Contractor shall conduct a Crossing Safety Assessment (CSA) for the Grade Crossing equipment with GCWS to be modified or added.

a) Design contractor may use the existing CSA report provided by Metrolinx as the baseline for the CSA.

b) Design contractor is not required to conduct the CSA for minor changes (such as replacing incandescent bulbs with LEDs), and such requirement is specified in the contract requirements.

6.2.2 CSA shall be performed per the following:

a) Grade Crossing Handbook Article 31;

b) Canadian Road/Railway Grade Crossing Detailed Safety Assessment Field Guide, which provides a comprehensive guide for conducting grade crossing safety assessments; and

c) GO Transit Signals & Communications Standards - Codes of Practice provide additional information concerning evaluating Grade Crossings:

i. SCP-1210-5 Road Crossing Train Movement Data, to be used by the design contractor to determine and record train movement data;

ii. SCP-1210-6 Road Crossing Inspection Data, to be used by the design contractor to determine and record the proposed crossing warning system and warning device, location and road details, photographs, track data, track layout details, excavation data, power service data, clearance data, and hardware data (additional lights, cantilevers, switches in the approach); and

iii. SCP-1210-7 Road Crossing Vehicular Traffic Data is to be used by the design contractor to determine and record road data, road measurement, center line of the road, and interconnections.

6.2.3 While conducting the CSA design contractor shall fill the SCP 1210 forms (or forms in a similar format) for each road approach to the Grade Crossing to indicate the posted speed limit and the distance from the crossing to the obstruction or change in road direction that would prevent a clear view of the warning devices. The SCP 1210 form shall also indicate the distance from the crossing of all road accesses or intersections within 90 m (300 ft).

6.2.4 Design contractor shall provide CSA to Metrolinx for review, approval and record.

6.3 Grade Crossing Risk Assessment

6.3.1 Design contractor shall prepare a Risk Assessment identifying the risks which are not identified in CSA but do pose a danger to both road users and train operations, and the associated mitigations.

6.3.2 Design contractor shall provide RA to Metrolinx for review, approval and record.

6.4 Constant Warning Time Device (CWTD)

6.4.1 Design contractor shall design CWTD located in GCWS bungalows. CWTD shall be physically separated from the wayside bungalow for CTC Signal System applications.

a) If it is not feasible to separate CWTD from the CTC Signal System wayside bungalow, CWTD shall be physically separated from the CTC Signal System by having its own chassis, power bus, battery bank(s) and charger(s).

i. If CWTD battery bank(s) and charger(s) are combined with the CTC Signal System applications, the battery capacity shall consider the backup hours of both the CWTD and the CTC Signal System applications.

6.4.2 Control circuits that affect the safe operation of a CWTD shall activate the warning device if there is failure of a safety-critical component.

a) Control circuits shall prevent nuisance warnings during normal operations.

6.4.3 The CWTD shall include:

a) Constant Warning Activation Time (CWAT) such that the system:

i. is triggered by the approach and presence of any train; and

ii. accommodates all possible approach speeds.

b) Automatic deactivation of GCWS that has been activated for a train that has stopped for a predetermined amount of time (configurable) prior to the Grade Crossing;

c) The subsequent reactivation of the GCWS if the stopped train has resumed movements towards grade crossing;

d) The subsequent reactivation of the GCWS by the Operating crew of a train using commands entered on a Dual Tone Multi-Frequency (DTMF) keypad; and

e) Monitoring devices and recorders.

6.4.4 For the determination of train speed and position, the preferred technology currently in use in Metrolinx territory is a "crossing predictor," which is a device that can determine a train's speed and distance from the crossing and deduce the arrival time of the train at the grade crossing. The predictor provides the ability to provide a CWAT independent of the train's approach speed.

6.5 Island Circuit

6.5.1 The GCWS shall include an island track circuit that extends a minimum of 50 feet beyond both edges of the road (or sidewalk, if present) to detect a train within the grade crossing limits. In urban areas, an external DC track circuit with insulated joints shall be provided for the island, whereas in suburban areas, it is permissible to use the internal island of CWTD without insulated joints.

6.5.2 The GCWS shall be designed with a configurable LOS timer with an adjustment range of 0 to 5 seconds for both the external DC island or the internal island. The preferred setting is 2 seconds, unless otherwise directed by Metrolinx.

6.6 Adjacent Grade Crossings (DAXing or Remote Start)

6.6.1 DAXing (or remote start) shall be provided at a Grade Crossing where the train detection zone overlaps an adjacent grade crossing, either because the two adjacent crossings are closely spaced or because the Grade Crossing has long approach track circuits due to high train speeds. DAXing shall be provided when activating the warning system of a given Grade Crossing requires input from the adjacent upstream grade crossing on detecting an approaching train to achieve a constant warning time.

6.7 Crossing Frequency Selection and Ballast Resistance

6.7.1 The crossing approach frequency shall be selected based on the ballast resistance, approach distance, and any adjacent or conflicting frequencies on the rails and per manufacturers' specifications. Only common frequencies shall be used and high impedance termination shunts unless otherwise approved by Metrolinx.

6.7.2 If a crossing approach is terminated with a narrow band shunt, then a multi-frequency type shall be used in lieu of a fixed frequency unit to reduce maintenance spares. Such equipment shall be clearly marked on the Track Layout Plan, including details on strap placement or connections and dummy load(s).

6.7.3 The crossing approach distances for Grade Crossing Warning Systems shall be based on a ballast resistance of 2 ohms per 1000 feet.

a) Any deviation from 2 ohms per 1000 feet shall require approval from Metrolinx.

6.8 Grade Crossing Warning System Circuit Design

6.8.1 The design contractor shall provide GCWS circuit design for any alterations to an existing GCWS or the addition of a new GCWS. The alterations to an existing Grade Crossing may include:

a) Temporary GCWS to accommodate grade separation projects;

b) Design and installation of additional track(s);

c) Increase or decrease in track speed(s) for any or all types of trains;

d) Increase or decrease in road speed(s), and volumes of road users, or road alterations such as widening of the road, additional lanes, the addition of sidewalks;

e) Addition or removal of signal equipment, including the installation or removal of signals or switches, within the approach of the Grade Crossing; and

f) Safety enhancements include the addition of pedestrian gates, and upgrades for compliance with Grade Crossing Standards and Grade Crossing Regulations.

6.8.2 GCWS circuit design shall include the following as a minimum:

a) Index. Including:

i. Index number, title of the drawing, latest revision, date of the latest revision, page number;

ii. When new pages are needed, they shall be added at the end of the existing ones, and pages will be numbered starting with the following number; and

iii. Index will be on page 1, Signal Location (SL) on page 2 and so on.

b) Signal Location layout (SL) plan, including:

i. Crossing angle;

ii. Approach distances for all directions and all tracks;

iii. Crossing warning device layout including distance from the centerlines of the warning devices to the curb or edge of the road and distance to the gauge of rail (distance to gauge of rail to the closest part of the warning device, either the centerline of the warning device or the gate arm if the crossing angle is not 90 degrees, shall be minimum 12' unless otherwise directed by Metrolinx);

iv. Equipment response time (per the manufacturers' instructions);

v. Gate arm clearance time;

vi. Gate descent time (13 seconds unless otherwise directed by Metrolinx);

vii. Gate Horizontal time;

viii. Buffer time (5 seconds unless otherwise directed by Metrolinx);

ix. Pre-emption time;

x. Design speed (both rail and road);

xi. Clearance distance length and impact on the warning time;

xii. Design Vehicle class used to determine the gate delay;

xiii. Road gradient used to determine the gate delay;

xiv. Total warning time for crossing activation;

xv. Total time for crossing approach; and

xvi. Both imperial (feet and inch) and metric (meter) units shall be used for dimensions.

c) Track Layout Plan including:

i. Track and signal layout;

ii. Crossing predictors and frequencies;

iii. Crossing warning device layout;

iv. Crossing circuits, including termination shunts and frequencies, bypass couplers and frequencies. This includes all part numbers and strapping details, if applicable;

v. Adjacent crossing connections (DAXing or remote start if necessary);

vi. Interface to CTC signal system circuits (i.e., any DC island interfaces);

vii. Bungalow (size, orientation, name (i.e., R.C. 331.21), power off lights, test switch, entrance doors, DTMF and/or data radio capabilities);

viii. Power Services, including accurate location and capacity; and

ix. Interconnection with Traffic Signals where applicable.

d) Circuit diagrams include:

i. Crossing predictor circuit;

ii. Crossing controller circuit;

iii. Interconnection circuit;

iv. Gate and flasher circuits;

v. Deactivation jumper schematics;

vi. VHF connections (DTMF for public crossing); and

vii. Data communications.

e) Event recorder.

f) Program configurations of all electronic equipment in the bungalow.

g) AC and DC power distribution.

h) Layout including:

i. Equipment racks;

ii. Bungalow walls (all sides);

iii. Bungalow layout (plan view);

iv. Main terminal board; and

v. Equipment layouts.

i) Deactivation jumper schematics.

j) Wiring details on terminals and relay contacts.

k) Logic Activation Diagram.

6.9 Crossing Warning Time & Approach Calculations

6.9.1 The Grade Crossing warning time shall be calculated per articles 16.1 “Warning Time” and 16.2 “Consistency of Warning Times” of the Grade Crossings Standards.

