METRO NORTH RAILROAD

COMMUNICATION AND SIGNAL DEPARTMENT

TECHNICAL SPECIFICATIONS

FOR

FURNISHING PRE-WIRED SIGNAL HOUSES and CASES

FOR

NEW HAVEN LINE

GREENWICH, CT TO NEW HAVEN, CT

SECTION 1 – CP 229 to CP 241

CONTRACT DOCUMENTS - VOLUME II

Contract No. 1000027511
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1.0 INTRODUCTION

1.1 General

1.1.1 A subsidiary of New York's Metropolitan Transportation Authority (MTA), Metro-North was founded in 1983, when it assumed control of Conrail commuter operations in New York and Connecticut. It currently has a fleet of over 950 cars and locomotives, 384 route miles, and 775 miles of track.

1.1.2 Metro-North presently serves 119 stations distributed in seven counties in New York--Dutchess, Putnam, Westchester, Bronx, New York (Manhattan), Rockland, and Orange--and two counties in Connecticut--New Haven and Fairfield. Three main lines--the Hudson, the Harlem, and the New Haven--operate out of Grand Central Terminal in New York City, and two lines west of the Hudson River--the Port Jervis and the Pascack Valley Lines (extending 95 and 31 miles respectively)--operate out of New Jersey Transit's terminal in Hoboken, N.J. The Hudson Line extends 74 miles from Grand Central Terminal to Poughkeepsie; the Harlem Line, 82 miles to Wassaic; and the New Haven Line, which also has three branches--the New Canaan, Danbury, and Waterbury--72 miles to New Haven.

1.2 Project Background

1.2.1 This project is for Section 1 located on a portion of Metro-North's New Haven Line in the territory from Greenwich, CT to Norwalk, CT, an overall distance of approximately 12 miles. This is primarily a four track mainline territory which is entirely electrified, utilizing 25 kV AC overhead catenary.

1.2.2 Sections of the existing wayside signal infrastructure in this territory have reached the end of their useful life. In addition to improvements to the wayside systems, a new signal block design utilizing new cab signal codes has been developed to provide the necessary track capacity for the intended 2030 operating plan train schedule. Signal Design Speeds (SDS) up to 81 MPH will be included.

1.2.3 The work under this contract shall include, but not be limited to, the design and furnishing of a new wayside signal system to replace the existing vital relay based signal system, a non-vital system and communication links, and will provide the necessary upgraded block design.

1.2.4 The Contractor shall provide all services and facilities necessary to execute all of the work associated with the requirements of these Technical Specification, Plans and Contract Terms and Conditions. The services shall include, but not be limited to, project management, engineering, design, application, manufacturing and assembly, testing, documentation, training,

quality control and other requirements as specified within these Technical Specifications and Contract Drawings.

1.2.5 The work on the New Haven Line will be divided into the four (4) sections. Work within this Contract is for Section 1 only:

1.2.6 Section 1 (approximately 12 miles) includes, but is not limited to, the following items. Details for this work are provided elsewhere within these Technical Specifications and the Contract Drawings.

a. New interlocking equipment, systems and enclosures for CP-241 including interface to existing Intermediate Territory to the east.
b. New CP-229 interlocking equipment, systems and enclosures, to include interface to existing upgraded signal system to the west. Existing Interface House (LOC. D) to be retired.
c. New intermediate equipment, systems and enclosures between CP-229 and CP-230.
d. New CP-230 interlocking equipment, systems and enclosures.
e. New intermediate equipment, systems and enclosures between CP-230 and CP-232 (exclusive).
f. Upgrade interlocking equipment, systems and enclosures for CP-232 as required for SVN/NVN and CTC&D WAN/DLAN interface.
g. Upgrade interlocking equipment, systems and enclosures for CP-233 as required for SVN/NVN and CTC&D WAN/DLAN interface.
h. New CP-234 interlocking equipment, systems and enclosures.
i. New intermediate equipment, systems and enclosures between CP-234 and CP-235.
j. Upgrade interlocking equipment, systems and enclosures for CP-235 as required for SVN/NVN and CTC&D WAN/DLAN interface.
k. New intermediate equipment, systems and enclosures between CP-235 and CP-240.
l. Upgrade interlocking equipment, systems and enclosures for CP-240 as required for SVN/NVN and CTC&D WAN/DLAN interface.

1.2.7 The new signal system shall be supplied as pre-wired instrument houses and cases that will be installed by others and placed in service by Metro-North forces.

1.2.8 Interlocking equipment, systems and enclosures for the upgraded interlockings will be supplied to Metro-North. Metro-North forces will install and place in service.

2.0 CONTRACTOR REQUIREMENTS

2.1 General

2.1.1 The intent of these Technical Specifications and Drawings is to include all items necessary for the proper execution and completion of the Work. These Contract Documents shall be construed to include all work necessary to produce the intended results. If any portion of the Technical Specification and Drawings is in conflict with any other portion, the Engineer shall determine the governing Document.

2.1.2 Reference to "days" in these Specifications shall mean calendar days unless otherwise defined. Reference to "days" designated for Metro-North review shall mean working days.

2.1.3 The details for providing this system shall be determined and guaranteed by the Contractor, subject to the requirements of this Request for Proposal and the written approval of the Engineer.

2.1.4 The Contractor shall have an experienced engineering staff, manufacturing facilities and quality control procedures for designing, furnishing vital microprocessor signal systems equivalent in scope, complexity, and magnitude, and have provided all services as required within these Technical Specifications and Contract Drawings.

2.1.5 The contractor's engineering procedures and manufacturing facilities shall be officially certified in the ANSI /ASQC ISO 9001-2000 Quality Standard, and shall hold current certification.

2.1.6 The determination that the contractor meets the requirements of these Technical Specifications for the satisfactory completion of this Contract is at the sole discretion of the Engineer.

2.1.7 The Contract consists of engineering, designing, furnishing, and providing field support, factory testing, training, attending design meetings, and other services as required by this Request for Proposal.

2.1.8 The new interlockings, master locations and other signal equipment locations will be installed by others and placed into service by representatives of Metro-North.

2.1.9 System acceptance shall be in accordance with these Technical Specifications and Contract Drawings and subject to the approval of the Engineer, as described herein.

2.2 Proposal Requirements

2.2.1 The Contractor shall supply within the Contract Proposal all documents and information as required by these Technical Specifications and Contract Terms and Conditions.

2.2.2 Certain elements of the project are security sensitive, such that restrictions on distribution of documents and technical data will be required on certain components of the design and information supplied by Metro-North for use by the Contractor. The Contractor shall submit with the proposal a plan for implementation of a protocol for handling the security sensitive information.

2.2.3 Proposers are required to be officially certified in the ANSI /ASQC ISO 9001-2000 Quality Standard and shall hold a current certification. The Proposer shall submit current certification of adherence with the ISO 9001-2000 quality standard as well as the current Quality Plan that will be utilized for this Project.

2.2.4 The Proposal shall contain complete hardware and software technical information and descriptions of the proposed system for interlockings, master, electric lock locations and communication systems, including all subsystems. This shall include, but not be limited to, block diagrams with each unit identified and described, and calculations to support the ability to meet the requirements specified herein. Any products, lists of material, lists of services or designs submitted with the proposal shall not be construed as replacing the Technical Specification requirements for submittals and approval of products, designs and subsequent design calculations or services necessary to meet the project requirements.

2.2.5 The Contractor shall submit with his Proposal a detailed description of the vital and non-vital interfaces being proposed between the new vital processor signal system and the existing adjacent territory interlockings at CP-229, CP-230, CP-232, CP-233, CP-234, CP-235, CP-240, and CP-241.

2.2.6 The Contractor shall provide a detailed description on how the staged cutover of the wayside system will be supported. This shall include discussions on how the new vital and non-vital systems will be developed to permit pieces of the system to be placed into service while the existing systems remain in service.

2.2.7 The Contractor shall submit with his Proposal a complete signal communications network design definition, including both text and block diagrams, covering all aspects of the proposed networking designs including, but not limited to, topology, protocols used, failure modes and prevention, performance and integration with the overall signal design.

2.2.8 The Contractor shall submit with his Proposal a description of similar work previously completed by them. The description shall include the prime contractor, owning/operating agency, period of performance and any other germane information required to fully describe the scope of work. The proposal shall also contain a list of points of contact where similar systems are currently in operation. Metro-North may require a visit to the sites of these similar systems, to help determine the suitability of the system for use by Metro-North before award of the Contract.

2.2.9 The Contractor shall only submit as reference those systems that adhere to the Rules, Standards and Instructions, Governing the Installation, Inspection, Maintenance and Repair of Signal and Train Control Devices and Appliances as prescribed in the Code of Federal Regulations Title 49, Part 236 (49 CFR 236) and Part 234 (49CFR234).

2.2.10 The Contractor shall furnish, with the Proposal a recommended reliability back up equipment list to support the apparatus furnished for this contract. The list shall include, but not limited to, all reliability back up equipment listed in these technical specifications. The list shall indicate reference number, brief description of parts, recommended quantity, unit price and total price.

2.2.11 The Contractor shall respond to each section and subsection of this specification with a written compliance statement as part of the Proposal.

2.2.12 The Contractor shall submit, with the Proposal, a detailed staffing plan for all aspects of the projects. This shall include an organization chart showing all staff, engineers, checkers, designers and quality assurance staff. A narrative shall be supplied that indicates the functions of each member of the Contractor Team along with detailed resumes of related work experience.

2.2.13 The Contractor shall clearly show the intended use of any sub-contractors or contract employees who are not full time employees of the Contractor.

2.2.14 The Contractor shall demonstrate in the proposal, to the satisfaction of the Engineer, that the full range of services required can be furnished as specified, and that the Bidder has successfully and satisfactorily completed these comparable contracts on time and within budget using vital microprocessor interlockings, equivalent in scope, complexity, and magnitude, for other North American railroads.

2.2.15 A total of ten (10) copies of the completed Proposal shall be submitted to Metro-North.

2.3 Services to Be Provided

2.3.1 The Contractor shall supply all required services consisting of engineering, designing new locations, designing interfaces to existing tie-in locations, furnishing of material and pre-wired systems, shipping, providing field cut-in support, providing documentation and CAD requirements, factory testing, training, attending design and project meetings, providing review and approval and other services as required by the Request for Proposal and these Technical Specifications and Contract Drawings.

2.3.2 The Contractor shall provide vital, non-vital microprocessor system and related systems as defined by these Technical Specifications and Contract Plans. The use of vital and non-vital relays shall be limited.

2.3.3 The Contractor shall provide the necessary equipment, software, interfaces and systems to support the final block layout. This will include, but not be limited to, providing Master Location (ML) instrument houses and Track Circuit Transformer Coupling (TCML) instrument cases in the intermediate territory, Central Instrument Locations and auxiliary interlocking instrument case(s), as required.

2.3.4 The Contractor shall provide pre-wired microprocessor and relay equipment racks and all other hardware and software required for the interfaces between the new signal systems and the existing vital processor at CP-240 and CTC interface to existing vital relay interlockings namely, CP-232, CP-233 and CP-235. This shall include, but not be limited to, additional I/O capacity in the current existing equipment sufficient to provide the necessary interface.

2.3.5 All new vital wayside signal equipment shall be based on a 3-zoned non redundant microprocessor design. This shall include the interlockings, intermediate territory and interfaces to existing interlockings.

2.3.6 The vital zones of the interlocking, intermediate and interface locations shall be interconnected over redundant, vital fiber-optic cable links utilizing TCP/IP communications protocol over Ethernet. These vital data links shall provide for traffic direction logic, cab signal aspect selection, and all other vital signal functions between the interlockings and throughout the automatic block sections. The fiber optic cables outside the enclosures will be provided by others.

2.3.7 All existing copper signal cable (**with exception below**) for traffic circuits, cab signal aspect selection and all other applications shall be eventually retired as part of this project. The Contractor shall not establish any new vital data circuits over copper cable, outside of the pre-wired or existing enclosures, as part of this project. The retirement of the copper cables will be by others.

a. Copper signal cable will remain in service between CP-232 & CP 233.

2.3.8 The existing Phase Selective track circuits (**with exception below**) shall be replaced by steady energy track circuits grouped at the Master Locations and Interlockings in accordance with these Technical Specifications and Contract Drawings, and incorporating transformer coupled remote track feeds. The track circuit transformer coupling case locations shall be connected to the Master Locations and/or Interlockings using new six pair twisted and shielded copper signal cables, to be provided by others.

b. Phase Selective track circuits will remain in service between CP-232 & CP-233.

2.3.9 The Contractor shall provide CTC interfaces for the new interlocking signal systems at CP-229, CP-230, CP-234, and CP-241. The Contractor shall provide dedicated redundant non-vital fiber optic cable links utilizing TCP/IP communications protocol over Ethernet as required by these Technical Specifications and Contract Plans. The fiber optic cables will be provided by others.

2.3.10 The Contractor shall arrange for conversion of the existing 4-wire Normal and Alternate circuits at CP-232, CP-233, CP-235, and CP-240 to provide CTC interfaces for the interlocking signal systems. The Contractor shall provide dedicated redundant non-vital fiber optic cable links utilizing TCP/IP communications protocol over Ethernet as required by these Technical Specifications and Contract Plans. The fiber optic cables will be provided by others.

2.3.11 The Contractor's designs shall establish four separate types of networks to provide vital and non-vital data transmission for the new signal system. They shall be designated the North Vital Network (NVN), South Vital Network (SVN), Diagnostic Local Area Network (DLAN) and CTC & Diagnostic Wide Area Network (CTC&D WAN). These networks are depicted in the Contract Drawings, "Signal Network Overview Block Diagram," shall be carried over redundant path-diverse fiber optic cables to be provided by others.

2.3.12 A Remote Diagnostic System shall be provided under this contract at all new interlocking houses, grouped track circuit master location houses and the adjacent territory interface houses, as defined in these Technical Specifications and Contract Drawings.

2.3.13 The Remote Diagnostic System shall monitor and provide alarms for conditions such as, but not be limited to, vital and non-vital processor errors, the health status of fiber optic links, Ethernet switch failures, and other discrete equipment failure alarms, on a per device basis.

2.3.14 The Remote Diagnostic System shall provide for local and remote access to the vital and non-vital field microprocessor signal equipment, based on the diagnostics and maintenance functions provided by the equipment manufacturer, which shall include, but not be limited to, "troubleshooting" to the PC Board level.

2.3.15 The Remote Diagnostic System shall also provide for both manual and automatic retrieval of data from the event recorders in the field locations, as provided in these Technical Specifications and Contract Drawings.

2.3.16 The Contractor shall provide the necessary Snow Melter Cabinets as required by these Technical Specifications and Contract plans.

2.3.17 A redundant (north and south) 100 Hz signal power system is presently provided through the entire territory. The Contractor shall provide the necessary equipment to interface to this system as specified within these Technical Specifications and Contract Drawings.

2.3.18 All local and express cables required for the new signal system (copper and fiber optic) will be provided by others. The Contractor shall provide all termination systems for the copper and fiber optic cables as defined elsewhere within these Technical Specifications and Contract Drawings.

2.3.19 The Contractor shall provide staging designs, required software versions and necessary extra hardware to provide for both cutover staging of the new wayside system and for cab signal upgrade implementation staging.

2.3.20 The Contractor shall support the necessary staged cutover of the new wayside system by supplying various software versions and any hardware required to implement the system in small sequential sections. The wayside equipment provided in Segment 1 shall require several cutover segments for each.

2.3.21 The cutover staging of the new cab signal aspects shall implement interim four aspect cab signal sequences in sequential cutover stages. A future series of cab signal upgrades shall be supported and the cab signal implementation staging shall upgrade the cab signal sequences to provide the new 270 (60 MPH) speed control code, in accordance with the requirements of these Technical Specifications and Contract Drawings. These staging designs shall be included in the overall signal system design submittals.

2.3.22 The Contractor shall attend monthly Project Progress meetings in New York City at Metro-North facilities.

2.3.23 The Contractor shall attend monthly Design and Technical meetings in New York City at Metro-North facilities. All necessary Contractor engineering staff as deemed by Metro-North shall be in attendance.

2.3.24 Teleconferencing or telephone attendance is not acceptable methods to attend any Project or Technical meetings.

2.3.25 When possible, the Project, Technical and Coordination meetings will be held on the same day or days to make efficient use of Contractor and Metro-North resources.

2.3.26 The Contractor shall provide all CAD work as specified within these Technical Specifications. The Contractor shall perform all CAD work utilizing the Metro-North CAD standards.

2.3.27 The Contractor shall provide separate unique sets of plans for each wayside location. The plan format and content shall be submitted for review and approval. The use of typical plans, drawings or documentation is not permitted in the final documentation. All documentation shall be site and product application specific.

2.3.28 The Contractor shall provide engineering calculations as required by these Technical Specifications to support requirements for the systems designed. The Contractor shall provide the engineering calculations list below to include, but not be limited to, the following.

a. AC and DC signal power load calculations for all new signal locations shall be provided.
b. Calculations for the sizing of the HVAC system shall also be provided.
c. Floor loading calculations.
d. Enclosure lifting calculations and plans.
e. System, subsystem and component performance metrics.
f. Vital and non-vital networks system, subsystem and component performance metrics.

2.3.29 The Contractor shall also provide weight calculations for all new instrument houses, cases and racks for use by Metro-North during the installation.