6.9.2 Grade Crossing approach distance calculations shall be per AREMA C&S Part 3.3.10 "Recommended Instructions for Determining Warning Time and Calculating Minimum Approach Distance for Grade Crossing Warning Systems. "

6.9.3 The approach distance shall consider equipment response, integrity check and switching times.

a) Equipment response time shall account for relay response time and communications latency time for remote starts.

6.9.4 A buffer time of 5 seconds (minimum) shall be provided to accommodate minor variations in train handling, track circuit variability and allowable tolerance within the train speed measurement apparatus.

a) For Grade Crossing in the vicinity of the station platform, the buffer time shall be calculated based on the worst-case train acceleration towards the Grade Crossing from the station platform.

b) The buffer time is the time lost, assuming the train continues accelerating on the crossing approach from the station platform.

c) If the calculated buffer time is longer than 5 seconds, the calculated time value shall be built into the total warning time.

6.9.5 If a station stop is within a crossing approach, the settings from the previous design must be analyzed, and if there are no other options available in the new equipment, they must be reused and validated through the testing and commissioning process. If the new equipment has new features to cope with accelerating trains, these must be used. If the designer considers that the old setting are not appropriate, Metrolinx must be consulted.

6.10 Flasher

6.10.1 12" LED signals shall be used for the flashing signals installed on the signal mast and/or cantilever.

6.10.2 Flashing signal shall be numbered sequentially, starting from 1 for each signal mast or cantilever. Odd numbers (i.e., 1, 3, etc.) are for the signals on the field side, and even numbers (i.e., 2, 4, etc.) are for the signals on the roadside (this would make numbers 1 and 2 for the approach side, and numbers 3 and 4 for the backlights). The gate arm lights shall begin after the last 12" LED signal number and be sequentially numbered.

a) Signal mast and cantilever shall be numbered sequentially, starting from 1 for the signal mast on the north (west) side.

b) Cantilevers shall be numbered following the signal masts, starting from the cantilevers on the north (west) side.

c) Signal mast for pedestrian gates shall be numbered following the road signal masts and cantilevers, starting from the signal mast on the north (west) side.

6.11 Gate Arm

6.11.1 The gate arm shall be installed perpendicular to the longitudinal axis of the road approach.

6.11.2 The gate arm clearance time is the time, in seconds, that a design vehicle will take to travel from either the Stopping Sight Distance (SSD) position or the Stop position, prior to the gate, to a point beyond and clear of the gate arm.

6.11.3 Given that many grade crossings are unique, a design calculation for each crossing shall be provided for the gate arm clearance time as shown in the Grade Crossing Standards section 10.4, "Gate Arm Clearing Time."

a) Gate arm clearance time for pedestrian gates shall be calculated per the Grade Crossing Handbook, section 10.4.2.

6.11.4 The gate arm's decent and ascent time shall be designed based on the manufacturer's recommendations and Grade Crossing Standards Article 15.2.2.

6.12 Signs and Road Marking

6.12.1 The traffic and railway signs and road markings shall comply with the Transport Canada Grade Crossing Standards, Section 8, "Signs."

6.12.2 In addition, the road markings for grade crossings shall comply with the Manual of Uniform Traffic Control Devices (MUTCD) for Canada.

6.13 Battery BackUp

6.13.1 The design shall comply with the Grade Crossing Standard requirement to provide warning system battery backup for 8 hours of continuous activation or 24 hours of normal railway operations, whichever is greater.

6.14 Power Off Lights

6.14.1 In addition to a reliable battery backup, GCWS shall be equipped with two LED power-off lights, clearly visible from 100 feet, from both railway and road approach during normal sunlight conditions. One power-off light shall be placed above the bungalow entrance door to draw the attention of the Operating crew of the train, and another power-off light shall be placed on the roadside to draw the attention of the maintainers and the passing road traffic.

6.14.2 The power off lights shall:

a) Be continuously lit during normal operating conditions; and

b) Flash to indicate a defect per CROR 103.1(h), including AC power off, charger failure, or if a deactivation jumper is applied.

6.14.3 The power-off light model shall be VELCORP GEMS LC2-001WB-WG4.

6.15 Battery Chokes and Track Filters

6.15.1 Choke coils shall be provided at the battery end if Grade Crossing train detection is used anywhere within the confines of a DC track circuit. This applies to DC track circuit battery feed, and track circuit relay feed where the relay coil is 1 ohm or less.

6.15.2 Design contractor shall design the track filters following the manufacturer's instructions if Grade Crossing train detection is in the vicinity of the coded track circuit.

6.15.3 Design and installation space for 60 Hz and associated harmonic filters must be provisioned. Their optional wiring must be shown on the plans, and installation instructions must be left in the logbook. This filter may be needed if there is power grid induction into the rails post-installation and commissioning.

6.16 Road Traffic Signals

6.16.1 An Interface with Road Traffic Signals is required to activate or change the sequencing of road traffic signals, at location where there are queuing issues at the crossing surface; or when an advance warning signal is required, at a location where the sighting distance within the Stopping Sight Distance (SSD) is inadequate. The function of this interface is also referred to as preemption.

6.16.2 The design of the interconnection of the GCWS with traffic signals shall comply with:

a) Section 19 of Transport Canada's design standards for pre-emption of traffic signals; and

b) Part 3.1.10 of the AREMA C&S Manual.

6.16.3 Design contractor shall coordinate with Metrolinx for Grade Crossing with existing or new interconnections with road traffic signals and shall ensure the interface meets the requirements of each road authority.

6.16.4 The GCWS shall design a manual test switch that:

a) Initiates a pre-emption signal where the interconnection is for an advance warning signal or for queue-cutter traffic signals to display stop; and

b) Initiates or does not initiate a clear-out phase of the traffic signals before activation of GCWS, per the individual road authority's requirements and Metrolinx's directions.

6.17 Manual Grade Crossing Activation and Deactivation

6.17.1 The GCWS shall provide the manual activation and deactivation via:

a) Dual Toned Multi-Frequency (DTMF) links (initiated within the cab of the train, hi-rail equipment or maintenance personnel); and

b) The manual test switch. The test switch must have its positions labelled: NORMAL, TEST, and EMERGENCY.

6.17.2 The GCWS shall provide deactivation jumpers for applicable approaches and islands per the following:

a) Deactivation jumper terminals shall be located together in one area on the wall in the bungalow, clearly visible to maintainers;

b) Deactivation jumper shall have caps and shields to help prevent unintended deactivations;

c) Deactivation jumper terminals shall be installed on the jumper panel with a yellow surface and clearly identified jumper number;

d) Deactivation jumper function and terminal numbers shall be clearly marked in the plan set with instructions to maintainers;

e) Deactivation jumpers shall remove one entire track of approaches and islands per jumper unless crossovers or other operational considerations can be used within the approach when the track is deactivated. In this case, function and assignment shall be proposed by the design contractor and approved by Metrolinx; and

f) Whenever the deactivation jumper is applied, the power-off lights shall be flashing.

6.18 Event Recorder

6.18.1 Event recorder shall be provided for GCWS with sufficient capacity to record the following vital and non-vital events:

a) AC power on / off;

b) Charger failed;

c) Gate up (1 per gate);

d) Gate down (1 per gate);

e) EMG fault operations (gate arm knocked off / pumping);

f) Warning device health (bell and flashing lights);

g) Crossing predictor and controller health;

h) Ground fault;

i) Battery high and low voltage;

j) Warning system active;

k) Warning time;

l) Pre-emption active;

m) Approach track circuit;

n) Island occupancy;

o) DAXing or remote start;

p) DTMF activation;

q) Test switch activation;

r) Deactivation jumper; and

s) Data recorded in GCWS;

6.19 Crossing Remote Controls and Indications

6.19.1 Metrolinx will gradually implement remote reporting functions for remote monitoring and diagnostics purposes.

a) Design contractor shall design the infrastructure to support the remote reporting function.

6.19.2 Remote reporting functions shall follow AREMA C&S Manual Part 3.1.29.

6.19.3 Table 23 below defines the typical remote indications for a grade crossing warning system. The application will vary depending on the configurations of the Grade Crossing Warning System at individual crossing locations.

a) Remote control is reserved for the future.

Table 23: Grade Crossing Remote Indications

Equipment Type	Function Description	Indications	Indications True	Indications False
Activate Crossing	Crossing Activated by Train	Future	NA	NA
Crossing Controller	Warning Activated	XK	Crossing Not Activated	Crossing Activated
	Health	CHEALTHK	Controller Healthy	Controller not Healthy
Train Detection	Predictor Health	PHEALTHK	Predictor Healthy	Predictor not Healthy
	Constant Predictor	MDK (1MDK, 2MDK, ….)	Approach not Occupied	Approach Occupied
	Island Track Circuit	ISLK	Island Not Occupied	Island Occupied
	DTMF	DTMFK	DTMF not Activated	DTMF Activated
	Test Switch Opened / Closed	TESTSWK	Test Switch Closed	Test Switch Open
	Test Switch Up	TESTSWUPK	Test Switch at Gate Up Position	Test Switch Not at Gate Up Position
	Remote Activation	DAXK (e.g., 1WDAXK)	Remote not Started	Remote Started
	Pre-Emption	PREEMPK	Preemption Not In Effect	Preemption In Effect

Equipment Type	Function Description	Indications	Indications True	Indications False
Flashing Light Signals and Bell	Flashers Operating	FLASHK	Signals Flashing	Signal Not Flashing
	Flasher Light Out	FLASHLOK	Signal Light OK	Signal Light Out
	Bell Operating	BELLK	Bell On	Bell Off
Gate	Gates Up	GPK (1GPK, 2GPK, …)	Gate Up	Gate not Up
	Gates Down	GDK (1GDK, 2GDK, …)	Gate Down	Gate not Down
EGM (electronic gate mechanism)	Fault Operations	EGMK (1EGMK, …)	Normal	Faulty
AC Power, Battery and Faults	Power On	POK	AC Power On	AC Power Off
	Ground Fault Detected	GFK	Grounded	Not Grounded
	Low Battery Alarm	LOWBATTK	Low Battery Voltage Alarm	No Low Battery Voltage Alarm
	High Battery Alarm	HIGHBATTK	High Battery Voltage Alarm	No High Battery Voltage Alarm
	Charger Health	CPOK	Charger Healthy	Charger Fail
Bungalow Door	Door(s) open / close	DOORK	Door closed	Door open
Deactivation Jumper	Deactivation Jumper Applied or Not	JUMPK	Jumper Not Applied	Jumper Applied
Communication Status	NV Communications Link Health	NVCOMHLTHK	Comms OK	Comms Fail
	Vital Communications Link Health	VCOMHLTHK	Comms OK	Comms Fail

7. Defect Detection System

7.1 Introduction

7.1.1 Defect detection equipment shall comply with AREMA C&S Manual Section 5 – Defect Detection Systems, and GO Transit Signals and Communications Standards, SCP 921 – Wayside Inspection System (WIS) Site Selection Guidelines.

7.1.2 Metrolinx continually develops and utilizes various systems to detect the changing physical condition of the track roadbed and embankments caused by unforeseeable environmental events, as well as wayside inspection devices to detect potentially hazardous equipment defects. Depending on the design, these systems may detect and report hazards and defects differently. Failures may be detected mechanically or electronically, and the failure may be reported to train crews via a train-to-wayside radio, reported as an alarm to the GTCS and/or acted upon by the CTC Signal System.

7.1.3 The following sections provide requirements for the various types of defect detectors that shall be provided per the specific contract requirements.

7.2 Railway Grade Failure Detector

7.2.1 Railway Grade Failure Detectors, also referred to as Washout Detectors (WOD) or Ballast Integrity Sensors (BIS), are trackside devices that will guard against the possibility of derailments by detecting ballast erosion or shifting of ballast and the sub-grade beneath the railway tracks.

7.2.2 The WOD or BIS shall transmit alarms directly to the wayside CTC Signal System, then to GTCS, or to GTCS.

7.2.3 The WOD shall broadcast alarm messages to the Operating crew of a train.

7.2.4 The WOD or BIS shall comply with:

a) AREMA C&S Manual Section 5.1.13 – Recommended Design Criteria for Ballast Integrity Detectors.

7.3 High Water Alarm Detector

7.3.1 High Water Alarm Detectors (HWADs) shall monitor the rise of water that could impair the loading capability of the track structure or of a bridge and/or create inadequate clearance for boats on navigable waters to pass under railway bridges.

7.3.2 The HWAD shall transmit alarms to the wayside CTC Signal System, then to GTCS, or to GTCS directly.

7.3.3 The HWAD shall broadcast alarm messages to the Operating crew of a train.

7.4 Wayside Inspection System

7.4.1 The Wayside Inspection System (WIS) comprises trackside devices that shall monitor various equipment components of a train as it passes an inspection point and report any exceptions to normal operational levels, including detection of:

a) Hot Journal/Bearing (HBD);

b) Hot Wheel (HWD);

c) Dragging Equipment (DD).

7.4.2 The WIS shall broadcast alarm messages to the Operating crew of a train and transmit alarms to GTCS.

7.4.3 The WIS devices shall comply with the following:

a) AREMA C&S Manual Section 5.3.11 – Recommended Instructions for Inspection and Test of Wayside Inspection Systems; and

b) GO Transit Signals and Communications Standards SCP 901, SCP 902, SCP 921, GI 301(h), GI 501, and GI 501(a).

7.5 Wheel Impact Load Detector

7.5.1 Wheel Impact Load Detectors (WILD) shall measure wheel loads to identify out-of-round conditions or flat spots.

7.5.2 The WILD shall detect impact loads greater than 90,000 lb, which is specified in Rule 41 of the AAR Interchange Manual as the threshold for wheel replacement.

7.5.3 The WILD shall transmit alarms to the Willowbrook Yard Mechanical Department, but no further action is required on the wayside CTC Signal System or GTCS.

7.6 Automatic Equipment Identification

7.6.1 The Automatic Equipment Identification (AEI) devices shall read AEI tags affixed to the trains that comply with AAR standard S-9203. The AEI reader system shall be able to generate "clean consist lists" where a clean consist is defined as: "A train consist, properly identified in standing order, where the orientation of tagged equipment is provided, location of untagged equipment moving on wheels is provided, and the total count is accurate."

7.6.2 The AEI reader shall comply with AAR RP-9203.

7.6.3 The CTC Signal System shall not take any action in terms of stopping or alarming trains due to the output of the AEI devices.

7.6.4 The AEI devices shall comply with:

a) AREMA C&S Manual Section 5.3.2 - Recommended Instructions for Automatic Equipment Identification (AEI), System Site Configuration and Section 5.3.12 - Recommended Instructions for Inspection and Test of Automatic Equipment Identification (AEI) Reader Systems, and

b) GO Transit Signals & Communications Standards GI 301(h), GI 336, GI 336(a), and GI 336(b).

8. Data Communications System

8.1 CTC Signal System Location

8.1.1 VMIS shall include Ethernet ports to support interface with adjacent VMISs, and include serial and/or Ethernet ports to interface with a non-vital system such as the GTCS.

8.1.2 Communications between a VMIS and the GTCS shall be redundant.

a) Redundant fibre (ring topology preferred) shall be the preferred means of communication.

b) ATCS data radio and LTE shall be the primary and secondary means of communication respectively, for locations where fibre is not feasible.

i. Dual LTE is the primary and secondary means of communication at the Guelph subdivision.

8.1.3 Design contractor shall design the data communication infrastructure in the field to support the interface with GTCS, and the remote monitoring and diagnostic functions.

8.2 Grade Crossing Location

8.2.1 The primary means of communication between GCWS and the NOC/BRC shall be via a fibre optic connection. A LTE connection is acceptable where fibre is unavailable; however, the fibre connection capabilities shall be reserved in the design.

8.2.2 Besides the remote monitoring and diagnostic function, grade crossing location may be required to provide CCTV and Intercommunication between the crossing location and NOC/BRC.

8.2.3 Design contractor shall design the infrastructure in the field to support such data communications.

9. Power Service

9.1 General

9.1.1 The AC power shall be designed for 120V/240V and/or up to 600 V applications, depending upon the utilities available at the location and the actual applications.

9.1.2 Utility service shall be 200A (nominal). A suitably rated isolation device shall be placed after the meter with a lockable enclosure. The handle shall also be lockable in the energized or de-energized position.

9.1.3 Design contractor shall coordinate with utilities for AC power service requirements.

9.1.4 The AC power distribution shall be designed from the utility drop to a NEMA 4X rated power case, and then distributed from the power case to the equipment house and SCD;

a) Equipment house power feed shall be designed for 100A (nominal).

b) SCD power feed shall be determined from the manufacturers' specifications and shall take into consideration future upgrades and expansions. If required, start delay timing shall be provided to stagger the start times of the SCDs and clearly stated in the signal plans for each SCD.

9.1.5 Step-up and step-down transformers shall be provided as necessary.

a) Transformer shall be placed outside the equipment house.

b) Transformers shall be dry-type and CSA-approved.

c) Transformers shall be in a NEMA 4X enclosure if not rated for outdoor use.

9.2 Design Submittals

9.2.1 The design contractor shall provide an electrical design including the following:

a) Single line power distribution diagram, including breaker sizes, wire gauge sizes, type of cable, etc.;

b) Bill of Material (BOM);

c) Cable routing diagram, including design of conduit and typical trench cross sections, if applicable;

d) Power calculations;

i. Load calculations;

ii. Product sizing;

iii. Voltage drop; and

iv. Breaker coordination study.

9.2.2 Design contractor shall produce the following additional analysis when directed by Metrolinx to show compliance for the mitigation of electrical hazards for the AC power distribution system:

a) Arch flash analysis;

b) Lightning protection analysis;

c) Grounding and bonding study; and

d) Step and touch potential analysis.

10. Gas Distribution and SCD Design

10.1 General

10.1.1 The natural gas distribution designs shall consider future known upgrades and expansions of track infrastructure. Future considerations shall be applied to meter station capacities and main and branch gas line sizing.