2.3.30 The Contractor shall provide an Enclosure Placement Plan that details the lifting procedures for placement of Houses or Central Instrument Location (CIL) enclosures. The Contractor shall take into consideration the limited vertical height along the railroad right-of-way when providing the plan. The plans shall include crane capacities, lifting configurations and other site specific details as necessary to position the enclosures. All Calculations submitted for review shall

bear the seal of a Professional Engineer registered in the State of New York or Connecticut according to the geographic location of the enclosure.

2.3.31 The Contractor shall supply Project Management Administration as specified in this Technical Specification. A single Project Manager shall be assigned to this project for the duration of the project.

2.3.32 The Contractor shall provide a dedicated engineering and design team, as required by these Specifications, for the duration of the project.

2.3.33 The Contractor shall supply Quality Assurance plans and services as necessary to meet the requirements of this Technical Specification.

2.3.34 The technical, application and engineering details of providing this system shall be determined and guaranteed by the Contractor, subject to the requirements of this Technical Specification and the written approval of the Engineer. The Contractor is responsible for the correctness of all the engineering.

2.3.35 System acceptance will be at the sole determination of the Engineer, as described herein.

2.3.36 The Contractor shall maintain strict confidentiality regarding the system designs within this contract consistent with the contract Terms and Conditions.

2.3.37 The Contractor, each member of the Contractor's staff and any sub-contractor staff shall be required to sign and follow a confidentiality statement supplied by Metro-North prior to beginning any work consistent with the contract Terms and Conditions.

2.3.38 All designs and documentation developed as a result of the work in this scope shall be the property of Metro-North Railroad consistent with the contract Terms and Conditions.

2.3.39 The Contractor shall supply and maintain, within 30 days of Notice of Award, a complete submittal list for the total duration of the project. The list shall detail each deliverable.

2.3.40 The Contractor shall submit specifications, descriptions, plans, and diagrams of all systems and subsystems to the Engineer for approval. Each Submittal shall be numbered sequentially.

2.3.41 The Contractor shall furnish an integrated signal system, including vital and non-vital networks over redundant fiber optic cables (provided by others). These networks shall utilize the TCP/IP communications protocol (IETF

RFC1122) over Ethernet (IEEE 802.3), as defined elsewhere in these Technical Specifications and Contract Drawings which shall interface with Ethernet type services provided by Metro-North over their existing communications infrastructure. The purpose of this interface shall be to provide centralized traffic control and diagnostic communications between the field signal locations of this project and the existing Metro-North primary and backup control center office systems.

2.3.42 Within 24 hours of notification, the Contractor shall be prepared to answer questions and solve problems concerning the design, testing, installation and drawings. The Contractor shall answer questions and resolve problems during the installation and system testing. The Contractor shall perform these services by telephone, at meetings held in New York City, or on the job site, as determined by the Engineer. The Contractor shall furnish the time, effort and personnel necessary to answer the questions. The Contractor shall assume all costs for this service.

2.3.43 The Contractor shall provide submittals of all deliverables for approval by Metro-North, as required in these Technical Specifications. This shall include, but not be limited to, hardware, software, power calculations, signal and communication system performance calculations, testing, training, design philosophy, documents, manuals and version control. The submittals shall be identified in a complete listing, submitted to the Engineer for approval. Each submittal shall be sequentially numbered for reference in all correspondence. The Submittal Listing shall be supplied in both hardcopy and Microsoft Excel file format on CD-R media, as approved by Metro-North. The Submittal Listing shall be supplied within 30 days of Contract Award. The submittals shall be staged and distributed as required by these Technical Specifications.

2.3.44 The Contractor shall provide and maintain a complete detailed listing by location of all hardware and software elements for the total duration of the Contract. The listing shall contain, but not be limited to, the site or location name, description, part number quantity, location on rack or wall location. The format for the listing shall be submitted for approval within 30 days of Contract Award. The Listing shall be supplied in both hardcopy and Microsoft Excel file format on CD-R format, as approved by Metro-North.

2.3.45 The Contractor shall submit for review and approval a Failure Mode Effects Analysis (FMEA) for all lightning arresters and surge protection equipment required for vital circuit protection. The FMEA shall identify all potential system weaknesses, and evaluate each potential failure to determine its effect on system and subsystem operation. The FMEA shall be submitted within 45 days of Contract Award.

2.3.46 The Contractor shall initially progress the design of CP-241. Further progression will continue in an easterly path from CP-229.

2.3.47 Major milestones for completion of design and delivery of material are located in attached Appendix "E".

2.3.48 The Contractor shall provide final conformed documents within 14 days of receiving final Engineer's comments from Metro-North's 100% review. All Metro-North's 100% review comments shall be incorporated in the design prior to contractor's implementation.

2.3.49 Any design revisions in the hardware or software systems necessary at the Factory Testing shall be updated in the conformed design package and provided to Metro-North within 14 days of completion of the factory test. Approved Conformed Factory Test plans shall be part of any payment milestone.

2.3.50 Procurement or fabrication of the system shall be at the Contractor's risk until approval has been received from the Engineer for all relevant submittal documents herein specified. For each submittal, the Contractor shall conduct a review with Metro-North of the design, and shall incorporate the comments to the satisfaction of Metro-North.

2.3.51 The Contractor shall submit 60% design documents, which shall include, but not be limited to, the following; the detailed requirements to be submitted for each of these items listed below shall be in accordance with these Technical Specification and Contract Drawings. All components of this submittal shall be configured in a logical and cohesive manner. Fragments of code or circuits are not acceptable.

a. A complete Table of Contents for each new CIL, ML, TCML, or signal case.
b. Revisions to the Table of Contents for each existing location showing which sheets require revisions or the addition of new sheets.
c. All new instrument house and case sizes and layouts.
d. All existing instrument house and case layout drawings showing location of all new equipment.
e. AC and DC power calculations.
f. All local control and indication panel layouts to scale to the 90% level.
g. All new circuit plans and drawings to the 80% level.
h. All revisions to the existing circuit plans and drawings to the 80% level.
i. All new application logic and Boolean equations designed to the 60% level for all sections of the application.
j. All revisions to existing application logic and Boolean equations designed to the 60% level for all sections of the application.

k. Communications network design detailing all components, software, layout, cabling and operation.
l. All signal and communication network system performance calculations with supporting diagrams and drawings to the 60% level.
m. All factory and field test plans and procedures to a 60% level of detail. This shall include all network testing, office testing, wayside testing and complete integrated system testing elements.

2.3.52 The Contractor shall submit 90% design documents, which shall include, but not be limited to, the following; the detailed requirements to be submitted for each of these items listed below shall be in accordance with these Technical Specification and Contract Drawings. All components of this submittal shall be configured in a logical and cohesive manner. Fragments of code or circuits are not acceptable.

a. A complete Table of Contents for each new CIL, ML, TCML, or signal case to the 100% level.
b. Revisions to the Table of Contents for each existing location showing which sheets require revisions or the addition of new sheets to the 100% level.
c. All rack, wall, contact assignments and terminal board assignments to the 90% level.
d. All detailed cases, houses and CILs layouts of components to the 90% level.
e. All local control and indication panel layouts to scale to the 100% level.
f. All circuit plans and drawings to the 90% level.
g. All revisions to the existing circuit plans and drawings to the 90% level.
h. All application logic and Boolean equations designed to the 90% level for all sections of the application.
i. All revisions to existing application logic and Boolean equations designed to the 90% level for all sections of the application.
j. An updated version of the signal communications network design definition, covering all the same topics as the 60% submittal and incorporating, explicitly identifying and explaining all revisions made between the 60% and 90% submittals.
k. All signal and communication system performance calculations with supporting diagrams and drawings to the 90% level.
l. All instrument house, case, and rack weight calculations shall also be submitted and shall include all lifting, pick points and placement procedures. Drawings including proper rigging, crane requirements and required hardware shall also be submitted.
m. All factory and field test plans and procedures to a 90% level of detail. This level shall refine all previous elements of the integrated network, office and wayside testing plans.

2.3.53 The Contractor shall submit 100% design documents, which shall include, but not be limited to, the following; the detailed requirements to be submitted for each of these items listed below shall be in accordance with these Technical Specification and Contract Drawings. All components of this submittal shall be configured in a logical and cohesive manner. Fragments of code or circuits are not acceptable.

a. A complete Table of Contents for each new CIL, ML, TCML, or signal case to the final level.
b. Revisions to the Table of Contents for each existing location showing which sheets require revisions or the addition of new sheets to the final level.
c. All rack, wall, contact assignments and terminal board assignments to the final level.
d. All detailed case, house and CIL layout of components to the final level.
e. All local control panel layouts to scale to the final level.
f. All circuit plans and drawings to the final level.
g. All application logic and Boolean equations designed to the final for all sections of the application.
h. All components of this submittal shall be configured in a logical and cohesive manner.
i. All revisions to existing application logic and Boolean equations designed to the final level for all sections of the application.
j. A final version of the signal communications network design definition, covering all the same topics as the 90% submittal and incorporating, explicitly identifying and explaining all revisions made between the 90% and 100% submittals.
k. Signal and communication system performance calculations with supporting diagrams and drawings to the final level.
l. Final Instrument house, case, and rack weight calculations shall also be submitted and shall include all lifting, pick points and placement procedures. Drawings including proper rigging, crane requirements and required hardware shall be submitted and shall be sealed by a Professional Engineer registered in the State of New York or Connecticut, based on final field site location.
m. Final signal and communication network system test factory and field plans and procedures to a final level.

2.3.54 The Contractor shall provide final conformed 100% documents within 14 days of receiving final Engineer's comments.

2.3.55 The Contractor shall allow thirty (30) working days for Metro-North to review and provide comments for each design level. Twenty (20) working days shall be allowed for review of product submittals. This review time shall be

added to the Contractor's overall project schedule.

2.3.56 The Contractor, at its cost, shall supply any necessary software development, management or programming tools or development hardware required by the Contractor for this project.

2.3.57 Field test and cut-in support shall be required during weekends and/or nights as required by the Metro-North train operation. This cutover support shall be for not greater than twenty (20) separate weekends, providing full support for each cutover until the respective revision stage is in service.

2.3.58 The Contractor shall fully cooperate with the Engineer in all possible ways including adjustment of the delivery schedules.

2.3.59 Before beginning design, the Contractor's engineering team shall attend a pre-engineering meeting with Metro-North in New York City.

2.3.60 Previous work performed by the Contractor for Metro-North shall not be construed as implied acceptance of work to be performed under this Contract.

2.4 Management and Administration

2.4.1 The Contractor shall be responsible for management of their activities over the course of the entire project, including the management of all manufacturers and sub-Contractors utilized by the Contractor.

2.4.2 Safety training of the Contractor's forces shall be required for any employee entering Railroad right-of-way property. The Railroad will provide safety training to the Contractor's forces at Railroad facilities. Safety Training will last one-half day in duration. The Contractor is responsible to cover any of its cost related to attending any Metro-North supplied training.

2.4.3 The Contractor shall provide a Project Management Team that shall be responsible for the implementation of the elements of the Contract as defined.

2.4.4 Beginning with the initial work plan through the design, review, factory acceptance, fabrication, assembly, installation (by the Railroad) and final acceptance and warranty period, the Project Management Team shall document, monitor and facilitate the creation of the System. The work plan shall be updated monthly and submitted to the Engineer by the 10th of each month for the duration of the project.

a. The Contractor shall establish and maintain a Safety Assurance Program as specified elsewhere in these Technical Specifications.

b. The Contractor shall establish and maintain a Reliability, Maintainability & Availability Program as specified elsewhere in these Technical Specifications.
c. The Contractor shall establish and maintain a Quality Assurance Program as specified elsewhere in these Technical Specifications.

2.5 Project Team

2.5.1 A dedicated Project Team shall be assigned to the project until final Metro-North system acceptance. The team shall consist of a minimum of four key personnel. The key members are the Project Manager, Signal Engineer, Application Engineer and Network Engineer.

2.5.2 The Contractor shall submit a listing and organization of other personnel required to support the key personnel.

2.5.3 The Contractor shall submit a listing of principal staff assignments and responsibilities for this Contract, all others assignments for these individuals external to this Contract, including percentage of time allocated to this Contract for each staff member. The listing shall include the key personnel assignments including resumes for approval by the Engineer.

2.5.4 Resumes of all staff members shall be submitted for review and approval.

2.5.5 Once approved by the Engineer, there shall be no substitution of the key personnel (Project Manager, Signal Engineer, Application Engineer and Network Engineer), and these personnel shall not be removed from this project without the written approval of the Engineer.

2.5.6 The key personnel (Project Manager, Signal Engineer, Application Engineer and Network Engineer) are expected to perform the majority of designs and engineering. Checking processes shall be performed by others within the Contractors team.

2.5.7 The Project Manager, Signal Engineer and Application Engineer shall be assigned to this project at a full-time level for the duration of the design phase of this project. The Contractor shall propose, in their Project Proposal, the level of involvement during completion of factory testing and during cut-in support.

2.5.8 Principal participants shall have previous experience in a similar position on at least three other projects similar in scope and magnitude to this project.
2.5.9 The assignment and reassignment of Project Manager, Signal Engineer, Application Engineer and Network Engineer to other projects or work

by the Contractor shall be subject to the approval of the Engineer.

2.6 Project Manager

2.6.1 The requirements of the Contractor's Project Manager shall include, but not be limited to, the following:

a. The Contractor shall designate a full-time employee of their staff to act as the Contractor's Project Manager.
b. The Contractor's Project Manager shall be experienced in administration and supervision of similar signal projects including the management and direction of sub-Contractors and their work, as necessary.
c. The Contractor's Project Manager shall be assigned to this project for the duration.
d. The Contractor's Project Manager shall have the authority to make both engineering and contractual commitments and decisions that are binding on the Contractor.
e. The Contractor's Project Manager shall interface with the Railroad to coordinate all project activities.

2.6.2 The Project Manager shall have a minimum of 10 years' experience in the development and management of railroad wayside signal projects. This shall include, but not be limited to, engineering, designing, testing, installing, configuring, debugging and documenting of all necessary hardware activities and related software activities.

2.6.3 The Project Manager shall be experienced in the management of large and complex engineering and design projects, and experienced in public works contracting.

2.6.4 Project Management responsibilities by the Project Manager shall include, but not be limited to, the following:

a. Preparation of all project reporting and correspondence documents in accordance with the Terms and Conditions of the Contract Document, this Scope of Work and as approved by the Engineer.
b. Attendance at all design, coordination and project meetings in conformance with the Contract Terms and Conditions and this Scope of Work.
c. Preparation of minutes of all Project and Engineering meetings. Minutes shall be forwarded to the Engineer for approval within five (5) working days of the meeting.

d. Preparation of all submittals called for or inferred in the Contract Documents, in accordance with the section on Submittals, to the Engineer for approval.
e. Supervise Contractor activities as defined.
f. Develop work plans and timetables for project completion.
g. Develop, update and submit overall monthly project schedules.
h. Develop and maintain procedures regarding submittals.
i. Conduct regular meetings to review project progress and modifications.
j. Provide process for design review.
k. Provide and coordinate system of securing, maintaining and distributing documents.
l. Supervise ongoing work to include, but not be limited to:

    1. Submittals
    2. Quality Control measures
    3. Coordination with Railroad activities
    4. Technical Specification
    5. Technical plans and drawings
    6. Provisioning tables
    7. Engineering calculations
    8. Cost estimates
    9. Schedules
    10. Documentation
    11. All Deliverables

2.7 Signal Engineer

2.7.1 The Contractor shall assign a Signal Engineer responsible for the engineering, design and application engineering and development of the signal systems. The Signal Engineer shall be assigned permanently for the project duration of this project and approved by the Engineer. The Signal Engineer shall attend all Technical Meetings.

2.7.2 The Signal Engineer shall have a minimum of 10 years' experience in development of hardware for railroad wayside signal projects. This shall include, but not be limited to, engineering, designing, testing, installing, configuring, debugging and documenting of all necessary hardware and applications.

2.7.3 The Signal Engineer shall be authorized to direct the Contractor's personnel so the design and construction can proceed without delay. The Signal Engineer shall have experience in related signal projects of comparable size and complexity.

2.7.4 The Signal Engineer shall be experienced in the field wayside signal systems controlled by the CTC systems. This shall include, but not limited to, the requirements of the communications necessary to tie the CTC office to the field signal equipment.

2.7.5 The Signal Engineer shall be a full time employee of the Contractor and shall be present during all factory tests and on-site during all in-service tests.

2.7.6 It is understood that the actual title for the employee designated as the Signal Engineer may be different than "Signal Engineer." For purposes of this Contract, the designated employee will be referred to as the Signal Engineer.

2.8 Application Engineer

2.8.1 The Contractor shall assign an Application Engineer during the design, application development and installation of the wayside signal system. The Application Engineer shall be assigned permanently for the project duration of this project and approved by the Engineer. The Application Engineer shall attend all Technical Meetings.

2.8.2 The Application Engineer shall be responsible for all details of the vital and non-vital programs logic and for the Software Quality Assurance Plan and execution.

2.8.3 The Application Engineer shall have a minimum of 10 years' experience in development of software application for railroad wayside signal projects. This shall include, but not be limited to, engineering, designing, testing, installing, configuring, debugging and documenting of all necessary hardware and related vital and non-vital software systems.

2.8.4 The Application Engineer shall be a full time employee of the Contractor and shall be present during all factory tests and on-site during all in-service tests.

2.8.5 It is understood that the actual title for the employee designated as the Application Engineer may be different than "Application Engineer." For purposes of this Contract, the designated employee will be referred to as the Application Engineer.