10.2 Gas Design

10.2.1 The natural gas design shall be per CSA B149 standards.

10.2.2 Design contractor shall provide a single-line gas pipe layout showing the meter station, SCDs, layout and size of pipes, pressure at the meter station, pressure at each SCD, flow rate for each size of pipe, flow rate at each SCD and other critical details for high-level design of the gas distribution system.

10.2.3 Design contractor shall provide a scaled gas pipe layout, including any relevant installation details, typical cross sections, method of construction, diameter and type of each segment of pipe, etc.

10.2.4 Design contractor shall consult the appropriate utility company during the design phase to ensure the feasibility of the meter station location. The design contractor shall provide these details, including the pressure required at the proposed meter station and pad design, so that the construction contractor can request the appropriate station from the utility company.

10.2.5 If possible, track crossings shall be avoided or minimized. If track crossings are required, they shall be per Transport Canada Standards Respecting Pipeline Crossings Under Railways (TC E-10).

10.3 SCD Design

10.3.1 All SCD equipment shall be per Metrolinx Specification 34 42 05 Hot Air Switch Clearing Device Specification.

10.3.2 Remote and local monitoring of the SCDs shall be provided per manufacturers' instructions. Metrolinx's preference of the design for each manufacturer is described below:

a) Railway Equipment Company (RECO) Magnum Series

i. For no. 16 turnouts and higher, Model 953 is required for each movable point or movable frog area. For no. 12 turnouts and lower, Model 950 is required for each movable point.

ii. Each controlled location shall be equipped with the Rail-NET remote diagnostic monitoring system. Each controlled location shall be equipped with a master unit, and, if required, additional slave units so that all SCD units are monitored.

iii. Each SCD shall be controlled with a contact from the "SMZ" relay, controlled either locally or remotely via LCP or GTCS, respectively. The "SMZ" relay should be wired from a VMIS output. Additional "SMZ" relays required shall be wired as repeaters from the first relay or alternatively wired from an additional VMIS output controlled with the same logic as the first relay output.

iv. Each SCD shall have one run indication relay and one alarm indication relay located in the bungalow. These relays shall be powered from a suitably sized transformer producing 24 VAC fed to the SCD control module from the bungalow.

v. One SCD run indication input shall be input in the VMIS. All SCD run relays shall be wired in series.

vi. Once SCD alarm indication input shall be input in the VMIS. All SCD alarm relays shall be wired in parallel.

b) Thermon Fastrax Hellfire Series

i. For no. 16 turnouts and higher, FHF900 is required for each movable point or moveable frog area. For no. 12 turnouts and lower, FHF400 is required for each moveable point.

ii. Each controlled location shall be equipped with the Energy Management System (EMS) capable of controlling and monitoring up to 4 SCDs. Each EMS shall be equipped with a master SCD, equipped and cabled with a precipitation sensor back to the EMS in the bungalow.

iii. Each EMS shall be controlled with an "SMZ" input locally or remotely via LCP or GTCS. The "SMZ" input should be wired from a VMIS output. The EMS shall then be used to control the operation of the SCDs.

iv. The EMS shall control each SCD. In addition, each SCD shall have a Snow Melter Force Off "SMFOZ" relay contact to force the SCD off remotely in the case of an emergency. The "SMFOZ" relay shall be controlled either locally or remotely via LCP or GTCS, respectively. The "SMFOZ" relay should be wired from a VMIS output. Additional "SMFOZ" relays required shall be wired as repeaters from the first relay or alternatively wired from an additional VMIS output controlled with the same logic as the first relay output.

v. Each SCD shall have a run indication wire running from the EMS and returning to the bungalow. If only one SCD is controlled from the EMS, the second SCD run input on the EMS shall be jumpered from the first SCD to allow proper logic operation.

vi. One SCD run indication output from each EMS shall be input into the VMIS.

vii. Once SCD alarm indication output from each EMS shall be input into the VMIS.

11. Signalling System Hardware

11.1 General Requirements

11.1.1 Signalling System hardware shall comply with AREMA C&S Part11.5.1 "Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment."

11.1.2 Design contractor shall provide a Bill of Material (BOM) to Metrolinx for review and approval. The BOM shall contain all key equipment, descriptions, quantities, part numbers and associated lead times.

11.2 Batteries and Chargers

a) The design of the batteries and chargers, and minimum standby power requirements, shall comply with:

   i. SCP-1401 Safety Instructions for Vented Storage Batteries;

   ii. SCP-1402 Storage Batteries and Rectifiers; and

   iii. Transport Canada Grade Crossing Standards.

b) The battery bank capacity shall be calculated using the following guidelines for key equipment powered from each bank. The table lists typical equipment used on Metrolinx property and the rated current draw for each individual piece of equipment, assuming full capacity is used.

Table 24: Standard Signal Equipment and Rated Current Draw in Amps (A)

Equipment	Rated Amps (A)	Equipment	Rated Amps (A)	Equipment	Rated Amps (A)
3TC	2.00	CDU-1	0.17	SEARII / SEARIIi	0.80
2TC	1.30	VPM-3	0.88	Communications Manager	6.00
TD-4	9.00	UCI-3	0.05	ILOD	0.30
PSO4000 Transmitter	0.61	GFD-1	0.25	DAU	0.70
PSO4000 Receiver	0.76	CIO-1A / -2A / MDA / CLA	0.13	XTI-1S (Normal)	1.50
PSO4000 Crossing	0.63	VTI-2S	0.36	XTI-1S (Standby)	0.50
Ritron Radio	2.08	VIO-86S	3.09	IXC-20S	1.30
NAS DTMF	2.00	VLD-R16S	0.18	NSM-1	0.11
Microhard LTE	0.12	WSDMM	2.13	Vital Relay	0.10
RuggedCom RX1512	2.20	CNLCP	0.30	GEMS LED	0.27
RuggedCom RX1510	4.34	Signal LED Module	1.10	Electronic Bell	0.15
VHF Communicator	0.80	GCP4000 CPUII+	0.50	Crossing LED Module (Pair)[1]	1.50

Equipment	Rated Amps (A)	Equipment	Rated Amps (A)	Equipment	Rated Amps (A)
GFT II	0.30	GCP4000 Track	1.30	Gate LED (Pair)[2]	0.35
SSCCIII+ (40A)	0.85	GCP3000+ CPUII+	0.26	EGM	0.50
IPITC	0.55	GCP4000 SSCCIIIi	0.56	GCP 4000/3000+ Display (80407)[3]	0.31
GCP4000/3000+ CPUIII	0.60	GCP4000 Transfer	0.23	GCP 4000/3000+ Display (80485)	0.66
GCP3000+ RIO	0.69	GCP3000+ Transfer	0.50	SSCCIV (40A)	0.85
GCP3000+ Track	0.97	HD Link	1.40	ULCP	0.45

[1] LED module pairs. One pair of flashing LEDs are counted as one LED module.
[2] Gate LED pairs. One pair of flashing LEDs are counted as one LED module. The gate tip LED is counted as one Gate LED module.
[3] Display backlight off and heater disabled.

c) The functional design and operating guidelines for battery chargers shall comply with AREMA C&S Manual Part 9.2.6, "Recommended Functional/Operating Guidelines for a Battery Charger."

d) Chargers shall be equipped with at least 1 Form C dry contact for local monitoring purposes, and all charger failures shall be detected and reported to GTCS. The 12 VDC monitoring circuit shall be normally energized and wired in series through all chargers equipped with the contact.

e) The preferred charger type for 12 VDC operating banks is C-Can RLW 12/600E, or equivalent approved by Metrolinx. The charger shall be connected via Ethernet cable to a monitoring system, if available.

f) The preferred charger type for 110 VDC switch banks is C-Can RLW 125M, or the equivalent approved by Metrolinx. The charger shall be connected via Ethernet cable to a monitoring system, if available.

11.3 Vital Microprocessor Interlocking System

11.3.1 New VMIS shall support the interfaces with existing Signalling System equipment. Where necessary, the VMIS shall include vital relays (such as for switch machine control) to provide an interface to wayside equipment.

11.3.2 The VMIS shall be equipped with a data recorder and diagnostic system capable of being accessed locally, and shall support remote access capability.

11.3.3 The VMIS diagnostic system shall be capable of identifying a failure, the nature of the failure, and the components that have failed.

11.3.4 VMIS time shall be synchronized with the GTCS via code line.

a) Time of VMIS shall be synchronized with the other electronic equipment within the same equipment house.

11.3.5 VMIS shall be protected against electric noise transmitted from external sources, including radio, vehicle propulsion systems and high-voltage commercial power lines. Lightning protection, including appropriate lightning arresters and equalizers, shall be appropriately sized and provided at all interface input terminals.

11.3.6 As directed by Metrolinx, the VMIS for a location critical to Metrolinx train service shall incorporate redundancy so that if one controller fails, another controller shall immediately and automatically assume control of its functions and territory without operational impact.

11.4 Local Control Panel

11.4.1 Each Control Point shall be equipped with a Local Control Panel (LCP) that:

a) Consists of a mechanical panel performing local control panel functions;

b) designed and installed with the same orientation as the track and signal layout outside of the bungalow; and

c) sized such that it can display the complete layout of the territory controlled from the location.

11.4.2 Preferred LCP type is QLCP or CNLCP, or equivalent approved by Metrolinx. Computerized LCP may be provided subject to Metrolinx approval.