2.9 Network Engineer

2.9.1 The requirements for the Contractor's Network Engineer shall include, but not be limited to, the following:

a. The Contractor shall assign a Network Engineer who has a minimum of ten (10) years' documented experience in the engineering, design, construction, application, provisioning, testing, debugging and operation of complex data communications networks utilizing the TCP/IP protocol stack (IETF RFC1122) over Ethernet (IEEE 802.3).
b. The Network Engineer shall be knowledgeable in the details of integration and installation work and shall have the authority to instruct and/or direct the Contractor's personnel so that design and construction work can proceed without undue delay.
c. The Network Engineer is to be assigned to this project for all phases of construction and testing, and shall be located in the field (within daily commuting distance to Metro-North) during Railroad installation activities.
d. The Network Engineer shall be knowledgeable and experienced in the application of network technology and protocols specifically to railroad signaling applications.

3.0 SYSTEM REQUIREMENTS

3.1 General

3.1.1 These Technical Provisions specify the functional and system requirements of a new signal system including the various sub-systems. The details for providing these systems shall be determined and guaranteed by the Contractor, subject to the requirements of this Request for Proposal and the written approval of the Engineer.

3.1.2 All aspects of the system design, material, installation, documentation, testing, and operation shall conform to the following:

a. Code of Federal Regulations, Title 49 Parts 234 and 236.
b. The American Railway Engineering and Maintenance-of Railway Association (AREMA) Communications and Signals Manual, which supersedes the former Association of American Railroads C&S Division, the American Railway Engineering Association and former standards and recommended practices of the predecessor Associations.
c. The Institute of Electrical and Electronic Engineers (IEEE)
d. The Electronics Industries Association (EIA)
e. The National Electrical Code (NEC)
f. Metro-North Railroad Standards
g. Generally accepted North American Railroad signaling practice.
h. ANSI software standards

3.1.3 In the event of a conflict, the more restrictive standard shall apply unless otherwise directed by the Engineer.

3.1.4 All communication and signal apparatus furnished under this Contract shall be suitable for operation without adjustment between the temperature limits of minus 40º Centigrade to plus 70º Centigrade and humidity levels of 0-95% non-condensing. No additional heating or cooling of the apparatus shall be required to meet this operating requirement.

3.1.5 The Contractor is responsible for furnishing all apparatus required for the proper operation of the systems supplied except were otherwise explicitly indicated in these Technical Specifications and Contract Drawings.

3.1.6 The systems supplied shall not impact existing Metro-North radio, information technology, signal and other communications systems. All applicable FCC requirements apply.

3.1.7 The Contractor shall provide a reliable, available and maintainable signal system, which meets the requirements of these Technical Specification and Contract Drawings that operation within a 12 KV 60Hz AC Catenary Propulsion System. The system provided shall operate in the environment with normal operation faults or grounds that can be induced or coupled into any cable in the house or case.

3.1.8 The Contractor shall provide systems and components that are compliant with MIL-STD-461F.

3.1.9 Electrical and electronic components shall operate without being adversely affected by or emitting electromagnetic interference (EMI) and radio frequency interference (RFI) emissions. Transmissions from components, either radiated or conducted, shall not cause interference to other Railroad components.

3.1.10 Communication and Signal components shall not be adversely affected by any electromagnetic frequency and shall not interfere with the transmission and reception of the following established Railroad frequencies:

a. Audio frequencies for overlay track circuits, highway crossing approach and island circuits, and electrical lock circuits at the following frequencies; 156, 211, 285, 348, 430, 525, 645, 790, 970, 1180, 1450, 1770, 2140, 2630, 3240, 4000, 4900, 5900, 7100, 8200, 8300 Hz; 10, 11.5, 13.2, 15, 15.2, 17.5 and 20.2 kHz; 86-790 Hz for grade crossing predictor units (GCP).
b. Audio frequency overlay for other train control functions at the following frequencies; 525, 645, 790, 970, 1180, 1450, 1770, 2140, 2630, 3240, 4000, 4900, 5900, 7100, 8200 and 8300 Hz; 10, 11.5, 13.2, 15, 15.2, 17, and 20 kHz.
c. Signal power at; 200 Hz @ 120VAC; 100 Hz @120, 1200 and 2400 VAC; 25 Hz @2200 and 440 VAC and 91.6 Hz @2200 VAC
d. Cab Signals at 250 Hz, 200 Hz and 91.66-100 Hz
e. Automatic Equipment Identification at 902 and 928 MHz.
f. Radio frequencies at the following MHz; 153.845, 154.115, 160.106, 161.220, 160.320, 160.335 160.380, 160.395, 160.410, 160.455, 160.545, 160.605, 160.620, 160.725, 160.770, 160.785, 160.920, 160.950, 161.070, 160.160, 161.285, 161.280, 161.385, 161.445, 161.490, 161.536, 162.475, 162.550, 452.8266, 452.9125, 464.6250 and 469.5250.
g. Known Advanced Train Control System (ATCS), Incremental Train Control System (ITCS) and other Positive Train Control (PTC) system radio frequencies (including but not limited to):
    HF Band: 4.5 MHz - 27.115 MHz
    VHF Low-Band: 39.0 - 50.0 MHz

VHF High-Band: 153.0 - 163.0 MHz
UHF Band: 896.0 - 898.0 MHz and 935.0 - 940.0 MHz
Unlicensed Microwave Band: 2400.0 – 2483.5 MHz

h. Wi-Fi Frequencies; 2400.0 – 2483.5 MHz, and 5725.0 – 5875.0 MHz

3.1.11 These Technical Specifications and Contract Drawings specify the functional and system requirements of new three zoned (non-redundant) vital microprocessor based signal systems for all new interlockings, interfaces to existing interlockings and master locations. The three (3) zone configuration shall provide; one (1) zone each for Tracks 3 and 4 respectively, and one (1) zone for Tracks 1 and 2 combined.

3.1.12 Relay placement in the racks shall be such as to eliminate undesirable magnetic coupling between the coils of processor driven relays and line relays, to prevent line noise causing output errors and inadvertent system shutdowns. The Contractor shall identify any design requirements for placement of relays, cabling or any special requirements for the system design that relates to the elimination of such interference.

3.1.13 Interface to the locations west and east of each interlocking shall be by dedicated redundant vital and non-vital fiber optic cable links utilizing TCP/IP communications protocol.

3.1.14 This system shall utilize steady energy 100 Hz AC Track Circuits supporting the transmission of bi-directional 100 Hz cab signal code both in and outside of interlocking limits and between interlockings, except where noted.

3.1.15 These Technical Specifications specify the functional and system requirements of a non-vital (not zoned) microprocessor based, user programmable field code system and data transmission system for all interlockings.

3.1.16 The non-vital field code system shall provide for the control of all the interlockings from the existing Metro-North primary and backup Operations Control Center (OCC) locations. Communications to the OCCs shall be via a primary and alternate fiber optic communication cables, provided by others, utilizing TCP/IP communications protocol.

3.1.17 The Contractor shall provide each field code unit with entrance-exit functionality for the interlocking Local Control Panel (LCP) as defined in these Technical Specifications.

3.1.18 The Contractor shall provide each Master Location with a Local Indication Panel as defined in these Technical Specifications.

3.1.19 These Technical Specifications and Contract Drawings specify the functional and system requirements of a new remote diagnostic system at all new interlocking houses, master locations houses, and adjacent territory interface house locations, which shall be provided by the Contractor.

3.1.20 The Contractor shall design the systems to eliminate any "boot strap" conditions during initial power up, after a long extended power outage or after errors clear. The signal system shall reboot automatically under these conditions without the requirement for manual or remote reset of the system.

3.1.21 The Contract Drawings represent a preliminary Signal Circuit design consisting of signal circuits and logic equations for the system, shown in "typical" format. Not all required circuits and equations are shown. The Contractor shall provide "complete" final circuits using the Technical Specifications and Contract Drawings as a guide for methodology, not content.

3.1.22 The Signal Block Plan and the Routings and Aspect Chart (Control Line) drawings are definitive and are final as presented.

3.1.23 The Signal Block Plan and the Routings and Aspect Chart are provided for both interim cab signal sequences utilizing the present four (4) aspect system and the final upgraded cab signal sequences which employ the new 60 MPH, 270 code rate. These Routing and Aspect drawings are included in the Contract Drawings package, and shall be followed and incorporated in the Staging Plans, 270 Cutback plans, and Final design of the Pre-Wired Signal System, as shown. The Existing Routing Plans have also been included for reference. An electronic form of these drawings will be provided to the Contractor awarded the project.

3.1.24 The Contractor shall provide all drawings in approved AutoCAD formats. All existing circuit drawings within the limits of this Project, whether hand-drawn or computer drafted, shall be re-drawn and provided to Metro-North utilizing drawing standards specified in Metro-North's "CAD Files" and Documentation Requirements, of these Technical Specifications and Contract Drawings. The Contractor shall number the plans in accordance with Metro-North's "Drawing Standards", as approved by the Engineer.

3.1.25 The wired instrument housings, cases and racks covered by this specification, shall be used to provide for the operation of the interlocking signals, switches, CTC system, local control panel, intermediate master locations, interface location, network components and the cab signal system.

3.1.26 The Contractor shall furnish signal instrument housings and cases with apparatus wired in place, in accordance with plans approved by the Engineer.

3.1.27 The equipment provided in the houses and cases shall not be customized in any way that precludes future change-out if required by Metro-North maintenance forces with the same "off the shelf" replacement products. This shall include physical modifications to the equipment casing, custom wiring or wire connectors, and any other equipment changes that would make the available replacement equipment unsuitable for a direct one for one change-out with the original installed equipment.

3.1.28 Batteries specified herein shall not be shipped within the housings. They are to be shipped separately and direct from the manufacturer upon Engineer's request within 30 days of notice.

3.1.29 Once signal and communication circuit designs, programming and submittals are approved, no modifications changes or substitutions are permitted of any nature without the written approval of the Engineer.

3.1.30 Revisions to the circuit plans or house and case layout may be required before the Contractor can commence wiring.

3.1.31 The Contractor shall submit the size of each house or case and a detailed floor and wall layout showing the location of all apparatus for approval.

3.1.32 Houses and cases shall be sized to allow for expansion of rack-mounted, wall and floor apparatus over and above the spare rack(s) required elsewhere in these Technical Specifications and Contract Drawings.

3.1.33 The Contractor shall furnish only new apparatus. New apparatus shall be the latest version of the manufactures product line and be approved by the Engineer. The use of reconditioned or previously used material is not permitted.

3.1.34 The routing of energy supply wires to the terminals of shunt type surge protection devices shall be configured as Kelvin (in-out) connections. Parallel "T" type connections to the surge protection devices shall not be utilized.

3.1.35 Energy loops shall not be used. Individual wires shall be run from the relay coil, contact or device requiring the energy to the energy source bus. Vital relay repeaters shall not be wired in multiple. The Contractor shall provide 20% spare linked bus space. Energy loop jumpers shall only be permitted on individual relay plug boards. Energy loop jumpers between relay plug boards shall not be permitted.

3.1.36 All Signal Power shall be 100 Hertz. All "hotel" power shall be 60 Hertz.

3.1.37 The CIL houses shall be wired to utilize 220 VAC, three wire, 100 Hz signal power feed and utilize 240 VAC, three wire, single phase, 60 Hz power feed for hotel power as specified herein.

3.1.38 The Master Locations (ML) shall utilize 110 VAC, two wire, 100 Hz signal power feed, as specified herein. Also, certain other track cases and locations shall utilize 110 VAC, two wire, 100 Hz signal power in cable from the interlocking CIL, Master Location houses or adjacent locations in accordance with the Contract Drawings.

3.1.39 The Contractor shall provide a separate circuit breaker and primary surge protection for each equipment case power feed from the nearest CIL, Master Location or case. The breakers shall be sized and wired for 150% of its load calculations. The loads attached to the buses shall be balanced.

3.1.40 The Contractor shall provide all signal and/or control center system interface designs and apparatus supplied to be fully compatible with and interfaced to all applicable, existing Metro-North communications infrastructure, including such infrastructure that is new, but furnished under other contracts, at the time of this project.

3.1.41 The Contractor shall provide for the control of routes, signals, fleeting, switches, traffic, switch blocks, track blocks, absolute block requests and maintainer call. Metro-North standards shall be followed.

3.1.42 The Contractor shall furnish a cab without wayside signal system throughout the complete area of work. The code rates shall be 0, 75, 120, 180 and 270 PPM at 100 Hz.

3.1.43 Steady Energy AC track circuits shall be used both within interlocking limits and in the intermediate territory outside of interlocking limits to implement train detection and provide for the turn-on and bi-directional transmission of 100 Hz coded cab signal energy, as required by the Routings design, defined in the Routings and Aspect drawings. The typical interlocking and intermediate block track circuit applications are shown in the Contract Drawings.

3.1.44 To provide for the movement of trains with failed cab signals, the Contractor shall provide the necessary "ABPR" Logic in the design of the final traffic line circuits. The "ABPR" logic shall be checked in the signal logic to enable track circuit controlled absolute clear block signal aspects. This logic shall provide for the display of Metro-North Rule 11-B(2), Absolute Block Signal, in conjunction with an Absolute Block Request control from the Operations Control Center or Local Control Panel.

3.1.45 The Absolute Block aspect, in accordance with standard Metro-North practice, shall govern over all possible routes from Home Signal to the next Home Signal or End of Block sign, checking the required direction of traffic and that all intervening track circuits are unoccupied, and all hand throw or electric-lock switches (where applicable) are in normal and electrically locked position.

3.1.46 The Electric Lock Switch Location NHL-293 shall be controlled from CP-229.

3.1.47 The Electric Lock Switch Location NHL-337 shall be controlled from CP-234.

3.1.48 The Electric Lock Switch Location NHL-340 shall be controlled from CP-234.

3.1.49 The Electric Lock Switch Location NHL-369 shall be controlled from ML-369.

3.1.50 The Contractor shall provide, for the Electric Lock Switches, the necessary processor and associated vital relay-based control and indication circuits in the Master Location or Control Point. The applications shall operate in conjunction with the external vital fiber optic traffic circuit. The following relate to the Electric Lock Switch:

a. The switch indication/padlock repeater (unlock request) circuit and the electric switch lock control circuits shall be carried between Electric Lock Switch Location and associated control point in dedicated 27c #14 cable. The Contractor shall provide within the pre-wired location all equipment and logic necessary to control the electric lock switch and derail, in accordance with the Contract Drawings (see NHL3401000 and NHL3401001).
b. All external cable, bonding, junction boxes, conduits, clamps, stranded wire, electric switch lock mechanisms, switch and lock movements, rods, lugs, plates, hardware, wooden ties and lubrication will be procured, installed and tested by Metro-North. T-21 Switch and Lock Movements in conjunction with SL-25 Electric Locks will be utilized by Metro-North for these switches and derails.

3.1.51 As Information, Metro-North uses the following typical cable sizes in accordance with Metro-North's standard "Cable", as approved by the Engineer:

a. Power Switches - 5c #9, 12c #14 (17c composite cable)
b. Color Light Dwarf (Go/No-Go) Signal - 7c #9
c. Searchlight Dwarf (Stamford Yard) Signal - 9c #9
d. Signal Power Drop – 2c #2, 3c #1/0

e. Signal Power Local Distribution - 2c #4
f. Track Leads - 2c #6 Twisted
g. Express track circuit cable - 6 Pr. #14 Twisted & Shielded
h. Express signal cables- 19c #14, and/or 27c #14
i. Electric Lock Switch Cable – 19c #14
j. Derail Indication Cable – 7c #14
k. Vital and Non-Vital Processor or device link cables - Fiber Optic – 24 Single Mode Fiber cable
l. Copper communications cable – 100PR and/or 25PR #19

3.1.52 The Contractor shall design the system based on the standard Metro-North cables as specified herein, with the conductor sizes described above.

3.1.53 The Contractor shall design the system based on the maximum lengths for the following cables:

a. Signal Lighting cables shall not exceed 1,200 feet.
b. Switch Cables shall not exceed 1,000 feet.
c. Track Wire shall not exceed 150 feet.

3.1.54 The Track and Cable Plans as included in the Contract Document package define the proposed interlocking/intermediate cable layout and composition. The Contractor shall notify the Engineer, within 90 days of contract award, if any of the proposed express and local cable plant (including provision of 10% spare cable conductors) appears to be inadequate for the Contractors planned signal system design. If, based on the Contractor's calculated loads and the power cables as indicated in the Contract Drawings, additional power transformers or batteries are necessary for power distribution; these shall be provided as a part of the pre-wired signal system at no additional cost to Metro-North.

3.1.55 The Contractor shall design the interface between the existing relay based system and the new vital microprocessor based system being installed at CP-232, CP-233 and CP-235. The Contractor shall be responsible to ensure that the final vital processor design being provided is compatible with this interface design, and that the signal system is fully safe when interconnected and functioning with these interface circuits. The Contractor shall notify the Engineer, within 90 days of contract award, if for any reason the interface design is not compatible with the intended new system design, with recommended signal circuit revisions to provide the desired functionality.

3.1.56 At CP-232, CP-233 and CP-235, the design must include a new cable interface that preserves the existing control and indication wiring which originated in the Genisys equipment (to be removed) to the Weidmueller cable termination

blocks. All cabling from the new non-vital code system for controls and indications (OCC and LCP) shall be reused with minimal disruption to the interlocking.

3.1.57 The Contractor shall be responsible for the design of the vital and non-vital interfaces to the existing AnsaldoSTS MicroLok II vital processor interlocking at CP-240. These existing interlocking systems are to be retained. All design, including signal circuits and signal system hardware, and the necessary revisions to the vital and non-vital application software and upgrades of executive software as required shall be provided by the Contractor. Where compatible vital processor interlocking equipment is proposed, the existing system shall directly interface to the new vital serial links of the new system. Where the supplier's vital processor interlocking equipment is not compatible with the existing signal system, an alternative interface may be proposed. The Contractor shall supply, under all circumstances, the complete design plans and all hardware and software necessary to provide the required interconnection between the old and new systems, including necessary changes to the existing signal equipment.

3.1.58 The Contractor shall notify the Engineer by written letter, to be submitted no later than the 100% design submittal, certify that the overall complete interface designs for CP-232, CP-233, CP-235, and CP-240 have been fully checked, that the Contractor takes responsibility for the integrated design in its final form (including the interface portion originally provided by others), and that this overall design is fully safe when the new signal system is interconnected and functioning with the adjacent territory interface circuits as shown in the final drawings.

3.1.59 All materials shall economically and safely perform within their operating environment and in accordance with their intended function. Workmanship shall conform to the best manufacturing practices in all respects. All materials shall be new and of recent manufacture.

3.1.60 All products provided by the Contractor shall have been in use for at least five (5) years of reliable service on another similar cab signaled commuter or intercity passenger railroad in North America, unless otherwise specified within these Technical Specifications and Contract Drawings.

3.1.61 Should the Contractor propose to use material or equipment that has less than five years of reliable service in an equivalent railroad environment, the Engineer shall specify all acceptance criteria for this equipment. The Contractor shall, at no additional cost or time extension, be responsible for the complete testing, verification and validation necessary to confirm that the proposed product will meet the requirements of these technical Specification and Contract Drawings.

3.1.62 The Contractor shall maintain records that trace materials to their manufacturers, and help verify compliance with quality standards specified or cited in this document.

3.1.63 Whenever a commercial material is not covered by a specification or standard, the material shall be identified by the commercial trademark, and name and address of the supplier. A description of the material composition shall be submitted for approval.

3.1.64 The utility wiring for lights, HVAC, etc., shall be run in conduit. The wire shall be THW or THHN and sized in accordance with the NEC.

3.2 Signal System Performance Requirements

3.2.1 The Contractor shall provide all necessary design and engineering calculations to verify the systems and components provided meet or exceed the required performance metrics. In addition to the supporting calculations, the Contractor shall verify that the actual system provided meets the metrics.

3.2.2 The Contractor shall be responsible for all work necessary to correct any systems, subsystems or component performance that fails to meet the requirements of these technical Specifications and Contract Drawings. Any additional work necessary shall be a no additional cost or extension of time.

3.2.3 The Contractor shall provide all necessary hardware and systems required to validate the performance metrics. The Contractor shall formally validate all performance metrics through calculations and actual testing of the systems and subsystems being provided under this Contract. This validation shall be performed on the actual hardware and with the actual software provided for this Contract. The validation shall be performed prior to the Factory Test where practical. The Factory Test shall not be considered successful unless all metrics have been validated.

3.2.4 The overall performance of the combined vital and non-vital signal system is critical to Metro-North's passenger rail operation in this territory. The Contractor shall supply the vital and non-vital system to receive and process controls and indications in less than two seconds, in accordance with AREMA Signal Manual Part 2.2.12 *Recommended Functional/Operating Guidelines for Vital Software-Based Interlocking Systems*. For the purposes of this requirement, the timing for vital reactions to a change in field inputs, including communications and processing time, shall not exceed two seconds, as measured between the indication inputs and control outputs on the vital and non-vital circuit cards and the terminals of the local control panel devices. Total combined serial communications lag time between local processors, either vital or non-vital, shall not exceed one (1) second.

3.2.5 The performance of the Contractor's system shall meet or exceed criteria that includes, but is not limited to, the following:

a. Under the maximum possible processor loading conditions every Non-Vital Microprocessor-based Interlocking Code System (NVMIS) shall:

    1. Complete the execution of the application program cycle within 500msecs, including transfer of updated control data to the VMIS, and the update of all partners connected to the NVMIS, including the office system and the Local Control Panel.
    2. Respond to an office polling cycle interval of between 200msecs and 1000msecs, with a nominal cycle of 500msecs.
    3. Respond to all connected partners within 500msecs of being polled with updated data.
    4. Process controls from the Local Control Panel within 250msecs of change in state of any input.

b. Under the maximum possible processor loading conditions every Vital Microprocessor-based Interlocking System (VMIS) shall:

    1. Process any control received from the controlling non-vital interface within 400msec of receipt of the control or change of input state.
    2. Update the NVMIS, or any other non-vital partner of the VMIS, with indication data within 800msec of a change in the status of the input image of the VMIS.
    3. The VMIS shall complete the execution of the vital application program cycle within 1 second, including the update of all physical outputs and communication data for connected vital partners.
    4. Respond to connected vital partners within 800msecs of being polled with updated vital data. Time sensitive outputs, such as cab code and block information status shall be updated as required to maintain safe and reliable operations as described later in this section.

c. The Contractor's system design shall minimize propagation delay, such that the required operational performance levels are achieved without reducing safety by encroaching on the safe braking reaction time / free running factor.
d. The Contractor's system shall support communication port prioritization, such that communications affecting safety and operations can be performed ahead of non-safety critical communications.

3.2.6 The Contractor shall provide a system with overall performance such that the total aggregate route clearing time for any route shall not exceed ten (10) seconds. This time measurement shall consider all elements in the entrance-exit route clearing process, including switch operating time (assumed as worst case 4 to 5 seconds to line any route), time to establish a turn of traffic direction, all NVMIS and VMIS processor execution time, and all processor to processor vital data link processing time. The aggregate time shall be measured from the time that a route request is initiated, (exit selected or transmit of control) until the requested signal is displayed in the field (determined from the indication that the route is lined and locked and actual signal displayed). This analysis and subsequent performance verification testing shall be based on local control panel and non-vital processor interface requests and indications from the CTC office.

3.2.7 Switch position requests shall be implemented by the VMIS within one (1) second, measured from the time the VMIS receives the switch control request from a non-vital interface (either entrance-exit determined request or direct switch position request) to energy to throw the switch being applied at the switch machine motor.

3.2.8 Wayside signals shall display a Proceed Cab aspect, Metro-North Rule 11-B(1), within one (1) second, measured from the time all requested switches indicate in final position and including the process of verifying that the requested route is lined. Wayside signals shall display the Absolute Block Signal aspect, Metro-North Rule 11-B(2), within one (1) second, measured from the time the VMIS receives the absolute block control request from a non-vital interface, and including the process of vitally verifying the block is clear.

3.2.9 The Contractor shall provide a system with overall performance such that for the worst case (greatest number of intermediate Master Locations) the changing of the traffic direction occurs in five (5) seconds or less. This shall include all NVMIS and VMIS processor execution time, and all processor to processor vital data link processing time between the several adjacent locations through the automatic territory. This time shall be measured from the traffic request from the field code unit (office control) and local control panel to the local indication of the changed traffic direction.

3.2.10 For all steady energy track AC circuits provided in this contract, the cab signal code shall be enabled by the signal system after the track circuit becomes occupied. The required code rate shall be applied to the rails within 250msecs, measured from the time when a train passes the insulated joints and has shunted the track circuit (based on the track relay opening of front contacts).

3.2.11 The changes in cab signal code rates resulting from changes in block conditions in advance (either upgrade or downgrade) shall be seamless, to prevent cab signal flip conditions. Cab Signal code rates shall be provided in

accordance with the sequences depicted in the routings (control line) drawings included in the Contract Drawings package. The propagation of cab code aspect changes to the rear of a location in response to changed block conditions in advance of this location shall have performance requirements as follows:

a. The change in code rate shall be implemented within one (1) second in the block immediately to the rear of the location where the upgrade can be provided.
b. The change shall be implemented within one (1) second in all blocks to the rear of the location where a changed code rate must be provided.

3.2.12 Where timed cab signal Code Change Points are utilized, five (5) seconds loss of shunt protection shall be provided for the timing function. In addition, the timing function shall be activated each time a train occupies the track circuit, and not reset once the circuit is occupied, regardless of conditions ahead of the block that would not require timing, in order to preclude the effects of intermittent track circuit operation or other conditions occurring in advance of the track circuit where the timed code change is effective.

3.2.13 Track and switch blocks shall be applied or removed by the VMIS within 1 second after receiving the respective request from a non-vital interface.

3.2.14 A wayside interlocking signal shall display a Stop Signal aspect, Metro-North Rule 11-B(3), in accordance with the following performance requirements:

a. A Stop Signal shall be displayed in one (1) second or less measured from the time the VMIS receives the signal cancel command, or a track block command affecting the signal, from a non-vital interface.
b. A Stop Signal shall be displayed in one (1) second or less measured from the time that any interlocking condition affecting the safe display of a signal over the route (for example, the loss of switch correspondence) occurs.

3.2.15 All other miscellaneous functions, such as fleeting, shall be applied or removed by the VMIS within one (1) second after receiving a request from a non-vital interface.

3.2.16 The Contractor shall supply system timing and performance calculations for the signal and communication systems provided under this Contract in order to validate the system meets the requirements of these Technical Specifications and Contract Drawings.

3.2.17 The Contractor provided timing and performance calculations shall be provided with the 60% design submittal. The Contractor's calculated system

timing shall be verified as a requirement of Factory Acceptance Testing (FAT).

3.2.18 The calculations shall encompass local communications between dependent partners within a location (master/slave, peer to peer), and between communication partners on a system-wide level, including vital and non-vital microprocessor-based interlocking systems processing overhead.

3.2.19 The Contractor shall submit, for review and approval by the Engineer, all details, including assumptions, and system input and output criteria used in the system timing and performance calculations. The calculations shall include, but not be limited to:

a. Transaction speed between all communication partners, including non-vital to vital, and vital to vital exchanges, as well as non-vital communications between the field and the office.
b. Propagation delay associated with the update of time critical data that affects the safety and operational performance of the system, such as the update of block status information and interlocking status information.
c. Maximum data that can be transferred between systems without compromising required system responsiveness and safety, and projections of the practical data expected to be transferred based on the overall system design.
d. Time to turn traffic between blocks, including confirmation that traffic has reached the adjacent interlocking to lock out opposing moves.
e. Time to clear interlocking signals, and time required to upgrade cab code when favorable conditions permit.
f. Time to set interlocking signals to stop and downgrade cab code under various operating conditions (i.e. track occupancy, signal cancel commands, processor system shutdown).
g. Performance of the CTC communication interfaces, event recorder interfaces, and other non-vital network traffic.
h. Effects on system performance resulting from communication failures, such as intermittent and total failure of communications systems, collisions and other abnormal system states.
i. The time to restart each type of processing unit, including communication devices. Time shall be from the time restart is initiated until all critical functions affected by the processing unit have been restored to full functionality.

3.3 Signal System to Be Furnished

3.3.1 The Contractor shall provide all necessary pre-wired instrument houses, cases, racks and equipment as described within these Technical Specifications and Contract Drawings.

3.3.2 The Contractor shall provide all necessary pre-wired instrument CILs, houses, cases and equipment necessary at CP-229, CP-230, CP-234 and CP-241, all Master Locations, Snow Melter and Track cases, and provide all interconnections over vital and non-vital dedicated redundant vital fiber optic cable links utilizing TCP/IP communications protocol.

3.3.3 The Contractor shall provide all cases, racks and equipment necessary at CP-232, CP-233, CP-235 and CP-240 required for the conversion to vital serial link interfaces to the new signal system over dedicated redundant vital fiber optic cable links utilizing TCP/IP communications protocol over Ethernet.

3.3.4 At CP-234 the Contractor shall provide for control and interface to the Stamford Yard signals and switches.

a. Control of signals (10E, 66E, 8W, 10W, 12W, 66W, 1010W) and switches (68, 810, 1012) will be from existing Yardmaster's Control Panel.
b. Existing Phase Selective track circuits will be replaced by TRU-III.
c. Existing Searchlight signals to remain, Contractor to provide controls and indications to VMIS.

3.3.5 The Contractor shall provide the communications network interfaces at new and existing locations. The interface shall be by two (2) redundant, path diverse vital data links, two (2) redundant path diverse non-vital CTC links (normal and alternate) and one (1) non-vital diagnostic link. These new data links shall be redundant non-vital fiber optic cable links dedicated redundant non-vital fiber optic cable links utilizing the TCP/IP communications protocol stack (IETF RFC1122) over Ethernet (IEEE 802.3) with rapid spanning tree protocol.

3.3.6 The existing and proposed Block Plan is contained in Contract Drawings BP-101 through BP-107.

3.3.7 The Contractor shall utilize the Routing and Aspect documents provided in the Contract Drawings in the design of the system. These documents can be found on Sheets 0036 through 0578.

3.3.8 The typical drawings provided within the Contract Drawing document represent non-detailed layouts or various circuit types. The circuits represent a sub-set of the required drawings and plans. The Contractor shall use these as a basis for the design and application engineering. The Contractor shall be responsible for providing all details and a complete and separate standalone drawing package for each wayside signal location.

3.3.9 The detailed requirements for the systems, subsystems and equipment listed or referenced in this section shall be found in subsequent sections of these Technical Specifications and Contract Drawings.

3.3.10 Others will install the Contractor provided houses, cases, racks and equipment.

3.3.11 The Contractor shall supply all interface designs between the new and existing systems to permit installation by Metro-North forces.

3.3.12 While the material and equipment listings in this section are intended to be complete, lack of inclusion in this listing does not relieve the Contractor of the obligation to provide all vital, non-vital and communications equipment necessary.

3.3.13 The Contractor shall supply this signal equipment in accordance with the Metro-North standard material reference numbers. Each device, component or piece of equipment shall be provided a unique identification number and complete material description. The reference number for each device shall be provided on the circuit plans contained in a circle. The Contractor shall use existing Metro-North Material Reference numbers and add to the listing any new devices. The Contractor shall submit for approval all proposed new reference numbers. The Metro-North Material Reference Documents will be provided at time of Contract Award.

3.3.14 The Contractor shall provide the pre-wired cases, houses, equipment and racks as listed in the table below. The Track and Cable plans within the Contract Drawings show the referenced locations:

LOCATION NAME	CHAINING	DESCRIPTION
CP 229 (GREEN) Location A		High Double Case
CP 229 (GREEN) Location B		High Double Case
CP 229 (GREEN) SM1		Snow Melter Case
CP 229 (GREEN) Location C		High Double Case
CP 229 (GREEN) SM2		Snow Melter Case
CP 229 (GREEN) CIL		House
CP 229 (GREEN) Location D		High Double Case
CP 229 (GREEN) Location E		High Double Case
CP 229 (GREEN) SM3		Snow Melter Case
CP 229 (GREEN) Location F		High Double Case
EL 293		High Double Case
CP 230 (COB) Location A		High Double Case
CP 230 (COB) SM1		Snow Melter Case

LOCATION NAME	CHAINING	DESCRIPTION
CP 230 (COB) Location B		House
CP 230 (COB) SM2		Snow Melter Case
CP 230 (COB) CIL		House
TCML 308		High Double Case
ML 312		House
TCML 315		High Double Case
ML 318		House
CP 232 (SELLECK) (Existing CIL)		Vital and Non-Vital Equipment and Racks
CP 233 (W STAM) (Existing CIL)		Vital and Non-Vital Equipment and Racks
CP 234 (STAM) Location A		High Double Case
CP 234 (STAM) Location B		House
CP 234 (STAM) SM1		Snow Melter Case
CP 234 (STAM) Location C		High Double Case
CP 234 (STAM) SM2		Snow Melter Case
CP 234 (STAM) SM3		Snow Melter Case
CP 234 (STAM) CIL		House
CP 234 (STAM) SM4		Snow Melter Case
CP 234 (STAM) Location D		High Double Case
CP 234 (STAM) SM5		Snow Melter Case
CP 234 (STAM) Location E		High Double Case
CP 234 (STAM) SM6		Snow Melter Case
CP 234 (STAM) Location F		High Double Case
CP 234 (STAM) SM7		Snow Melter Case
CP 234 (STAM) Location G		House
CP 234 (STAM) Location H		High Double Case
CP 234 (STAM) Location J		House
CP 234 (STAM) SM8		Snow Melter Case
CP 234 (STAM) Location K		High Double Case
CP 234 (STAM) SM9		Snow Melter Case
CP 234 (STAM) Location L		High Double Case
EL 337		High Double Case
EL 340		High Double Case
CP 235 (E STAM) (Existing CIL)		Vital and Non-Vital Equipment and Racks
ML 354		House
ML 360		House
TCML 364		High Double Case
EL 369		High Double Case

LOCATION NAME	CHAINING	DESCRIPTION
ML 369		House
TCML 375		High Double Case
ML 379		House
ML 384		House
ML 393		House
TCML 401		High Double Case
CP 240 (W WALK) (Existing CIL)		Vital and Non-Vital Equipment and Racks
CP 241 (WALK) Location A		House
CP 241 (WALK) SM1		Snow Melter Case
CP 241 (WALK) Location B		High Double Case
CP 241 (WALK) SM2		Snow Melter Case
CP 241 (WALK) Location C		High Double Case
CP 241 (WALK) SM3		Snow Melter Case
CP 241 (WALK) CIL		House
CP 241 (WALK) Location C		House