11.5 Wire and Cable

11.5.1 Wire and cable design shall comply with the GO Transit Signals & Communications Standards, SCP 1000 series and AREMA C&S Manual Section 10.

11.5.2 Design contractor shall design direct connections between the Signalling System equipment inside the bungalow and shall avoid intermediate terminations.

a) If intermediate terminations are absolutely required, they shall be provided using a WAGO terminal or terminal straps.

11.5.3 Twisted pair cables shall be used for track circuits to minimize crosstalk between the pairs.

11.5.4 Communication and signalling cables shall be segregated from power cables while sharing a common trough or raceway.

11.5.5 Gauge of all wiring and cable shall be clearly identified within the circuit design.

11.5.6 No more than two wires are to be connected on any terminal or relay contact. This does not apply to a small wire from a resistor, diode or capacitor, which may be added.

11.5.7 All wires and cables shall be tagged in the circuit plan.

11.5.8 Signalling System cable (except cable for track circuit) shall include spare conductors (20% is desired).

11.6 Surge Arrestors

11.6.1 Surge protection shall be provided for all apparatus exposed to the effects of lightning and induced voltage surges per AREMA C&S Manual Parts 11.2 and 11.3, GO Transit Signals & Communications Standards SCP 1101, and equipment application recommendations from the equipment suppliers.

11.6.2 Surge protection shall be coordinated with the voltage-withstanding characteristics of the apparatus that it is to protect.

11.6.3 Suitable secondary surge protection that complies with AREMA C&S Manual Part 11.3.2 shall be provided between the power supply and electronic equipment.

11.7 Switch Machine

11.7.1 Dual-controlled M23B switch machine with a 110 VDC motor is the standardized switch machine for any switch machines outside of the USRC.

11.7.2 Switch machine selector lever contact of each end of a crossover shall be independently input into VMIS.

11.7.3 Switch position (NWP or RWP) of each end of a crossover shall be independently input into VMIS.

11.7.4 Field control of each end of a crossover shall be a combined input into VMIS.

11.7.5 A 24 VAC resistor heater shall be provided in each contact and motor compartment and fed from a transformer in the Equipment House. The feed shall be fused on the output side of the transformer.

a) Metrolinx's preferred transformer is Hammond FS500PR wired for 120/24 VAC.

11.8 Switch Clearing Device (SCD)

11.8.1 Hot air SCDs shall be designed per GO Transit Signals and Communications Standards – Switch Clearing Device Specification, RC-0506-03SIG-09.

11.8.2 SCDs shall comply with the AREMA C&S manual, part 12.6.20 “Recommended Design Criteria for an Ambient Air Switch Clearing Blower” and GO Transit Signals & Communications Standards - SCP 800.

11.8.3 SCDs shall be locally and remotely controlled, either by Signalling System or SCADA.

11.8.4 An external lockable disconnect switch shall be provided near each SCD.

11.8.5 Multiple SCDs fed from one location shall be programmed for staggered start.

11.8.6 Programming for each SCD EMS shall be clearly indicated on the signal plans.

11.9 Relays

11.9.1 Relays shall comply with AREMA C&S Manual Section 6.

11.9.2 Relays shall be mounted at eye level where possible to permit visual inspection.

11.9.3 Non-vital relays shall be of Potter and Brumfield manufacture, and provided with appropriate retaining springs.

a) General purpose 12 VDC relays shall be model KUP-14D15-12.

b) High voltage 240 VAC power off relays shall be model KUP-14A15-240.

11.9.4 Plug-in type relays shall be used for all vital circuits. The plugboard shall have a relay identification plate installed to prevent other types of relays from being installed on the plugboard.

11.9.5 Relays shall be named based on the nomenclature of the functions. The name shall be clearly indicated in the plans, with machine-generated labels fixed to the relay lower front, plugboard lower front and plugboard rear.

11.9.6 Metrolinx's preferred relay types for specific applications are listed below, to standardize spare material and allow greater interchangeability:

a) Regular-release biased-neutral track relays shall be used with DC track circuits. Contact arrangement shall be 4FB, 2F, 1B;

b) Regular-release non-biased-neutral relays shall be used for colour light signal circuits. Contact arrangement shall be 6FB with heavy-duty contacts;

c) Biased-neutral relays shall be used for switch motor control circuits. Contact arrangement shall be 2F, 2B with magnetic blowout contacts. The arrangement and polarity of the circuits shall be designed per the relay manufacturers' instructions; and

d) Regular-release non-biased-neutral relays shall be used for general-purpose circuits, such as DAX or repeater circuits. Contact arrangement shall be 6FB.

11.10 Load Center (Breaker Panel) and AC Circuits

11.10.1 Load center shall be CSA-approved, and CSA labelled.

11.10.2 Proper ampacity sizes and symmetrical short circuit ratings shall be coordinated with load and short circuit calculations per CSA C22.2 No 29.

11.10.3 Load center shall provide a minimum of 25% spare of each utilized type of branch breakers.

11.10.4 Panel circuits shall be phase-balanced and shall contain a panel circuit schedule. The schedule shall indicate the loads and the feeding breakers:

a) External service breaker shall occupy AC load center positions 2 and 4;

b) Generator service breaker shall occupy AC load center positions 6 and 8;

c) House lights and receptacle chain shall occupy AC load center position 10;

d) Ventilation fan assembly shall occupy AC load center position 12;

e) HVAC unit shall occupy AC load center positions 14 and 16;

f) All other non-signal system feeds shall occupy AC load center even positions;

g) House Primary Surge Suppression Device (SSD) shall occupy AC load center positions 1 and 3; and

h) All other signal system feeds for rectifiers, low voltage transformers and POE lights shall occupy AC load center odd positions;

11.10.5 Load center shall be configured to prevent any fault current from flowing through the neutral back to the power service and mitigate all electrical touch potential hazards.

11.10.6 Surge suppressor device shall be provided on the load center to protect all phases. ERICO EPD 120/240 TDFL is the preferred surge suppression device for such an application.

11.10.7 Interlocked switch transfer kits shall be installed between the service breaker and the generator power supply breaker.

a) The generator power supply breaker shall be mechanically interlocked with the service breaker to ensure only one supply is online at any given time.

11.10.8 Charger feed circuits shall be provided with the following provisions:

a) Switch bank chargers shall be provided with a dedicated 240V circuit from the load center;

b) Operating, lighting and control bank chargers shall be in series and provided with a dedicated 240V circuit. If crossing control equipment is contained within the same bungalow as CTC signal equipment, the chargers shall be on separate 240V circuits;

c) Each charger shall have an appropriate-sized Hubbell 20A 2320/2321 or 30A 2620/2621 twist lock plug and receptacle. SEOOW generator cable shall be provided between the charger and the plug; and

d) A 240V power-off relay shall be provided at the end of each charger circuit contained in a pull box with a clear viewing plate if any chargers in the string are not equipped with a Form C dry contact:

i. If all chargers in the circuit are equipped with Form C dry contacts, then 240V POR is not required.

11.11 Wayside Case

11.11.1 Wayside case is permitted where housing is required, but spatial constraints prevent the installation of a bungalow.

11.11.2 Wayside case shall comply with AREMA, and shall have been previously installed and approved for use by Class 1 railroads within North America.

11.11.3 Multiple unit terminal blocks for wire and cable conductors shall be per AREMA C&S Manual, Part 14.1.6.

a) Test links shall be provided for the connections between the cable and case wire.

11.11.4 Wayside case shall be equipped with 10% spare terminals.

11.11.5 A lamp holder with a 120 VAC lamp receptacle, light switch and LED light shall be provided in each wayside case. Where cases contain more than one (1) door, two (2) LED lights shall be provided.

11.11.6 A 120 VAC convenience receptacle shall be provided in each wayside case.

11.11.7 Metrolinx's preferred wayside case is L&W TCSA74X41X32-2.

11.12 Junction Box

11.12.1 Junction box shall be corrosion resistant, dust and waterproof enclosures.

11.12.2 Junction box shall have adequate venting to prevent condensation buildup.

11.12.3 Junction box shall be of sufficient size for the required number of terminals, including 20% spare terminals, with all terminals accessible from the front.

11.12.4 Junction box shall accommodate the minimum bending radius of wires and cables, and include strain relief of all cables.

11.12.5 Junction box covers shall be lockable and shall not open in the path of the train dynamic envelope. If possible, junction box covers shall open so maintenance personnel can face the track while facing the junction box.

11.13 Cable Terminals

11.13.1 Cable terminals shall comply with GO Transit Signals & Communications Standards, SCP 1003 – "Standard Terminals & Tools for case wiring."

11.13.2 Terminals and terminal blocks shall be provided per AREMA C&S Manual Section 14.

11.13.3 Test links shall be provided on terminals to isolate the wire connections to the equipment for test purposes.

11.13.4 Nuts and washers shall be per the AREMA C&S Manual Part 14.1.11. For moulded terminal blocks, 2 binding nuts, 1 clamp nut and 3 washers for all terminals, including spares, shall be provided for wayside case and junction box.

11.13.5 Low Impedance Ground Plane (LIGP) in the equipment house shall be equipped with terminal blocks for dirty and clean side terminations. These terminal blocks shall be through hole terminals with an insulation block connected to the aluminum ground plane.