3.3.15 The Contractor shall provide all pre-wired CILs, Slave CILs, houses, cases, systems, subsystems, equipment, components, software, firmware, devices and material necessary for the full installment and commissioning of the new wayside signal system. The material provided shall include, but not be limited to, the following:

a. CIL, Slave CILs, Houses and Cases
b. Racks, Shelves and Terminal Boards
c. Ladder Tray
d. Lights
e. Vital Microprocessors
f. Non-Vital Microprocessor
g. Batteries and Battery Racks
h. Battery Chargers
i. Vital Relays and Bases
j. Non-Vital Relays and Bases
k. Code Transmitters
l. Local Control Panel
m. Master Location Indication Panel
n. External Communication Termination Box
o. External Signal Communication Box
p. FRA Test Panel
q. TRU-III 100 Hz Track Circuit Equipment
r. Dual Frequency Code Reset Unit
s. Track Transformers

t. Auto Transformers
u. Isolation Transformers
v. 1:1 Isolation Transformers
w. Switch Machine Lock (SML) & Solid State Relay (SSR)
x. Ethernet Switches
y. Cab signal Equipment
z. AFO Track Circuits
aa. Fire Suppression System
bb. Fire Extinguishers
cc. HVAC System
dd. Vent Fans
ee. Heaters
ff. Intrusion Detection System
gg. Diagnostic System
hh. Power Supplies
ii. DC to DC Converters
jj. AC Power Transfer Panel
kk. Wayside Signal LEDs
ll. Grounding
mm. Ground Detectors
nn. Current Monitor Devices
oo. Circuit Breakers and Distribution Panels
pp. Surge Protectors
qq. Reactors
rr. Equalizers
ss. Capacitors
tt. Resistors
uu. Fuses
vv. Rectifiers
ww. Filtering Devices
xx. Lightning Arrestors
yy. Terminals
zz. Fiber Distribution Panels
aaa. Padlocks
bbb. Wiring and Cabling
ccc. Receptacles & Switches
ddd. Protected 66 Telephone Block
eee. Wall mount Telephone Jack and Telephone Wire
fff. Plan Cabinet and Desk
ggg. Plan Holder
hhh. Access Panel
iii. Miscellaneous Equipment and Mounting Hardware

3.3.16 The Contractor shall provide all necessary communications and signal systems, subsystems, equipment, components, software, firmware, devices and

material necessary for the full installment and commissioning of the new wayside signal system vital serial interface and non-vital code system conversions for CP-232, CP-233, CP-235 and CP-240 CIL houses. The material provided shall be compatible with existing material in the existing locations. The material provided shall include, but is not be limited to, the following:

a. Racks, Shelves and Terminal Boards
b. Vital Microprocessors
c. Non-Vital Microprocessors
d. LCP Cabling Interface
e. New AnsaldoSTS MicroLok II Executive and Application Programs
f. New AnsaldoSTS MicroLok II I/O Boards
g. Modifications to Local Control Panels
h. Serial to Ethernet Converters (SEC)
i. Vital Relays and Bases
j. Non-Vital Relays and Bases
k. External Fiber Distribution Panel
l. Ethernet Switches
m. Diagnostic System
n. Power Supplies
o. DC to DC Converters
p. Surge Protectors
q. Lightning Arrestors
r. Terminals
s. Fiber Distribution Panels
t. Wiring and Cabling
u. Miscellaneous Equipment and Mounting Hardware

3.3.17 The Contractor shall provide the reliability back up equipment, as listed below, necessary to support the requirements of Railroad operations and the environment of the Railroad. The Contractor shall supply a minimum of 10% reliability back up equipment for all components (no less than one) provisioned with the exception of the houses.

a. Track Circuits
    1. Track Transformers
    2. Auto Transformers
    3. TRU-III Code Reset Units
    4. TRU-III Units
    5. Track Resistors
    6. Track Coils
    7. Track Fuses – 1A
    8. Track Fuses – 30A
    9. Equalizers
    10. Track Relays

b. AFO
   1. AFO Series Pick
   2. Track Surge Protection
   3. DC Power Surge Protection

c. Switch Control
   1. SML-110s
   2. SSRs

d. Vital Processor
   1. Chassis
   2. Vital Input Cards
   3. Vital Output Cards
   4. Vital Lamp Driver Cards
   5. Code Rate Generator Cards
   6. Vital CPU Cards
   7. Surge Protections

e. Non-Vital Processor
   1. Chassis
   2. Non-Vital Input Cards
   3. Non-Vital Output Cards
   4. Non-Vital CPU Cards

f. Mini-Vital Processor
   1. Chassis
   2. Vital Input Cards
   3. Vital Output Cards
   4. Code Rate Generator Cards
   5. Vital CPU Cards
   6. Non-Vital Input Cards
   7. Non-Vital Output Cards
   8. Non-Vital CPU Cards

g. Power
   1. AC Line Protectors
   2. Battery Line Protectors
   3. Current Monitors
   4. Voltage Surge Protections
   5. Power distribution Blocks
   6. Isolation Transformers
   7. Power Transformers
   8. Rectifiers
   9. Isolation Transformers
   10. Circuit Breakers

11. DC Surge Protections
12. DC to DC Converters
13. Fuse Disconnects
14. Battery Chargers
15. Batteries
16. Transfer Panels

h. Communications
   1. Ethernet Switches (Layer 2)
   2. Ethernet Switches (Layer 3)
   3. Fiber Distribution Panels

i. LCP
   1. All Push Buttons Types
   2. All LED Colors & Types
   3. Tiles

j. Vital Relay
   1. Biased Neutrals
   2. Code Followers

k. Miscellaneous
   1. Ground Fault Detectors
   2. Non-Vital Relays
   3. Event Recorders
   4. Wayside Signal LEDs
   5. FRA Test Panel

3.3.18 Contract Drawings provide a high level overview of the fiber optic signal networks. The drawing illustrates the vital and non-vital network requirements. The interface to the existing Metro-North communication node locations is shown in the drawing. The limits of the vital and non-vital networks are shown. The drawing illustrates the new interlockings, master locations and existing interlockings.

3.3.19 Contract Drawings illustrate the vital signal network requirements and the high level functional connections to the new interlockings, master locations and interface locations.

3.3.20 Contract Drawings illustrate the non-vital network requirements and the high level functional connections for the Centralized Traffic Control (CTC) and Diagnostic systems.

3.3.21 Contract Drawings illustrate the cable plan for the express cables and local cables at the master locations and track cases.

3.3.22 Contract Drawings illustrate typical circuits to be used by the Contractor in the design of the system. Typical plans include designs for track circuits, switch machine control, signal lighting, vital and non-vital I/O, snow melter circuits, power circuits, case and house layouts, and rack layouts. These plans are not intended to be a complete set. The Contractor shall provide all necessary detailed plans.

3.3.23 Contract Drawings illustrate typical circuits to be used by the Contractor in the design of the system. Typical plans include various block diagrams for the vital and non-vital communication and signal apparatus, and other plans related to the master location. The indication panel shall display all track circuits controlled by the master location. These plans are not intended to be a complete set. The Contractor shall provide all necessary detailed plans.

3.3.24 Contract Drawings illustrate typical circuits to be used by the Contractor in the design of the system. The typical plans include various block diagrams and circuits for the vital and non-vital communication and signal apparatus, and other plans related to the electric lock locations. These plans are not intended to be a complete set. The Contractor shall provide all necessary detailed plans.

3.3.25 Contract Drawings illustrate typical circuits to be used by the Contractor in the design of the system. The typical plan includes various block diagrams and circuits for the vital and non-vital communication and signal apparatus, and other plans related to the track case locations. These plans are not intended to be a complete set. The Contractor shall provide all necessary detailed plans.

3.3.26 Contract Drawings illustrate typical circuits to be used by the Contractor in the design of the system. The typical plan includes various block diagrams and circuits for the vital and non-vital communication and signal apparatus, and other plans related to the interface to the existing relay based system at CP-232, CP-233, and CP-235. These plans are not intended to be a complete set. The Contractor shall provide all necessary detailed plans.

3.3.27 Contract Drawings illustrate typical circuits to be used by the Contractor in the design of the system. The typical plan includes various block diagrams and circuits for the vital and non-vital communication, local cable plans, Local Control Panel, signal apparatus, and other plans related to CP-229, CP-230, CP-234, and CP-241. These plans are not intended to be a complete set. The Contractor shall provide all necessary detailed plans.

3.3.28 Contract Drawings illustrate typical circuits to be used by the Contractor in the design of the system. The typical plan includes various block diagrams and circuits for the vital and non-vital communication and signal apparatus, and other plans related to the interface to the interlocking at CP-240.

These plans are not intended to be a complete set. The Contractor shall provide all necessary detailed plans.

3.3.29 The Contract Drawing package includes various plans from the existing interlockings at CP-232, CP-233, CP-235, and CP-240. These drawings are included for reference only to illustrate the existing circuits which the Contractor will be required to provide a detailed interface.

3.3.30 The processor based interlockings for CP-229, CP-230, CP-234, and CP-241 shall be zoned.

3.3.31 CP-229 shall be a single Master configuration.

3.3.32 CP-230 shall be a Master / Slave configuration.

3.3.33 CP-234 shall be a Master / Slave / Slave / Slave configuration.

3.3.34 CP-241 shall be a Master / Slave / Slave configuration.

3.3.35 They will be in accordance with the following:

a. The vital processor interlocking controllers shall be configured in three (3) separate zones named after the controlling track. The zone controlling Track 3 (Zone 1) will be named **T3**, Tracks 1 and 2 (Zone 2) will be named **T1.2**, and Track 4 (Zone 3) will be named **T4**.
b. The zoned vital processors in the centrally located interlocking house shall each directly interface to the interlocking home signals of the respective zone, and to the solid state switch controllers, with transfer from primary to alternate control arranged as described below.
c. Under this configuration, the single CIL location is the equivalent of the central instrument location of a relay based interlocking. The main interlocking logic shall be concentrated in the 3 zoned processors, which along with the indication relays of the switch repeating circuits and track circuit equipment shall reside in the CIL location.
d. The primary control and indication of the crossover switches connecting the adjacent zones shall be assigned to Zone **T1.2** which controls Tracks 1 and 2.
e. Indications of normal switch position for these switches, and the status of the detector track circuit in the normally controlling zone, shall also be provided to the vital processor controlling the adjacent zones.
f. Upon a failure of the adjacent zones processor with the crossover switches normal, these vital inputs shall be utilized in the signal control logic to provide for uninhibited train moves over the switch in the healthy zones.

g. Control shall be provided for these shared crossover switches from both of the adjacent zones processors (primary and alternate), such that if the adjacent zone processor fails with the crossover reverse, a vital time delay equal to at least the longest time locking for any signal that can be routed over the switch in the other zones, shall be run. Appropriate logic and external vital I/O shall be provided to insure that the affected signals in the adjacent zones have been held at stop for the entire time duration. Once this release time is satisfied, the crossover may then be controlled back to normal position by the remaining healthy processors, subject to full route locking in the active zone, but in accordance only with detector locking of the switch by the appropriate track circuit or circuits from the failing zones. Once the crossover is normal, it shall not be able to reverse the switch, and uninhibited train moves shall be possible over the switch in normal position through the healthy zone.
h. The switch position indications shall be provided utilizing external vital switch repeater ("NWPR" and "RWPR") relays, in order to provide isolation between the external line circuits and the separate vital processors.
i. Failures of non-vital or vital serial links that can result in total or partial loss of control of signal devices in a zone (even though the vital processor system remains healthy), or render switches locked and therefore unable to be controlled from the normally assigned zone processor, shall be detected and appropriate logic provided under these failure conditions to allow the safe transfer of switch control to the adjacent zone, as otherwise described in item "e." above.

3.3.36 A mosaic tile type local control panel (LCP) shall be provided within the CIL at CP-229, CP-230, CP-234, and CP-241 to provide for control of the local interlocking from the field in the event of failure of the non-vital microprocessor based, user programmable, field code system. The non-vital microprocessor based, user programmable, field code system shall provide the necessary I/O and program logic for entrance-exit control of the interlocking from the LCP, which shall be the normal mode of operation. When the field code system is unavailable, the LCP shall interface directly to the vital microprocessor interlocking systems (for all zones, where provided), to provide basic unit lever control of the interlocking.

3.3.37 A Test Panel shall be provided within the CIL CP-229, CP-230, CP-234, and CP-241 to facilitate FRA required switch locking, signal indication locking, route locking, and time locking tests. The Test Panel shall be mounted in an enclosure provided with a hinged cover, and shall be provided for and incorporated into the vital software design. The Test Panel shall provide the following:

a. Test Links to directly energize vital inputs of the vital processor performing the affected interlocking logic, providing for the following functions, where "xx" is the specific switch or signal designation:

   1. A normally closed test link shall provide a vital input (designated TPxxRGP) to be used to test signal indication locking, on a per-signal basis, which shall when opened cause the internal red signal repeater (RGP) logic state utilized in the AS logic equation for that signal to provide the "signal not at stop" state.
   2. A normally closed test link shall provide a vital input (designated TPxxLP) to be used to implement switch locking, an a per-switch basis, which shall when opened cause the individual internal switch locking states to provide the switch locked condition.

b. LEDs, located inside the Test Panel enclosure, which shall be controlled from vital outputs, and shall indicate the following internal vital processor logic states:

   1. Each of the switch lock logic states (designated TPxxLKE), which shall be illuminated when logic state is not asserted (condition for switch locked).
   2. Each of the signal indication lock logic states (TPxxASTEKE), which shall be illuminated when not asserted (condition for signal indication locking in effect) and which shall flash when not asserted and while time locking is effective ("AS" timing is being run).

3.3.38 The Contractor shall provide each of the services, systems or equipment listed below. The Contractor shall provide the engineering submittals, project and site specific documentation, plans and drawings, material, software and all other elements and services necessary to complete each element. Additional details are provided elsewhere in these Technical Specifications.

a. One computer engineering application specific to the Contractors vital and non-vital provided applications. This shall include, but not be limited to, the computer workstation, laser printer, compliers and all other software and licenses necessary for all elements of the products provided.
b. One portable diagnostic system test set for the vital and non-vital circuit boards.
c. One remote office diagnostic and test office system.
d. One wayside vital, non-vital microprocessor and communication system training system. This training system shall be included within the Contractors provided training courses. The system shall contain a complete representation of all hardware and software components used with the Contractor provided system and shall include, but not be

limited to, the zoned vital and non-vital processors, track circuit hardware, communication apparatus, fiber optic interconnecting cables, cabinets and racks as require and local control panels.

e. The Contractor shall provide reliable back up equipment.
f. The Contractor shall provide system, subsystem and component training.
g. The Contractor shall provide engineering, design, and support work required to control CP-229, CP-230, CP-232, CP-233, CP-234, CP-235, CP-240, and CP-241 from the existing Metro-North primary and backup Operations Control Center (OCC) locations. Metro-North will be responsible for revisions to the OCCs.
h. The Contractor shall provide engineering, design, drafting, CAD work and circuit design including, but not limited to, circuit plans, all hardware, software and field support engineering.
i. The Contractor shall perform factory testing including simulation of interlocking operations, apparatus, code systems and systems testing to the satisfaction of the Engineer.
j. The Contractor shall provide all required documentation.
k. The Contractor shall provide support for installation and connection of equipment, including on site assistance at field pre-testing, cut over and in-service testing.
l. The Contractor shall provide training on the theory of operation, adjustment, maintenance, trouble-shooting and modification of vital microprocessor interlocking control systems, non-vital microprocessor code systems, track circuits, communication hardware and system.

3.4 Signal Communications Networks to Be Furnished

3.4.1 The Contractor shall provide all necessary communication and data networking designs and apparatus necessary to meet the requirements of this Technical Specification and Contract Drawings.

3.4.2 The Contractor shall provide only apparatus that meets or exceeds the temperature, humidity, vibration and shock and electromagnetic interference requirements as defined within these Technical Specifications.

3.4.3 The Contractor shall provide communications and data equipment, apparatus, designs, provisioning, software, diagnostics, fiber distribution panels, fiber optic jumpers, fiber terminations, Ethernet switches and related devices.

3.4.4 The Contractor shall provide only fiber optic cable devices and connectors for single mode fiber. Devices requiring multi-mode fiber connectors or cable are not permitted to be used.

3.4.5 The Contractor's designs shall establish four (4) separate types of networks, each with their own unique function and performance requirements. The general names and functions of these four (4) network types are defined as follows:

a. The *South Vital Network* (SVN) shall transport all vital and non-vital communications necessary for uninterrupted local signal system operation, but explicitly excluding diagnostic data per Item c. below, between Master Locations (ML) and Central Instrument Locations (CIL).
b. The *North Vital Network* (NVN) shall be functionally identical to the South Vital Network and shall serve as a full-time redundant (not "hot stand-by") network to the SVN.
c. The *Diagnostic Local Area Network* (DLAN) shall transport diagnostic requests and data between ML and CIL for relay to/from the wide area diagnostic network defined in Item d below.
d. *The Centralized Traffic Control & Diagnostic Wide Area Network* (CTC&D WAN) shall transport CTC and diagnostic communications between CIL and existing Metro-North communications nodes. Communication transport between those nodes and the existing primary and backup control centers will be provided by Metro-North over their existing infrastructure.

3.4.6 The Contractor shall neither make changes to, nor request that changes be made, to the outside cable plant to be furnished by others under separate contract. The Contractor's proposed designs shall make use of outside cable plant as it is shown in the Contract Drawings.

3.4.7 The networking equipment provided by the Contractor shall have a proven record of successful performance in railroad applications and interfaced with signal equipment provided by the Contractor. This comparison shall include, but not be limited to, complexity of track layout (four-track electrified territory), volume of traffic and on-time performance requirements (major metropolitan commuter operation).

3.4.8 The SVN, NVN and CTC&D WAN shall be designed and furnished such that no single point of failure of either equipment or cable plant, whether or not the failed component was furnished by the Contractor, will result in lost or diminished communications (defined below) over these networks. Removal and replacement of any such single failed component while under live traffic shall also not result in any lost or diminished communications over these networks. Note that this requirement does not pertain to the DLAN.

3.4.9 Failure to meet any performance requirement of the integrated signal system as defined by these Specifications, if such failure can be attributed to the

SVN and/or NVN, shall constitute "lost or diminished communications" of the SVN and/or NVN per the above Section.

3.4.10 Failure to meet the following criteria shall constitute "lost or diminished communications" of the CTC&D WAN per the above Section. These criteria shall also be met under normal operating conditions.

a. Duplicate messages sent to the office simultaneously via the normal and alternate CTC communications ports at any given CIL shall not experience latency relative to each other greater than 30ms under normal operating conditions.
b. No indication in the office shall be delayed by the CTC&D WAN more than 1 second from the actual change of status in the field.

3.4.11 The Contractor's provided designs for the SVN, NVN, DLAN and CTC&D WAN shall only use Ethernet switching for the directing of data traffic. Internet Protocol (IP) routing shall not be used.

3.4.12 Transport over the existing Metro-North communications infrastructure will also be provided solely as a switched Ethernet service. However, Contractor furnished signal field devices shall communicate end-to-end with existing Metro-North office systems or other signal field devices using the TCP/IP protocol stack (IETF RFC1122) over Ethernet. All IP routing functions necessary for communication between the field and existing office systems will be performed by Metro-North within their existing office networks.

3.4.13 The network design shall utilize standard IEEE 802.1Q Virtual Local Area Network (VLAN) techniques to segment the overall physical networks provided under this Contract into logical segments such that traffic does not propagate between segments unless expressly necessary for correct function of the integrated signal system. These segments are indicated explicitly on the Signal Network Overview Block Diagram, but can be generally described as spanning from Control Point to Control Point for the SVN, NVN and DLAN, and from communications node to communications node for the CTC&D WAN.

3.4.14 Both the SVN and NVN shall be physically and logically isolated from the DLAN and the CTC&D WAN, as well as any other existing Metro-North network.

3.4.15 The SVN shall be physically and logically separate from the NVN so that any disruption in one network, such as an equipment failure or data storm, has no impact on the other network.

3.4.16 All Ethernet switches to be furnished by the Contractor shall be equipped with alarm relay contacts as defined elsewhere in these Specifications.

For the SVN and NVN, these relay outputs shall be connected to discrete I/O points of their associated vital processors so that critical failures of SVN or NVN switches can be reported via the Remote Diagnostic System defined elsewhere in these Specifications. This will be the only connection permitted between the SVN or the NVN and the remote diagnostic system or any other network.

3.4.17 The Contractor shall provide all network devices with firmware that is the most recent version at the time of shipment. If any network device is found to have outdated firmware upon shipment, the Contractor shall install the most recent version in the shipped units at no additional expense to Metro-North.

3.4.18 Network devices shall be non-proprietary and interoperable with required configuration.

3.4.19 The Contractor shall furnish Metro-North with electronic copies of each and every configuration file for each network device. The electronic copies shall have file names that use the associated network device's location and network designation so that it is clear which device correlates with each configuration file.

3.4.20 The Contractor shall furnish each networking device to be connected to the 12VDC vital power bus with its own DC-to-DC converter and DC surge protection as defined elsewhere in this Specification. The DC-to-DC converters shall provide electrical isolation between the signal and communication systems. In particular, grounds on the communication system shall not result in grounds on the vital signal power bus.

3.4.21 If any communications link between signal equipment and networking devices, including, but not limited to, copper Ethernet or serial connections, creates a ground path between the vital signal ground and earth ground, the Contractor shall correct said condition at no additional cost to Metro-North. The method proposed to correct such grounding faults shall first be submitted to Metro-North for approval.

3.4.22 All networking devices that are to be furnished by the Contractor for installation by Metro-North Force Account shall be tested, and their configuration proven, during factory integration and acceptance testing as defined elsewhere in this Specification.

3.4.23 The Contractor shall furnish and install a minimum of two (2) Layer 2 Ethernet switches, as defined elsewhere in these specifications, in each of the new Central Instrument Location houses at CP-229, CP-230, CP-234, and CP-241. At each location, these switches shall be utilized for the SVN and NVN respectively.

3.4.24 The Contractor shall furnish and install a minimum of three (3) Layer 2 Ethernet switches, as defined elsewhere in these Specifications, in each new Slave CIL(s) and Master Location house. At each location, these switches shall be utilized for the SVN, NVN and DLAN respectively.

3.4.25 The Contractor shall furnish and install a minimum of two (2) Layer 3 Ethernet switches, defined elsewhere in these specifications, in each of the new Central Instrument Location houses at CP-229, CP-230, CP-234, and CP-241. At each location, these switches shall be utilized as redundant units for the CTC&D WAN.

3.4.26 The Contractor shall furnish, for installation by Metro-North Force Account, a minimum of two (2) Layer 2 switches at CP-232 CIL, CP-233 CIL, CP-235 CIL, and CP-240 CIL. These switches shall be utilized for the SVN and NVN respectively.

3.4.27 The Contractor shall furnish a minimum of two (2) Layer 3 switches, for installation by Metro-North Force Account, at each of the existing CP-232, CP-233, CP-235 and CP-240 Central Instrument Locations. At each location, these switches shall be utilized as redundant units for the CTC&D WAN.

3.4.28 Each pre-wired CIL, Slave CIL and Master Location furnished by the Contractor shall be equipped with fiber distribution panels (FDP) as defined elsewhere in these specifications and as shown on the Contract Drawings. Slave CIL and Master Location (ML) houses shall be furnished with two (2) FDP, one (1) internal to the house and one (1) in an external wall-mounted enclosure. Central Instrument Locations shall be furnished with three (3) FDP, one (1) internal to the house and two (2) each in their own external wall-mounted enclosure.

3.4.29 Interface rack design for CP-232, CP-233, CP-235 and CP-240 should include fiber distribution panels (FDP) as defined elsewhere in these specifications and as shown on the Contract Drawings. Two (2) FDP, one (1) internal to the house and one (1) in its own external wall-mounted enclosure shall be provided to Metro-North for installation by Force Account.

3.4.30 Each pre-wired CIL, Slave CIL, Interface House, and ML furnished by the Contractor shall be equipped with an RJ-11 telephone wall jack, suitable for mounting of a mini wall-type telephone, and a 25-pair protection block as defined elsewhere in these specifications and as shown on the Contract Drawings. The Contractor shall wire the wall jack to the protection block in a manner suitable for two-line telephone applications.

3.4.31 In addition to any components expressly named in this Section, the Contractor shall furnish all miscellaneous hardware necessary for a complete,

functional installation. This shall include, but not be limited to, cross-connect wire, fiber optic jumpers, innerduct, Category 5 cables, serial cables, mounting hardware, etc.

3.5 Contract Drawings

3.5.1 The plans and drawings included with these Technical Specifications and Contract Drawings are intended to assist the Contractor in preparing the design. The plans represent a preliminary level of design. These plans are not fully detailed and do not represent a complete quantity of systems, subsystems, electronic apparatus, relays, circuits, or logic required. It is the responsibility of the Contractor to use these plans and drawings to complete the design and application engineering for the full extent of the contract related work.

3.5.2 Tie-in drawings included in the Contract Drawings package are provided for information only, to assist the Contractor in the design.

3.5.3 The addition or deletion of apparatus by the Contractor shall be in accordance with the requirements of the Technical Specifications and as determined by the specific requirements of the application. The Contractor is responsible for designing the detailed circuits and the application of the apparatus.

3.5.4 Appendix "C" of this document contains the listing of drawings supplied within the Contract Drawing document.

3.5.5 Appendix "D" to this document provides typical processor based vital and non-vital logic for the new interlockings and intermediate locations. It contains logic statements in Boolean expression format which are intended to assist the Contractor in preparing the application software design. Appendix "D" represents a preliminary non-site specific level of design. The Contractor is responsible for designing the final, complete, site specific application logic program for CP-229, CP-230, CP-234 and CP-241. The Contractor's design shall satisfy all requirements of these Technical Specifications and Contract Drawings.

3.6 Special Conditions

3.6.1 Polarity Compensation Points are shown on the Contract Drawings. These locations have been established to provide back-to-back track circuit feed configurations at locations where the signal power system can be remotely sectionalized. When this sectionalizing occurs, the signal power feeding adjacent track circuits may not have the same phase reference. Such a condition will affect integrity of broken down insulated joint protection for a feed/relay configuration. The track circuit Polarity Compensation Points shall be maintained

in the configurations shown to support the existing signal power sectionalizing arrangement.

3.6.2 In accordance with the requirements of the federal "Rail Safety Improvement Act of 2008" Metro-North will be required to implement Positive Train Control (PTC) functionality for the Commuter Rail territory included in this project. The PTC apparatus and systems will be added at a future date. To support the future PTC requirements, the Contractor shall provide in the new interlockings at CP-229, CP-230, CP-234, and CP-241 additional discrete vital I/O points, as follows:

a. Vital inputs and outputs, on a per home signal basis by processor zone to provide a future dedicated vital enable output for "radio release" control for each home signal.
b. A vital input, on a per zone basis, to provide an external enable control for PTC.

3.6.3 These additional PTC I/O points shall be considered in the in-service count, and shall be over and above the requirements for spare I/O points as defined elsewhere in these Technical Specifications.

3.6.4 Audio Frequency Overlay (AFO) Track Circuits shall not be utilized for any application except for electric lock locations.

3.6.5 Series type Audio Frequency Overlay (AFO) track circuits shall be utilized for local electric switch lock release.

3.6.6 All microprocessor-based products including the vital and non-vital microprocessor-based control system that shall be furnished as part of this Contract shall be proven products that have been "Grandfathered In" as to the requirements of the Code of Federal Regulations, Title 49, Part 236, Subpart H – Standards for Processor-Based Signal and Train Control Systems. (49 CFR 236, Subpart H)

3.6.7 Should the Contractor propose a "new or novel product" as defined within 49 CFR 236, Subpart H, or should an existing proven "Grandfathered product" be significantly modified for use on the Contract, all provisions of 49 CFR 236, Subpart H, shall apply and the Contractor shall be required to submit all documentation including the Product Safety Plan defined within 49 CFR 236.907.

3.6.8 The term "Grandfathered In" as used within this Specification refers to existing microprocessor-based products which have been in service with a proven record of reliability and safety as of the publication date of the 49 CFR 236 Subpart H, Final Rule which is March 7, 2005.

3.7 Signal System Staging

3.7.1 The wayside signal systems included in this project are far too complex to be placed into service in a single cutover. The cutover process requires removal of the existing system along with installation and testing of the new system. The maximum time permitted for any cutover stage is approximately 48 hours. This period of time spans from Friday to Sunday. All work must be complete and full operation restored within this timeframe. To meet these requirements, the Contractor shall design the wayside hardware and software systems, subsystems and components to facilitate the staged sequential cutovers necessary to safely and efficiently maintain the Metro-North railroad train operation.

3.7.2 There will be a minimum of three (3) phases of cutovers, each requiring the Contractor to provide tie-in circuitry and microprocessor programming / relay circuit modifications at all interlockings. They are as follows:

a. Cutovers to support Final Routing Plans utilizing the upgraded 5 aspect cab signal system soon to be employed by Metro-North (**FINAL**).
b. Cutovers to support Final Routing Plans utilizing the current 4 aspect cab signal system employed by Metro-North (**270 CODE CUTBACK**).
c. Cutovers to support Staging Plans utilizing the current 4 aspect cab signal system employed by Metro-North (**STAGING PLANS 1 – 7**).

3.7.3 The 60 MPH cab rate will be upgraded when the Metro-North train equipment have had a cab signal upgrade deployed. The Contractor is not responsible for the onboard cab signal upgrade hardware.

3.7.4 The final number of cutover stages will be based on the design provided by the Contractor. Product selection, interface complexity, testing requirements and ease of implementation will drive the number of stages. These are the responsibility of the Contractor.

3.7.5 The suggested cutover stages outlined in this section are included to assist the Contractor in developing the designs and necessary support. They do not represent a final quantity. Where possible, practical and safe, modifications of these stages will be permitted. The time limits for the cutovers will drive the number of stages.

3.7.6 The Contractor shall provide a detailed plan for each cutover stage illustrating how they plan on supporting the staged cutovers with the design of the system and field support. All software, hardware and support necessary shall be provided by the Contractor. This shall include, but not be limited to, extra microprocessor systems, extra vital or non-vital I/O cards, vital and non-vital

relays and other components.

3.7.7 The Contractor shall provide designs to support the various stages by implementing external vital wired selections to activate sections or de-activate sections of the application logic in both the vital and non-vital systems. The details for this control shall be designed in a failsafe manner to prevent any unsafe conditions.

3.7.8 The Contractor shall provide full sets of plans for each stage or cutover necessary to support the tie-in circuits, relay logic revisions, cab signal changes and all other related plans and documentation.

3.7.9 There are three (3) distinct wayside territories for which specific staging designs shall be provided by the Contractor. These territories are as follows:

a. An entirely new signal system for CP-241 – **STAGE 1**.
b. An entirely new signal system for CP-229 to CP-232 (exclusive) – **STAGES 2, 3 and 4**.

    1. Tie-in revisions, final cab signal implementation circuits, SVN/NVN and CTC&D WAN logic revisions for CP-232 and CP-233.

c. An entirely new signal system for CP-234 to CP-235 (exclusive) to CP-240 (exclusive) – **STAGES 5, 6 and 7**.

    1. Tie-in revisions, final cab signal implementation circuits, SVN/NVN and CTC&D WAN logic revisions for CP-233.
    2. Tie-in revisions, final cab signal implementation circuits, SVN/NVN and CTC&D WAN logic revisions for CP-235.
    3. Tie-in revisions, final cab signal implementation circuits, SVN/NVN and CTC&D WAN logic revisions for CP-240.

3.7.10 Should it be necessary to support the Metro-North operation, additional cutover Sub-Stages shall be provided by the Contractor.

3.7.11 Stage 1 – CP-241

a. Install New Interlocking Signal Equipment.
b. Contractor to provide programming revisions to conform to Stage 1 Routing Plans, Project Sheets 0341 through 0359.
c. Contractor to provide Westward Tie-In circuit revisions / programming in New LOC A to Existing LOC A for:

    1. Phase Selective Track Circuits

2. Line Circuits
3. Traffic Circuits

d. Contractor to provide Eastward Tie-In circuit revisions / programming in New LOC C to Existing LOC C for:

1. Phase Selective Track Circuits
2. Line Circuits
3. Traffic Circuits

3.7.12 Stage 2 – CP-229

a. Install New Interlocking Signal Equipment.
b. Contractor to provide programming revisions to conform to Stage 2 Routing Plans, Project Sheets 0360 through 0377.
c. Contractor to provide Westward Tie-In circuit revisions / programming in new CIL for:

1. Existing SVN/NVN Fiber Optic Design

d. Contractor to provide Eastward Tie-In circuit revisions / programming in new CIL to existing CIL for:

1. Phase Selective Track Circuits
2. Line Circuits
3. Traffic Circuits

3.7.13 Stage 3 – CP-230

a. Install New Interlocking Signal Equipment.
b. Contractor to provide programming revisions to conform to Stage 3 Routing Plans, Project Sheets 0380 through 0397.
c. Contractor to provide Eastward Tie-In circuit revisions / programming in CP-229 CIL for:

1. SVN/NVN Fiber Optic Design to CP-230

d. Contractor to provide Westward Tie-In circuit revisions / programming in CIL for:

1. SVN/NVN Fiber Optic Design to CP-229

e. Contractor to provide Eastward Tie-In circuit revisions / programming in new CIL to existing LOC C for:

1. Phase Selective Track Circuits
2. Line Circuits
3. Traffic Circuits

3.7.14 Stage 4 – Intermediate Territory from CP-230 to CP-232

a. Install CTC&D WAN at CP-232 with LCP NV-MLKII revisions.
b. Contractor to provide programming revisions to conform to Stage 4 Routing Plans, Project Sheets 0400 through 0414.
c. Contractor to provide Eastward Tie-In circuit revisions / programming in CP-230 CIL for:

    1. SVN/NVN Fiber Optic Design to CP-232

d. Contractor to provide Westward Tie-In circuit revisions / programming in CP-232 CIL for:

    1. SVN/NVN Fiber Optic Design to CP-230

3.7.15 Stage 5 – CP-234

a. Install New Interlocking Signal Equipment.
b. Install CTC&D WAN at CP-233 with LCP NV-MLKII revisions.
c. Contractor to provide programming revisions to conform to Stage 5 Routing Plans, Project Sheets 0450 through 0480.
d. Contractor to provide Eastward Tie-In circuit revisions / programming in CP-233 CIL for:

    1. SVN/NVN Fiber Optic Design to CP-234

e. Contractor to provide Westward Tie-In circuit revisions / programming in CP-234 CIL / LOC B for:

    1. SVN/NVN Fiber Optic Design to CP-233

f. Contractor to provide Eastward Tie-In circuit revisions / programming in new CP-234 CIL / LOC G to existing LOC E for:

    1. Phase Selective Track Circuits
    2. Line Circuits
    3. Traffic Circuits

3.7.16 Stage 6 – CP-234 to CP-235 / ML-344

a. Install CTC&D WAN at CP-235 with LCP NV-MLKII revisions.
b. Contractor to provide programming revisions to conform to Stage 6 Routing Plans, Project Sheets 0500 through 0523.
c. Contractor to provide Eastward Tie-In circuit revisions / programming in CP-234 CIL / LOC G for:

    1. SVN/NVN Fiber Optic Design to CP-235, Tracks 1, 3, and 5

d. Contractor to provide Eastward Tie-In circuit revisions / programming in CP-234 CIL / LOC G for:

    1. SVN/NVN Fiber Optic Design to ML-344, Tracks 2 and 4

e. Contractor to provide Westward Tie-In circuit revisions / programming in CP-235 CIL and ML-344 for:

    1. SVN/NVN Fiber Optic Design to CP-234

f. Eastward Intermediate Territory on Tracks 1, 3 and New Canaan Branch will remain in service.
g. Contractor to provide Eastward Tie-In circuit revisions / programming in CP-235 CIL / ML-344 on tracks 2 and 4 for:

    1. Phase Selective Track Circuits
    2. Line Circuits
    3. Traffic Circuits

3.7.17 Stage 7 – Intermediate Territory from CP-235 / ML-344 to CP-240

a. Install CTC&D WAN at CP-240.
b. Contractor to provide programming revisions to conform to Stage 7 Routing Plans, Project Sheets 0550 through 0588.
c. Contractor to provide Eastward Tie-In circuit revisions / programming in CP-235 CIL / ML-344 for:

    1. SVN/NVN Fiber Optic Design to CP-240

d. Contractor to provide Westward Tie-In circuit revisions / programming in CP-235 CIL and ML-344 for:

    1. SVN/NVN Fiber Optic Design to CP-234

e. Contractor to Provide Eastward Tie-In circuit revisions / programming in CP-240 CIL:

   1. SVN/NVN Fiber Optic Design to CP-235 / ML-344

3.7.18 The Cab Signal Upgrade phases are planned to occur over three (3) stages. CP-229 to CP-232 will be one stage. CP-232 to CP-234 will be the second stage. CP-234 to CP-240 will be the third stage. Should it be necessary to support the Metro-North operation, additional cutover segments shall be provided by the Contractor.