11.14 Light Emitting Diode (LED) Signal

11.14.1 Tri-Colour LED signal shall be provided in compliance with the GO Transit Signals & Communications – Wayside LED Signal Module Specification, RC-0506-03SIG-05.

11.15 Ground Fault Detector (GFD) and Battery Monitoring Equipment

11.15.1 GFD shall be provided to detect a ground fault on both AC (if it is floating) and DC power distribution systems.

11.15.2 GFDs shall obtain operating power from the signal supply and be resettable locally.

11.15.3 The sensitivity and alarm threshold of each GFD or battery monitor shall be calculated using the following guidelines:

a) Ground fault threshold shall be calculated so that the leakage current value does not exceed 2mA, using the equations: Leakage Current = Calibrated Voltage / Ground Fault Threshold;

b) Ground fault time, if available, shall be set to 5 seconds;

c) Low battery alarm voltage, if available, shall be calculated and set to 1.2 volts per cell; and

d) High battery alarm voltage, if available, shall be calculated and set to 1.65 volts per cell. If the calculated bank voltage is higher than the highest adjustment setting of the equipment, the highest adjustment setting should be used. The associated alarm status in the software shall not be recorded to prevent nuisance filling of the data logs.

11.16 Temporary Monitoring Equipment

11.16.1 Any temporary monitoring equipment (for example, ground displacement monitoring equipment) set up for installation, construction, or post-construction monitoring shall be removed after completion of its intended use unless otherwise directed by Metrolinx.

12. Signalling System Software

12.1 General Requirements

12.1.1 The design contractor shall comply with the following design principles for application software and the configuration management process for maintaining version control of all vital and non-vital Signalling System software for executives and/or boot software (supplied by equipment supplier) and application software.

12.1.2 The requirements contained in this section shall apply to Signalling System products used in any vital applications, including:

a) Electronic Coded Track Circuits;

b) Grade Crossing Controllers, Predictors and Motion Detectors;

c) VMIS and all associated Printed Circuit Boards;

d) Electronic Timers;

e) Defect detectors; and

f) Other electronic devices.

12.2 Design Requirements

12.2.1 Principles defined in this manual shall be used as the guideline by design contractors to produce site-specific application software.

a) Design contractor shall ensure the safety and integrity of any application software that is placed in service.

b) Design contractor shall keep a record of issues found during staged testing, the successful resolution and the new application software information. The software tracking sheet and problem log shall be provided to Metrolinx for record purposes once the application software is in service.

12.2.2 Software configuration management shall comply with the recommendations and instructions specified in the following:

a) AREMA C&S Manual, Part 17.5.1 and Part 17.5.2; and

b) GI 301(t), GI 335(a) and GI 335(b).

12.2.3 When a location being modified requires an application software change, Metrolinx will provide the existing application software to the design contractor, who shall use those files as the revision baseline and modify the existing application software. The design contractor shall verify the version and configuration provided by Metrolinx are accurate to what is installed in the field location.

12.2.4 The design contractor shall incorporate the executive and boot software approved by Metrolinx. The latest executive software version is not always necessarily the version approved by Metrolinx. The detailed information of executive software, such as file name, part number, Checksum, CRC, etc., shall be clearly defined in the Program Configuration design within the circuit plans for the location.

12.2.5 The non-vital and vital software shall be segregated into application software.

12.2.6 Application software shall be documented using either Boolean Equations or Ladder Logic.

a) Configuration settings in application software for vital functions shall be cross-checked via hardware jumpers or dip-shunt switches. Cross-check is not required for non-vital functions.

b) All equations in application software shall have notes describing the equation functions.

12.2.7 All configuration settings shall be reflected in the Program Configuration design within the circuit plan for the location.

12.2.8 Vital timers shall be configurable by authorized users in the application software.

12.2.9 If the application software allows adjustable parameters that must be configured in the field (i.e., MDR warning times, approach circuit lengths, gate arm clearance time, etc.), these parameters shall default to a safe state and shall not be adjusted below a reasonable safe value (i.e., MDR warning time set below 20 seconds).

12.3 Typical Nomenclature for Application Software

12.3.1 The nomenclature related to controls and indications of the Signalling System shall be as defined in Section 5 and Section 6 in this manual.

12.3.2 The nomenclature of discrete inputs, outputs, and key variables within the application software shall be defined in Table 24 for the CTC Signal System location.

Table 24: Typical Nomenclature for CTC Signal System Location

Nomenclature	Attribute	Example
AUX	Auxiliary input of Coded track circuit	1WTAUX – Auxiliary input on 1WT
T	Code 1 received on Coded track circuit	3WT – Code 1 received on 3WT
TOUT	Code 1 transmitted on Coded track circuit	1WTOUT – Code 1 transmitted on 1WT
TC2IN	Code 2 received on Coded track circuit. Same principle applied to all other codes.	1WTC2IN – Code 2 received on 1WT
TC2OUT	Code 2 transmitted on Coded track circuit. Same principle applied to all other codes.	1WTC2OUT – Code 2 transmitted on 1WT
LO	Signal Light Out (detected by Lamp Driver	1WAGLO - Signal 1WA Green Light Out; 1WAYLO – Signal 1WA Yellow Light Out; 1WARLO – Signal 1WA Red Light Out.

Nomenclature	Attribute	Example
RLO	Remote Signal Light Out (Initiated from Intermediate Signal Location)	T1RLO – Light Out bit received from T1, indicating LO condition of intermediates on T1
POR	Power Off Input	POR
RPOR	Remote Power Off (Initiated from intermediate Signal Location)	T1RPOR – Power Off bit received from T1, indicating PO condition of intermediates on T1
DOOR	Door Contact Input	DOOR
SMP	SCD Operating Input	SMP
SMALP	SCD Alarming Input	SMALP
NWP	Switch Normal Position Input	1ANWP – Switch 1A Normal Position Input
RWP	Switch Reverse Position Input	1ARWP – Switch 1A Reverse Position Input
NJP	Switch On Hand Input	1ANJP – Switch 1A on Hand Input
FCN	Switch Field Normal Request Input	1FCN – Crossover (or Switch) 1
FCR	Switch Field Reverse Request Input	1FCR – Crossover (or Switch) 1
T	OS Track Input	1AT – Follow Track Circuit naming convention
GFD	Ground Fault – Input or Internal bit	B12_1GFD – B12 bank #1 ground fault
RBE	Remove Block Enable Input	One per location
TU	AS Time Release Jumper Input	One per location
GE	Signal Green Output	1WAGE – Signal 1W A Head Green Output
FGE	Signal Flashing Green Output	1WAFGE – Signal 1W A Head Flashing Green Output
YE	Signal Yellow Output	1WAYE – Signal 1W A Head Yellow Output
FYE	Signal Flashing Yellow Output	1WAFYE – Signal 1W A Head Flashing Yellow Output
RE	Signal Red Output	1WARE – Signal 1W A Head Red Output
VSTOP	Vital Signal Stop Relay Output	1EVSTOP – Vital Stop Relay for Signal 1E
NW	Switch Normal Control Output	1ANW – Switch 1ANW
RW	Switch Reverse Control Output	1ARW – Switch 1ARW
SMZ	SCD Control Output	1ASMZ – Switch 1A SMZ
SMFOZ	SCD Force Off Output	SMFOZ – One Per Control Point
AS	Variable – Approach Stick	1WAS – Signal 1W Approach Stick
GZP	Variable – Signal Request Repeater	1WGZP – Signal 1W GZP
COGZP	Variable – Signal Call-On Request Repeater	1WCOGZP – Signal 1W COGZP
TE	Variable - Timer Complete	1WASTE – Signal 1W ASR Timer
TEN	Variable - Timer Enable	1WASTEN – Signal 1W ASR Timer

Nomenclature	Attribute	Example
RP	Variable – Red Repeater	1WRP – Signal 1W RP
OL	Variable – Overload	1AOL – Switch 1A OL
L	Variable - Switch Locked	1AL – Switch 1A L
LS	Variable - Switch Locking Stick	1ALS – Switch 1A LS
NWCP	Variable – Normal Switch Correspondence	1ANWCP – Switch 1A NWCP
RWCP	Variable – Reverse Switch Correspondence	1BRWCP – Switch 1B RWCP
ERS	Variable – Eastbound Route Stick	1ERS – Track Circuit 1T ERS
WRS	Variable – Westbound Route Stick	1WRS – Track Circuit 1T WRS
TP	Variable – Track Repeater	1TP – Track 1T Repeater
HD	Variable – Codes Received for Permissive Signal Aspect	1WHD – Track 1WT HD
COS	Variable – Call-On Stick, Per Control Signal	1WCOS – Signal 1W Call-On Stick
RTTS	Variable – Return to Train Stick	1WRTTS – Track 1WT Return to Train Stick
NWZP	Variable – Normal Switch Request Repeater	1NWZP – Crossover (or Switch) 1 NWZP
RWZP	Variable – Reverse Switch Request Repeater	1RWZP – Crossover (or Switch) 1 RWZP
STK	Variable - Directional Stick	ESTK – Eastbound STK WSTK – Westbound STK
Z	Variable – Power Up Stick	Z

12.3.3 The nomenclature of key inputs and outputs within the application software for GCWS shall be as defined in Table 25.