3.7.19 The Contractor shall design the vital and non-vital communication networks such that each territory, new interlocking, interface to an existing interlocking or master location can be independently placed in service when the field equipment is in place and the fiber optic cable installed and terminated. The network design shall not in any way preclude the independent testing and placing into service the vital or non-vital signal system components or elements.

3.7.20 The Contractor shall design the non-vital communication networks such that the conversion of the existing four wire normal and alternate CTC interface circuits at CP-232, CP-233, CP-235 and CP-240 to TCP/IP communications protocol over Ethernet can be accomplished on an individual location basis. The network design shall not in any way preclude the separate and independent conversion to the final network based CTC interface at these interlockings. It shall be possible for any of these locations to be placed in service separately once the local field equipment is in place and the fiber optic cable installed and terminated for the associated territory.

3.7.21 The Contractor's staging design shall be based upon the entire vital and non-vital fiber optic communication network configuration in each of the new signal system segments being fully in service prior to initial testing and the staged cutovers for that segment. The required Ethernet services, to be provided by Metro-North to support each segment, will be available at the fiber nodes prior to beginning of testing and cutover in each of the independent territories.

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4.0 CONSTRUCTION OF ENCLOSURES

4.1 General

4.1.1 The requirements in this section apply to all signal instrument enclosures (CILs, houses, cases and cabinets) to be supplied under this Contract.

4.1.2 The signal equipment enclosures described in this section are shown in the Contract Drawings as listed in these Technical Specifications and Contract Drawings.

4.1.3 The Contractor shall submit for review and approval detailed Shop Drawings for each enclosure provided under this Contract. The Shop Drawings shall include, but not be limited to, material lists, fully dimensioned plans, section details, structural details, welding or fastening details, caulking, painting, insulation, shelves, main terminal boards, apparatus boards, HVAC, fire suppression, entry alarm and electrical details. The Contractor shall submit both hard copies and electronic copies of the Shop Drawings as defined within these Technical Specifications.

4.1.4 The Contractor shall provide enclosures that are watertight and insulated.

4.1.5 The Contractor shall provide the CILs, houses, cases and cabinets that meet the following minimum required sizes:

a. CIL house 10' x 30' (with a minimum inside height of 10' to Peak).
b. House (intermediate location or as required) 10' x 12' (with a minimum inside height of 10' to Peak).
c. Case (high single door case) 41" x 24" (with minimum height of 73").
d. Cabinets minimum 30" wide, 40" tall and 12" deep.

4.1.6 The Contractor shall provide larger sized enclosures or additional enclosures as necessary to meet the requirements of these Technical Specifications, Contract Drawings and the Contractor's design.

4.1.7 Instrument enclosures shall have exterior surfaces (roof, walls, doors, inner floor and outer floor) of 12-gauge minimum galvannealed sheet steel, CS Type A or Type B, in accordance with ASTM A653 (Specification for Steel Sheet, Zinc-Coated [Galvanized] or Zinc-Iron Alloy Coated [Galvannealed] by the Hot-Dip Process).

4.1.8 The zinc/iron alloy shall have a coating weight of A40 to A60. Acceptable material includes "Zincgrip Paintgrip" by Armco, "Satincoat" by

Dofasco, "Durgrip" by Inland, "Colorbond/Stelanneal" by Stelco, "Galvannealed" by U.S.Steel, or approved equal.

4.1.9 All floor, wall and roof framing beams, not exposed to the outside environment of the enclosure, shall be constructed of structural steel shapes conforming with ASTM A36 for L, MC. Other miscellaneous tubular or HSS steel framing components, not exposed to the outside environment of the enclosure, where used shall conform with ASTM A53 Grade B and ASTM 500 Grade B, respectively.

4.1.10 Any structural member whose surfaces, edges, corners or seams are exposed to the outside environment of the enclosure shall be made of stainless steel or other weathering steel suited for the application. The Contractor shall identify any materials and locations within the enclosures where this application exists.

4.1.11 The undersides of the enclosures shall be painted with a black mastic covering.

4.1.12 The exterior of the enclosures shall be de-greased, primed and painted Aluminum/Silver in accordance with the requirements of AREMA Signal Manual of Recommended Practices Part 2.4.30.

4.1.13 Standing seams, necessary for joining segments of house panels or other elements, shall not be formed externally. They shall be formed facing inward and fully caulked on the exterior with a flexible waterproof caulking material. The caulking shall be compatible with the interior and exterior painting materials.

4.1.14 Cases and cabinets shall be constructed without any standing seams. Continuous panels are required.

4.1.15 No penetrations, vents or other components are permitted on or through the roof of any enclosure.

4.1.16 The Contractor shall paint the interior surfaces of all enclosures with approved primer and finish with two (2) coats of flame resistant paint, as approved by the Engineer.

4.1.17 Each enclosure shall be fitted with screened and adjustable ventilator openings. Each opening shall be provided with replaceable air filters. The filters shall be commercially available and standard sized. Quantity, size and placement of the ventilator openings shall be submitted to the Engineer for approval.

4.1.18 The Contractor shall submit the maximum weight of each enclosure before delivery.

4.1.19 Each enclosure shall have sufficient structural strength to permit lifting by overhead crane or lifting from below, with all equipment installed, without additional bracing. Eye bolts, or suitable arrangement shall be provided for lifting, including, but not limited to, structural skid pads under the enclosure to permit lifting and sliding into place.

4.1.20 The Contractor shall submit detailed methods and procedures for lifting and placement for each enclosure. The procedure and plans shall be approved and signed by a licensed Professional Engineer in the state where the enclosure will be placed. The plan shall include, but not be limited to, the weight, requirements for lifting, lifting points, lifting equipment, and drawings showing method of installation as well as any overhead wires or other obstructions.

4.1.21 The Contractor's design for enclosure lifting shall take into consideration the low clearances due to overhead wires and cables adjacent to and over the railroad right-of-way. The Contractor shall provide special lifting rigs and beams designed to permit the installation of the enclosures under the overhead obstructions.

4.1.22 Each enclosure shall have main terminal boards constructed of ¾" NEMA grade GPO-3 fiberglass reinforced thermoset polyester sheets, or approved equal.

4.1.23 All terminals and equipment shall be installed on the front facing side of the main terminal board or apparatus board. No terminals or equipment shall be installed on the rear of the boards.

4.1.24 A full complement of shelves shall be provided for the CILs, houses and cases. The width of the shelves shall be a minimum of 12 inches. Wider shelves shall be provided for equipment deeper than 12 inches. No equipment shall overhang any shelf. The shelves shall be of ¾" fire resistant, marine grade plywood, or other approved material, painted with fire retardant white paint shall be furnished on the sides of all houses. Any holes drilled in the boards for wiring or cabling shall be painted after drilling.

4.1.25 A full complement of apparatus boards of ¾" fire resistant, marine grade plywood, or other approved material, painted with fire retardant white paint shall be furnished on the sides of all houses. Any holes drilled in the boards for wiring or cabling shall be painted after drilling.

4.1.26 The apparatus boards shall be securely fastened to the walls in such a manner to permit mounting of battery charging equipment, transformers,

terminals and other equipment.

4.1.27 Sufficient space shall be maintained at the rear of the terminal boards and apparatus boards to allow easy access to the cables, wiring and connections.

4.1.28 The Contractor shall submit for review and approval the design proposed for the following:

a. Main terminal board structural design, mounting methods and layout.
b. Apparatus boards and shelves structural design, spacing, mounting methods and layout.
c. Details concerning the work space behind apparatus boards, wire chases, wire management and tagging mounting hardware, overhead cable trays and all other related material.

4.1.29 The surface of mounting racks, apparatus boards, hardware and fittings shall be primed and then finished with two (2) coats of flame resistant White ASA No. 61 paint.

4.1.30 The Contractor shall provide mounting studs, in each enclosure, used for mounting equipment to the apparatus or main terminal boards. The studs shall consist of carriage bolts mounted through the mounting boards and shall be independently secured to the backboard with flat and lock washer and hex head nut. The minimum size for the studs shall be ¼-20. The stud shall remain captured in place when the equipment removed. The use of lag bolts or wood screws is not permitted.

4.1.31 Interior insulation shall be painted after installation with a fire-retardant white paint. The fire-retardant paint shall be compatible with the proposed insulating material. Insulating material, detailed methods of installation and the proposed fire-retardant white paint shall be submitted to the Engineer for approval.

4.1.32 Foundations of pre-cast concrete shall be furnished for all enclosures. This includes, but not limited to, CILs, Slave CILs, houses, cases and cabinets. Design of the foundation piers shall be submitted for approval. The pre-cast foundations shall be delivered after the CIL, Slave CIL, house, case and cabinet enclosure sizes have been approved. The Engineer will authorize delivery the foundations.

4.1.33 The Contractor shall provide a detailed foundation layout plan for each location. The design of the foundation locations shall accommodate the cable vaults beneath each CIL, Slave CIL, and house and the hatch provided within each enclosure. The plan shall clearly indicate the foundation location and

reference pull boxes and enclosure hatches. All dimensions shall be in English units.

4.1.34 The Contractor shall furnish insulated mounting pads to separate the instrument house or case from the concrete foundation upon which it is to be installed. Mounting pads for each support point shall be of minimum 3/16" thickness of No. 60 Dura Neoprene as manufactured by Syntex Rubber Co. of Bridgeport, Connecticut, or approved equal.

4.1.35 Instrument houses and case floors shall be designed to hold 500 lbs. per square foot minimum with not more than 1/4" deflection. Should this requirement not be adequate to properly support the weight of the batteries to be provided under this Contract, the Contractor shall provide additional structural support or thicker floors or structural members to prevent the over stressing of the instrument house or case floor and meet this criteria.

4.1.36 Each enclosure shall have a sufficient number of aerial cable entrances and a sufficient number of underground cable entrances at the rear of the main terminal boards.

4.1.37 The Contractor shall provide cable chutes to accommodate burial cable entry into the CIL, Slave CIL, house and cases provided under this Contract. The cable chutes shall be made of stainless steel. The grade of stainless steel shall be compatible with the railroad environment and soil conditions. The chutes shall be 6" wide, 24" long and 30" tall at a minimum. The edges at the bottom of the chute shall be rolled to prevent any sharp edges or corners that may damage the cable. The chutes shall be dropped into place from within the enclosure and fit flush to the floor. The chutes shall line up behind the main terminal boards to permit a direct alignment for the cables and the board. Blank spacers shall be provided to close off unused areas of the chute. Fasteners shall be provided to secure the chute and blank spacers.

4.1.38 The cable entry shall be located so that cable pulling tensions and bending radiuses for cables installed therein is not exceeded.

4.1.39 Entrance hardware shall be included to provide weatherproof entrance of cables.

4.1.40 Cable supports shall be provided behind terminal boards for tie wrapping of incoming cables. The Contractor shall provide commercially available wire and cable management systems to accommodate the internal and external wires and cable.

4.1.41 On the basis of final cable plans, the Contractor shall provide sufficient quantity and size of cable entrances.

4.1.42 The Contractor shall provide a sufficient quantity of complete entrance hardware for each enclosure including cable chutes, gaskets, aerial cable entrances, and fastening hardware. A minimum of 30% spare capacity is required in the entrance facilities once all cables have been installed.

4.1.43 Steel racks, of a design and size for mounting the battery trays and batteries specified within these Technical Specifications and Contract Drawings shall be furnished in all houses. The battery racks and mounting arrangement shall be submitted to the Engineer for approval.

4.1.44 The application of two or more newly wired houses or cases mounted side-by-side, and connected by cable or conduit, is not permitted.

4.2 CILs, Slave CILs, and Houses

4.2.1 The Contractor shall provide CILs, Slave CILs, and houses in quantities and sizes necessary and required to meet the requirements of these Technical Specifications and Contract Drawings.

4.2.2 The Contractor shall provide each house with rubber floor mats (ANSI/ASTM D 178-81 Class 0). The mats shall cover all exposed floor areas.

4.2.3 Houses shall have gable end roofs. The use of hip roofs is not permitted.

4.2.4 The interior and under floor of each CIL, Slave CIL, or house shall be lined with high efficiency "Thermax" insulation, or approved equal. Insulation shall be 2 inches thick on the walls and doors with an R value of 13 and 3 inches thick on the ceiling and under floor with an R value of 19. Ceiling insulation shall not be suspended, but shall be mounted directly to the house ceiling. After installation under the floor, the insulation shall be covered by sheet steel conforming to the same material used on the enclosures walls and floor. Access through the floor for the hatch and cable chutes shall remain unaffected.

4.2.5 Each CIL and Slave CIL(s) house(s) shall have three (3) cabinets installed on the outside of the enclosure and defined elsewhere within these Technical Specifications and Contract Drawings.

4.2.6 Each Master Location house shall have two (2) cabinets installed on the outside of the enclosure and defined elsewhere within these Technical Specifications and Contract Drawings.

4.2.7 Each housing door shall be 36 inch wide and equipped with three-point drawbar style vandal resistant locking arrangement. Doors shall be gasketed so that they will provide a dust proof and weatherproof seal. The three-point

drawbar latching arrangement shall be operated by a door handle with a bronze bushing, and will require at least an 80º rotation to unlatch it.

4.2.8 Each house shall have two (2) hinged access doors, one (1) at each end. Doors shall be positioned at the center of the end wall.

4.2.9 Each door shall contain ventilating openings, which shall be provided with replaceable air filters and protected by caps, to prevent entrance of moisture.

4.2.10 Only one (1) access door shall be secured from the outside. The second door shall be secured from the inside. The proposed locking arrangement, hinge configuration, door swing and location of doors shall be submitted to the Engineer for approval.

4.2.11 The equipment racks shall be aligned in bays unless otherwise approved by the Engineer. All cable entrance racks or terminal boards shall be accessible from within the house and not require an outside access door.

4.2.12 The Contractor shall provide a minimum of a 36 inch walkway between each finished rows or racks and equipment. The walkways shall be clear from top to bottoms and not permit offsets due to irregular shaped equipment or chassis.

4.2.13 The Contractor shall provide all electrical work within the enclosure to be compliant with the National Electric Code. The Contractor shall submit for review and approval all details of the electrical work. All electrical wiring shall be installed within conduit.

4.2.14 Each CIL and Slave CIL(s) house(s), shall be electrically wired and equipped with ten (10) 120 VAC, industrial duplex style convenience outlets. These outlets shall be on two (2) separate circuits with five (5) outlets on each side of the house protected with a separate Ground Fault Circuit Interrupter circuit breaker. These outlets shall be grounded in accordance with the National Electrical Code.

4.2.15 Each Master Location house shall be electrically wired and equipped with six (6) 120 VAC, industrial duplex style convenience outlets. These outlets shall be on two separate circuits with three (3) outlets on each side of the house protected with a separate Ground Fault Circuit Interrupter circuit breaker. These outlets shall be grounded in accordance with the National Electrical Code.

4.2.16 Two (2) main signal power feeds shall be provided in each CIL and house. The two (2) feeds shall be provided with two (2) independent sets of conduit, termination material, surge protection equipment and distribution

equipment. NEMA 1 enclosures shall be provided for each feed. The main feeds shall not be mounted on the main terminal board.