Table 25: Typical Nomenclature for GCWS

Nomenclature	Attribute	Example
GP	Gate Vertical (Up) Input	1GP – Gate 1 Up
GD	Gate Horizontal (Down) Input	1GD – Gate 1 Down
AXC_E_IN	Remote East Approach Start Input	AXC_1E_IN – Track 1 east approach remote start
AXC_W_IN	Remote West Approach Start Input	AXC_1W_IN – Track 1 west approach remote start
TESTSW	Test Switch Input	TESTSW
TESTSWGUP	Test Switch Gate Up Input	TESTSWGUP
XT	DC Island Input	1XT – 1XT DC Island Input
DTMF	DTMF Input	DTMF
AXC_E_OUT	Remote East Start Output	AXC_1E_OUT – Track 1
AXC_W_OUT	Remote West Start Output	AXC_1W_OUT – Track 1
BELL	Bell Output	1BELL - Bell 1 Control

Nomenclature	Attribute	Example
GATE_CNTRL	Gate Control Output	1GATE_CNTRL – Gate 1 Control
IXC_FLASH	Flasher Control Output	1IXC_FLASH – Flasher Output on #1 crossing controller
PER	Preemption Relay Output	PER
XR	Variable - Crossing Control	XR

12.4 Design Guidelines for Key Functions

12.4.1 Approach Stick (AS)

a) The AS variable shall be normally energized and shall be de-energized to lock the switches and route. The time-locking timer associated with the AS shall be normally de-energized and designed to energize the AS variable after a predetermined time period.

b) The AS variable shall become de-energized (false) when the associated signal is cleared or the route has been established. Time locking shall be employed using a timer variable that holds the AS false if the approach locking is not in effect until a pre-determined time interval has elapsed, after the signal request is cancelled, and the signal has returned to STOP.

c) The AS variable shall be restored, and time locking released after the sequential two-track release logic is established, taking into account that:

   i. Improper occupancy sequence of the two tracks shall not release the AS variable; and

   ii. Time locking shall be in effect during a VMIS reset, or when the VMIS power has been interrupted and restored.

12.4.2 AS Reset

a) The AS reset function shall allow the authorized personnel to reset or cancel the time-locking timer while the VMIS is in Local Control Mode to expedite testing.

b) The AS reset function shall only be enabled when the AS reset input has been energized by the manual placement of a jumper wire. It shall be automatically disabled when:

   i. VMIS is not in Local Control; or

   ii. Jumper wire is removed; or

   iii. 60 minutes have elapsed since the AS reset jumper wire has been applied.

12.4.3 Route Stick

a) Route stick equation shall be used to lock switches and routes.

b) The route stick equation shall lock a route when a route is lined. Track occupancy alone shall not lock the route.

c) The route stick equation shall be normally true.

12.4.4 Route Check

a) The route check shall provide a circuit check before a signal may be cleared by ensuring that:

i. The track switches are in correspondence with their control relays and locked;

ii. The opposing signals are in the stop position and are not requested;

iii. The opposing route is not established; and

iv. Track blocking is not in effect.

12.4.5 Switch Correspondence

a) Switch correspondence back check shall be made in each switch correspondence equation.

b) The NWP/NWPR false shall be used to enable the RWPR equation, and the RWP/RWPR false shall be used to enable the NWPR equation.

12.4.6 Vital Communication Link

a) Communication link status shall be checked in all received logic equations that utilize the associated link.

b) Link logic variable labels shall match the nomenclature on the hardware circuit plans.

c) Loss of vital link shall cause the associated received logic variables to revert to their most restrictive state.

d) Loss of vital links shall not cause an unsafe condition, such as prematurely establishing the Call-On or RTT sticks or resetting the AS variable.

e) Vital communication link protocol, IDs, IP addresses, timing differences, and any other configuration settings shall be reflected in the Program Configuration design within the circuit plan for the location.

f) Vital communication links shall be configured to automatically update the date and times of any remotely connected units based on the designated master unit date and time. This will assist field personnel in troubleshooting since all log times will be synchronized.

12.4.7 Power Up Stick (Z)

a) Z equation shall be employed to verify that the VMIS has initialized to a normal state without errors after being reset or when power is restored to the system.

b) Z shall be employed to check that all ASs are normal after power-up and that the key modules and vital serial links to other VMISs remain healthy once the system is running.

c) Z shall be used in AS to ensure that VMIS does not allow AS to energize immediately when VMIS first starts up, but only after the longest AS timer has expired. This is critical to safe operation since all track circuits will show as occupied during the system initialization, which in turn would allow the AS to energize immediately.

d) To avoid running time unnecessarily on VMIS start-up, Z may include a parallel path to verify that the OS track circuits are not occupied and all approach tracks are vacant.

e) A contact of Z shall be placed in each RTT and Call-On stick at the beginning of the energy path. This will ensure these sticks do not prematurely energize after the VMIS has initialized to a normal state without errors after being reset or when power is restored to the system.

12.4.8 Detector Track Circuits

a) All detector track circuits shall be configured with a 10-second slow pickup timer for loss of shunt protection.

i. Design contractor shall ensure loss of the shunt timer does not introduce a timing issue.

ii. For large plants or at Metrolinx direction, the design contractor may employ a bypass jumper and timer system to temporarily shorten the normal 10-second duration to 4 seconds to speed up the staged testing process.

b) Detector track locking shall be implemented on all switches.

12.4.9 Track Codes

a) Standard Metrolinx track code assignment shall be used for all new work unless Metrolinx specifically directs and approves an alternative. Deviations from using standard codes or their application may be required to tie into foreign railroads or when modifying an individual location to match the rest of a subdivision.

b) Transmission of any track codes at the Control Point for approach signal displaying permissive aspect shall check Code 1 is received.

12.4.10 Signal Approach lighting

a) Signals shall be constantly lit except when:

i. There is an AC power failure or charger failure at the location. Failure at adjacent locations shall not change the location into approach lighting;

ii. External vital input designed to facilitate test and maintenance is de-energized. An external two-way toggle switch or test strap for controlling this input shall be provided.

b) Signal approach lighting circuits shall be provided to light all approach lit signals when:

i. The track circuit in approach or in advance to the signal is occupied, vital track codes are removed, auxiliary input is de-energized, or HD inputs are de-energized;

ii. The track circuits in between signals are occupied;

iii. For intermediate signal locations, the adjacent track vital approach lighting input is de-energized.

c) For intermediate signal locations, a vital output shall be provided to control adjacent track approach lighting. This output shall be used to energize a relay, which adjacent track VMIS vital approach lighting input is cut through.

d) The abovementioned requirements shall not apply if the signal does not have an approach circuit of adequate sighting distance. Such signals shall be constantly lit under all conditions.

e) Where closely spaced signals exist, it may be necessary to employ lighting circuits to keep the far signal at a stop if there is a burnt-out lamp at the signal being approached. The practice is commonly known as leapfrog approach lighting. Such locations shall be clearly identified, if required.

12.4.11 Switch Overload

a) Switch overload protection shall be provided for all power-operated switches.

b) A configurable vital timer with a range of 5 to 22 seconds shall be provided for each switch or crossover. The timer shall be configured at 10 seconds for M23B switch machines, with a 189 to 1 gear ratio.

c) Application software shall reset the overload when the applicable detector track becomes occupied, when the opposite switch request is made or when the switch is placed on hand, as detected through the selector lever contact input.

   i. Selector lever contact input shall be configured with a 10-second slow pickup timer. The slow pickup timer complete status shall be used in the switch correspondence contacts.

12.4.12 Controls from GTCS

a) Controls from the GTCS shall be latched for 2 seconds and then discarded within the non-vital application software.

12.4.13 Chassis and Application ID

a) When applicable, the Chassis ID shall be programmed into all new and revised installations.

   i. Design contractor shall request Chassis ID assignments from Metrolinx.

b) When applicable, the Application ID shall enable vital configurations in application software. The vital program shall be enabled only when the vital configuration matches the Application ID.

   i. Vital features shall be protected with Application ID, such as vital aspect or vital code enable.

   ii. Non-vital features shall not be protected with Application ID, such as maintenance and block codes enabled.

12.4.14 Ground Fault Detection

a) Ground fault alarms shall be collected in the application software for all DC power busses within the Signalling System equipment housing.

   i. Based on the manufacturers' recommendations, ground fault calibrated voltage shall be set to the calculated float voltage of the battery bank.

   ii. Ground fault threshold shall be calculated so that the leakage current value does not exceed 2 mA. The ground fault threshold shall be calculated using the following formula:

   Leakage Current = Calibrated Voltage / Ground Fault Threshold

   iii. Ground fault time shall be set to 5 seconds.

   iv. Ground fault detector earth ground connection shall be equipped with a test strap to isolate the detector for maintenance and testing purposes.

12.4.15 Battery Alarms

a) Battery low and high voltage alarms shall be collected in the application software for all battery banks within the Signalling System equipment housing:

   i. Low battery alarm voltage shall be calculated using a voltage of 1.1 volts per cell; and

   ii. High battery alarm voltage shall be calculated using 1.65 volts per cell. If this calculated voltage is higher than the maximum equipment setting, the maximum equipment setting shall be used. The software status shall not be recorded if the maximum equipment setting is used.

12.4.16 Door Alarms

a) Door alarm circuit shall be employed for all bungalow doors. Magnetic reed switches, wired in series, are the preferred means of detecting door position.

b) Door alarm shall be triggered when the door input is de-energized.

12.4.17 Switch Clearing Device (SCD)

a) SCD "force off" control shall be implemented for all switch clearing devices except RECO SCD, based on the "force off" feature built into the product.

12.4.18 Stuck Mechanism

a) Where signal mechanisms are used, logic for the stuck mechanism shall be provided.

12.4.19 Vital Signal Lighting

a) Sufficient relay contacts shall be provided to light at least the top red lamp on each controlled signal when the Vital Stop Relay is de-energized.

   i. The lamp wiring for this circuit shall be appropriately fused to protect against short circuits.

b) Lamp Grant diagnostic feature shall be enabled, if available, with the following restrictions:

i. The feature shall be disabled for signals governing movements from CROR 105 territory or for signals that do not have an adequate approach track circuit length and

ii. The software logic shall disable the feature if vital track codes are not received or HD inputs are de-energized on the track circuit approaching the signal. In addition, the software logic shall disable the feature if any OS track is occupied between signals.

12.4.20 Light Out Downgrades

a) Application software shall comply with the light-out downgrade principles defined in this manual.

12.4.21 Directional Stick at Intermediate Signal Locations

a) This section defines the eastbound (southbound) directional stick operations. The same principles apply to the westbound (northbound) directional stick.

b) The west approach flag shall not be set until code for displaying a permissive aspect is received from the east and the west track circuit is occupied for 10 seconds.

c) After the west approach flag is set and the train shunts the west and east track circuits, the eastbound stick shall be energized.

d) When the eastbound stick is energized, the vital stick code shall be transmitted to the west, and the westbound signal shall display red.

e) The eastbound stick shall be de-energized when code 6 is received from the east, or any codes for displaying permissive aspects are received from the east, and the east block is energized.

12.4.22 Code 6 Transmission at Intermediate Signal Locations

a) Code 6 shall be transmitted to the east when code 6 is received from the west, and when no codes are received from the west (i.e., broken rail, block occupancy, etc.), code 6 shall be transmitted to the east. The same principles apply to code 6 transmitted to the west.

b) Auxiliary input is normally used as the input for either the hand throw switch or crossing DC island. When the east auxiliary input is de-energized:

i. No codes shall be transmitted to the east;

ii. Code 6 shall be transmitted to the west if the east stick is not established, followed by code 1; and

iii. Transmission of code 5 shall be discontinued to the west if it was transmitted before the auxiliary input was de-energized.

c) When the west auxiliary input is de-energized:

i. No codes shall be transmitted to the west;

ii. Code 6 shall be transmitted to the east if the west stick is not established, followed by code 1; and

iii. Transmission of code 5 to the east shall be discontinued if it was transmitted before the auxiliary input was de-energized.

12.4.23 Code Repeater Locations

a) Code repeater locations shall be designed so that all vital codes are repeated through the location, regardless if they are used within the block. This will ensure possible future upgrades do not need to modify the location.

12.4.24 Configurable Code 5 and Code M Settings

a) All CTC Signal System locations shall be designed with configurable code 5 and code M settings to allow either code to be repeated or started at the location.

b) All controlled locations shall be designed with configurable code 5 and code M settings to allow these codes to be enabled or disabled at the location.

12.5 Code Line Configurations

12.5.1 Complete code line configuration shall be provided. The code line configuration data shall appear on the Signalling System Program Configuration design.

12.5.2 Metrolinx will assign and maintain code line configuration data for leased fibre and LTE, radio code lines, and ATCS addresses for code line applications.

12.5.3 Design contractor shall request Metrolinx for code line configuration and ATCS addresses.

12.6 Event Recording

12.6.1 Recording equipment shall be provided to record the changes of states for vital and non-vital inputs and outputs, and variables.

12.6.2 Recording capacity shall be sufficient to provide at least 48 hours of activity under normal circumstances for the CTC Signal System.

12.6.3 As the minimum, the following bits shall be recorded within the VMIS:

a) Input and Output, including any physical inputs and outputs, and inputs and outputs in the vital communication link between VMISs;

b) Track circuit variable;

c) Applicable track code input status;

d) Applicable track code output status;

e) All vital variables;

f) All non-vital variables;

g) Link status;

h) Vital timers;

i) CTC indications;

j) CTC controls; and

k) Local control panel Inputs.

12.6.4 The following bits shall not be recorded:

a) Bit changing the status frequently, such as bit for flashing LED indicator on LCP;

b) Output for LCP indicators;

c) Non-vital timers; and

d) High battery alarm status.

12.7 Software Description Document

12.7.1 The design contractor shall provide a software description document that describes the required functions of the application software and operational changes for the revised software.

12.7.2 The following information shall be provided in the software description document.

a) Program name and locations to be used.

b) The version of the program, the date when the changes were made, the company that made the changes, the designer, checker and approver who made the change.

c) The name and version of the development environment (tools) used to create the software; the official authorization of the development tool from the VMIS supplier.

d) The applicable checksum, CRC and/or other unique identifier information for the program is provided by the application development tools.

e) Functional description of the functions and features implemented in the application software.

f) A compatibility summary describing any hardware or software configuration items in the system, including:

i. Any jumper, dipswitch or strap settings that may be required; and

ii. When applicable, any hardware or software revisions that are incompatible with this software shall be explicitly identified.

g) Any user requirements and operational constraints must be satisfied to ensure safety when using this software.

h) Any deviations from this manual.

i) Where applicable, a change summary showing the changes implemented in the software release compared to the previous revision(s).

12.8 Configuration Management

12.8.1 The configuration management will:

a) Establish the baseline of both executive, boot and application software products based on their approved version for testing;

b) Ensure a proper method is in place to document the tracing of all revisions to its respective baseline; and

c) Comply with AREMA C&S Manual and GO Transit Signals and Communications Standards GI 301 (t) – Software Configuration Management.

12.8.2 The design contractor or Field Engineer shall be responsible for issuing and documenting application software revisions that may be required once the design reaches the field.

12.8.3 The design contractor or Field Engineer shall only issue software revisions to the field when authorization has been provided from Metrolinx.

12.9 Configuration Information Reporting

12.9.1 Metrolinx is the custodian of the version control for the installed baseline of Metrolinx vital and non-vital software and executive/boot software.

12.9.2 When a new location is placed in service, or an existing location is revised, the field personnel responsible for the in-service testing shall submit to EOR and Metrolinx a copy of the Software Configuration Report within 24 hours of placing that location in service. The report shall be verified by the design contractor or Field Engineer, who shall notify Metrolinx for compliance and completeness.

12.10 Reduced Validation

12.10.1 The use of Reduced Validation Test Procedures for the Validation of application software requires written authorization from Metrolinx prior to test and execution.

a) When authorization is granted, it will be for a specific location and a specific revision.

b) This written authorization shall be a configuration item incorporated into the software revision control records.

12.10.2 The design contractor or Field Engineer shall be responsible for preparing the Reduced Validation Design package, before the production of the Reduced Validation Test procedures by testing personnel.

12.10.3 The Reduced Validation Design package shall be submitted to Metrolinx for approval, including the following configuration information:

a) Software description, including:

i. List of software modified;

ii. Revision of functional description and change summary;

iii. Explanations of engineering change process being implemented for the configuration control during revisions; and

iv. Explanations of procedures and tools employed to ensure the revision has been made only to the contents intended without accidentally or unintentionally modifying anything else.

b) Configuration data, including:

i. Part numbers and revision levels of all software and related hardware configuration items as applicable;

ii. Existing software Checksums, CRCs, or Unique Check Numbers UCNs, Software Version;

iii. Revised software Checksums, CRCs, or Unique Check Numbers UCNs, Software Version; and

iv. Configuration settings as applicable.

c) Difference report, including:

i. Detailed comparison report demonstrating existing and revised logics;

ii. Detailed comparison report demonstrating execution order changes, or lack thereof; and

iii. Detailed comparison report demonstrating any existing and revised configuration items.

d) Location design including:

i. Layout of all track and signal components (track circuits, signals, switches) with proper nomenclature;

ii. Aspect chart(s); and

iii. Design drawings (PDF) if applicable.

12.10.4 Reduced Validation Test Procedures shall include sequential and comprehensive test procedures outlining the following:

a) Resource, time, and duration plan;

b) Software installation procedures; and

c) Detailed reduced test validation procedures.

12.11 Software Storage and Archiving

12.11.1 Metrolinx maintains the EDRMS for the secure storage and easy access of Signalling System software programs.

12.11.2 When the contractor works on the changes to existing application software or creates a new application software, the design contractor and Field Engineer shall comply with its internal software management process and provide evidence of compliance to Metrolinx, whenever Metrolinx requests it.

13. GTCS Changes

To be developed.

14. Supervisory Control and Data Acquisition (SCADA)

To be developed.

15. Train Control System Interface

To be developed.

16. Electrification Compatibility

To be developed.