4.2.17 The Contractor provided main Power Transfer Panel shall be connected to the signal load center and main feeds through properly sized and rated wiring and conduit.

4.2.18 All AC power wiring shall be terminated and distributed through load centers of proper size and capacity.

4.2.19 In CILs and Slave CIL(s), a separate feed termination and equipment enclosure and load center shall be provided for "hotel" 60 Hertz power.

4.2.20 In CILs and Slave CIL(s), all entrance hardware, conduit, circuit breakers, and wiring for the two (2) load centers shall be separate.

4.2.21 The Contractor shall provide 50% spare circuit breaker space in all load centers. Of the 50% spare space, the Contractor shall provide 25% spare breakers.

4.2.22 A sufficient quantity of fluorescent lighting fixtures shall be supplied so as to provide floor level luminance of not less than 400 lux in any open area of the enclosure. Fluorescent lighting fixtures shall be placed such that they do not obstruct the overhead wire ways.

4.2.23 The lighting fixtures shall incorporate 4 foot long fluorescent tubes with covers and shall operate at both 60 Hz and 100 Hz with RFI suppression. Low temperature starting ballasts shall be provided.

4.2.24 In CILs and Slave CIL(s), the overhead lighting shall be divided into two (2) zones. The first zone includes the area over the Local Control Panel, entrance door, walk way and second door. The second zone includes all equipment bays. Two (2) light switches shall be provided adjacent to each entrance/exit door of the house. Lighting for other houses shall be controlled through a single zone. The Engineer shall approve all lighting arrangements.

4.2.25 The Contractor shall provide each CIL and Slave CIL(s) with a HVAC system and Fire Suppression system as defined within these Technical Specifications and Contract Drawings.

4.2.26 The Contractor shall provide two (2) 500W, 120VAC heaters for each house up to 12 feet long. The heaters shall be rated for both 60 and 100 Hertz power operation. Each house shall be supplied with a minimum of three (3) heaters for lengths up to 32 feet. For instrument housings longer than 32 feet, additional heaters are required at the rate of one per each 10 foot of length.

Each heater shall be wired to the approved load center and shall be thermostatically controlled.

4.2.27 Wiring between apparatus racks and terminal boards shall be carried overhead at rack-top level in metal or fiberglass ladder wire chases. Wire chases shall be free of sharp edges. All ladder rungs shall be insulated, and insulating grommets shall be applied to all cutouts in racks through which wires may pass. The overhead chase system shall be appropriately grounded.

4.2.28 Interior surfaces of each house, hardware and fittings shall be finished in accordance with AREMA Signal Manual of Recommended Practices, Part 2.4.30.

4.2.29 The Contractor shall furnish an unauthorized entrance alarm system for each CIL, Slave CIL and Master Location houses.

4.2.30 The intrusion detection device shall be a magnetic type door switch type, Pass & Seymour, Inc. 1201, or approved equal. It shall be applied to each door of each instrument house to detect the event of the door opening. There shall be a pushbutton switch furnished and installed. The pushbutton switch must be activated prior to the expiration of the preset timer to prevent the sonalert from sounding. If after opening the door, the push button is not activated within the preset time, the sonalert will sound indicating an unauthorized intrusion.

4.2.31 The intrusion detection unit shall operate from a 12VDC power input. The output shall be a nominal 12VDC. The intrusion detection unit shall be used to sense the opening of the door(s) and at that point trigger the timer. The timer shall be used to provide an adequate amount of delay time before activating an alarm. The timer shall be used for the delay after opening the door. The timer shall have the capability of being adjusted from 15 seconds to 2 minutes. The design of the alarm system shall include spare contacts to provide for intrusion alarm indications to be reported to the Operations Control Center.

4.2.32 Energy provided from a CIL or house to reach out over copper cables to adjacent cases or cabinets to obtain door entry indications shall be separately derived for independent power supplies to protect other equipment for surges and lightning impacts. The Contractor shall provide details on this design requirement for review and approval.

4.2.33 The Contractor shall furnish a fire alarm system within each house as follows:

a. The Contractor shall furnish each house with photo electronic smoke detectors as manufactured by System Sensor, Inc., Model no. 2012, or approved equal.
b. The smoke detectors shall be direct wired, with a built-in indication relay with one (1) Form A contact rated at 0.5 amps at 30VDC, and 85 dB electronic horn. The contact shall be used to indicate smoke detector activation to the control center. The smoke detectors shall operate from the 12VDC signal battery and shall provide coverage on smooth ceilings of 900 square feet. The Contractor shall provide as many of these units as is required for each instrument house, to provide adequate smoke detection in accordance with the manufacturer's standards.

4.2.34 Each CIL, Slave CIL(s) and Master Location house shall be equipped with a quantity of wall mounted, 120VAC thermostatically controlled exhaust fans. The fans shall operate on both 60 and 100 Hertz power. The fans shall have the capacity to exchange the air 7 times per hour. Exhaust fans shall be approved by the Engineer prior to installation. Sufficient inlet vents with replaceable air filters shall be provided in the floor of each house. Internal winter covers shall be supplied for both exhaust fans and air inlets. The Contractor shall submit all elements of the ventilation system to the Engineer for approval.

4.2.35 Each CIL, Slave CIL(s) and Master Location house shall be equipped with two (2) fire extinguishers with mounting brackets. The size shall be a minimum of 20 pounds each and they shall be rated ABC.

4.2.36 The Contractor shall furnish and install a metal cabinet in each CIL, and Slave CIL(s) house to file field circuit plans. The plan cabinet shall be (40 11/16" x 28 3/8" x 7 1/4") in size and wall mounted.

4.2.37 The Contractor shall furnish and install a metal wall mounted plan holder in each Master Location house to file field circuit plans. The plan holder shall be sized to hold the locations 11" x 17" circuit plans. Design of the wall mounted plan holder shall be submitted to the Engineer for approval.

4.2.38 All CIL, Slave CIL(s) and Master Location houses shall be outfitted with a removable floor access panel located adjacent to main terminal boards to provide access to pull cable from beneath house into main terminal board racks. The floor access panel opening to be a minimum of 24 inches wide and the have a length equal to that of terminal board racks. The removable panel shall be constructed, from the same material as the house with the same floor load ratting of the house. All edges to be finished to guard against sharp edges that could cause physical harm. The removable access panel to secure to the floor using threaded fasteners accessed from the inside. The access panel opening to incorporate a gasket to guard against debris infiltration.

4.2.39 Each CIL, Slave CIL(s) and Master Location house shall be provided with 20% spare space for additional racks. In addition to designated rack space, 10% spare floor space and 20% spare space for wall mounted apparatus shall be provided. This requirement shall not be met by utilizing the unusable space required for relay racks elsewhere in these Technical Specifications and Contract Drawings.

4.2.40 Each instrument house shall have racks for mounting apparatus. The apparatus shall be placed in a bay style arrangement. The Contract Drawings depict the general layout of a house and rack arrangement. Standard 19-inch EIA racks shall be used for the electronic equipment.

4.2.41 In addition to the required spare space on a per rack basis, a spare vacant relay rack identical to the others in the house shall be installed in each CIL, Slave CIL(s) and Master Location house supplied under this contract. The full complement of relay and energy bus mounting crossbars, including associated wire tie bars and all required brackets, shall be provided separately for each spare rack in unassembled form, including all necessary mounting hardware and insulating grommets, for future use by Metro-North. Locations of spare racks are indicated on these Technical Specifications and Contract Drawings.

4.3 Cases

4.3.1 The Contractor shall provide cases in quantities and sizes necessary and required to meet the requirements of these Technical Specifications and Contract Drawings.

4.3.2 Except as required within these technical Specifications, the Contractor shall only proposed cases that meet the AREMA recommendations for constructions and sizes.

4.3.3 Each case shall be designed and equipped to be lifted from above. Permanent lifting eyes shall be provided on each case.

4.3.4 Each equipment case shall have hinged doors both front and back. Each front case door shall contain ventilating openings at top and bottom, which shall be provided with replaceable air filters and protected by caps, which to prevent entrance of moisture.

4.3.5 Each door shall be equipped with three-point drawbar style vandal resistant locking arrangement. Doors shall be gasketed so that they will provide a dust proof and weatherproof seal. The three-point drawbar latching arrangement shall be operated by a door handle with a bronze bushing, and will require at least an 80º rotation to unlatch it.

4.3.6 Cases shall be provided with a sloped roofs permitting water to shed toward the rear of the case.

4.3.7 Hasps shall be provided to apply railroad padlocks to front and back doors.

4.3.8 All equipment shall be mounted and serviced from the front of the case. All cables shall be terminated on the front of terminal boards in all cases.

4.3.9 All equipment provided within the cases shall be wired to standard terminal strips with test links.

4.3.10 All cases shall be provided with a minimum of two porcelain lamp fixtures controlled from pull chains. All cases shall be provided with a minimum of one duplex convenience outlet with an appropriate fuse or circuit breaker. All equipment shall function properly on both 60 and 100 Hz signal power fed from the adjacent house or cases.

4.3.11 All equipment provide with the case shall be mounted on the main terminal board. Mounting equipment on the side walls, doors or rear of the main terminal board is not permitted.

4.3.12 The Contractor shall provide each instrument case with approved rubber floor mats (ANSI/ASTM D 178-81 Class 0) to cover all exposed areas of the floor.

4.3.13 Each case shall be designs and equipped to permit the installation of Contractor provided cable chutes behind the main terminal board. The number and size of the chutes shall be provided for review and approval.

4.3.14 The interior and under floor of each case shall be lined with high efficiency "Thermax" insulation, or approved equal. Insulation shall be 2 inches thick on the sides, top, bottom and doors with an R value of 13. After installation under the floor, the insulation shall be covered by sheet steel conforming to the same material used on the enclosures walls and floor. Access through the floor for the cable chutes shall remain unaffected.

4.3.15 The Contractor shall furnish and install a metal wall mounted plan holder in each case to file field circuit plans. The plan holder shall be sized to hold the locations 11" x 17" circuit plans. Design of the wall mounted plan holder shall be submitted to the Engineer for approval.

4.3.16 Interior surfaces of each case, hardware and fittings shall be finished in accordance with AREMA Signal Manual of Recommended Practices, Part 2.4.30.

4.3.17 Each case shall be provided with 10% spare floor space and 20% spare space for main terminal board apparatus. This requirement shall not be met by utilizing the unusable space required for equipment elsewhere in these Technical Specifications and Contract Drawings.

4.3.18 The Contractor shall provide for intrusion detection on each door of the case. The intrusion detection device shall be a magnetic type door switch type, Pass & Seymour, Inc. 1201, or approved equal. It shall be applied to each door of each case to detect the event of the door opening. The wiring for these devices shall be terminated on the main terminal board of the case and connected to and be made part of the wayside enclosure entry system. Connections to adjacent CILs or houses shall be required.

4.4 Cabinets

4.4.1 The Contractor shall provide cabinets in quantities and sizes necessary and required to meet the requirements of these Technical Specifications and Contract Drawings.

4.4.2 The Cabinets shall be designed to be mounted to the outside of CILs, houses or other locations as required. The cabinets shall house communication equipment and fiber or copper cable terminations or other applications as required.

4.4.3 The cabinets shall be provided to house other equipment cabinets as required. The "cabinet within a cabinet" approach is required to provide adequate consistent mechanical and environmental protections for the systems.

4.4.4 Each cabinet shall be provided with a two inch diameter watertight feed through connection between the cabinet and the enclosure that it is attached to. The cabinet and enclosure ends of the feed through shall be watertight. The location of the feed through connection shall be in the lower area of the cabinet and shall not obstruct any equipment or apparatus mounted within the cabinet.

4.4.5 The cabinet shall be provided with a main terminal and apparatus boards for mounting equipment.

4.4.6 All cabinets shall be provided with a minimum of one (1) porcelain lamp fixtures controlled from pull chains. All cabinets shall be provided with a minimum of one (1) duplex convenience outlet with an appropriate fuse or circuit breaker. Power for these devices shall be provided from the enclosure the cabinet is attached to. All equipment shall function properly on both 60 and 100 Hz signal power fed from the adjacent house or cases.

4.4.7 The interior of each cabinet shall be lined with high efficiency "Thermax" insulation, or approved equal. Insulation shall be 2 inches thick on the sides, top, bottom and doors with an R value of 13. Access through the bottom and rear for the cable conduits, mounting hardware or connections shall remain unaffected.

4.4.8 The cabinets shall be provided with a door on one side only.

4.4.9 The cabinet door shall be equipped with three-point drawbar style vandal resistant locking arrangement. The door shall be gasketed so that they will provide a dust proof and weatherproof seal. The three-point drawbar latching arrangement shall be operated by a door handle with a bronze bushing, and will require at least an 80º rotation to unlatch it. In addition, a separate hasp shall be provided to provide for the application of a railroad padlock to the door.

4.4.10 Interior surfaces of each cabinet, hardware and fittings shall be finished in accordance with AREMA Signal Manual of Recommended Practices, Part 2.4.30.

4.4.11 The Contractor shall provide for intrusion detection on each door of the cabinet. The intrusion detection device shall be a magnetic type door switch type, Pass & Seymour, Inc. 1201, or approved equal. It shall be applied to each door of each cabinet to detect the event of the door opening. The wiring for these devices shall be terminated on the main terminal board of the cabinet and connected to and be made part CIL or house entry alarm system to which the cabinet is attached.

4.5 Grounding, Surge and Lightning Protection

4.5.1 The Contractor shall provide for fusing, lightning arresters, equalizers and surge protection for all circuits as indicated on the Contract Drawings. This will include, but is not limited to, AC power supply primary and secondary, track circuits, audio frequency overlay track circuits, aerial cables and DC bus surge protection for all electronic devices.

4.5.2 The Contractor shall submit a complete plan showing the grounding requirements for the systems supplied. The grounding system shall be furnished as follows:

a. Four (4) external ground studs are to be installed at the four (4) corners of each CIL or house. Houses greater than twenty (20) feet of length shall have in addition to the four (4) ground studs, two (2) studs, one (1) on each side of the house, for every ten (10) feet of house length.
b. Each case and cabinet shall be supplied with two (2) ground studs.

c. All ground studs shall feed through the wall of the housing and shall be made of a non-rusting material such as silicon bronze.
d. Grounding bus bars for each CIL, house, case and cabinet shall be furnished. They shall be made of a hard-drawn pure copper bar having a minimum conductivity of 98 percent per ASTM B187-73. Each bar shall measure 1/8-inch by 3 inches by 12 inches minimum, and shall be insulated from the housing. Each bus bar shall have a minimum of 15% spare capacity. The ground bus for the cabinets shall be sized according to the requirements of the apparatus within the cabinet. Each grounding bus shall have a smooth flat surface drilled to accept the following connectors furnished by the Contractor.
e. Connectors suitable for connecting the ground bus to the racks within the housing.
f. Connector suitable for connecting the ground bus to all grounded components on terminal boards or apparatus boards.
g. Connector suitable for terminating the ground bus to the housing ground studs. Grounding shall be a minimum four-point grid type.
h. Grounding wire shall not be less than #10 AWG stranded green insulated copper wire, unless specified or approved otherwise.
i. No ground wire shall be run in any wire way with any other wires or cables. The ground wires shall be located as far from any other wires as possible. Ground wires shall not be run parallel to other wires or wire ways. These ground wires shall have no sharp bends and shall have the fewest number of gentle bends possible.

4.5.3 The following devices or apparatus shall be grounded to the main ground bus:

a. Battery charger chassis
b. Transformer chassis
c. Power distribution panel
d. Each equipment rack (ground stud)
e. Code line, track circuit, aerial cable, and any other lightning arresters
f. Local control panel
g. Terminal space for cable shields
h. Audio frequency overlay chassis
i. Network equipment

4.5.4 Number 6 stranded copper wire, with green insulation is to be installed from each stud to the main ground bus.

4.5.5 Grounding of microprocessor-based equipment shall be in accordance with manufacturers' specifications.

4.5.6 Grounding system shall not exceed five (5) ohms to ground for all made grounds.

4.5.7 Ground wiring shall be run along the bottom of the housings.

4.5.8 Ground rods shall be furnished by the Contractor for installation by others. Connections to ground rods shall be exothermic connections.

a. Ground rods shall comply with the standard of UL 467 and the recommendations of the AREMA Signal Manual of Recommended Practices, Part 11.3.4.
b. Ground rods shall be manufactured of copper-clad steel.
c. Ground rods shall be a nominal three-quarter inch diameter, not less than eight feet in length.
d. Ground rods shall be threaded top and bottom with a coupling of corrosion resistant copper alloy for joining.

4.5.9 No loops or daisy chains are permitted where surge control can be compromised.

4.5.10 Each battery charger or other electronic device shall be wired with an appropriate surge protection device on the AC power side and on the DC side. The rating of each device shall be submitted to the Engineer for approval and shall comply with the approved power calculations.

4.5.11 Each individual piece of electronic equipment, such as the ground detectors, vital microprocessor interlocking system, non-vital microprocessor code system, audio frequency overlay track circuit equipment, power supplies/chargers and DC-to-DC converters and network devices, shall have separate DC surge protection.

4.5.12 Transient voltage surge protectors for AC power shall be provided with one (1) internal form C contact for indication to the operations control center. All surge protection shall be in accordance with the manufacturer's standard.

4.5.13 AC and DC surge protection devices shall be as manufactured by Erico Inc., EPD series or Engineer approved equal.

4.5.14 Individual automatic ground fault detectors shall be provided in each CIL, house and case, to constantly monitor all power buses. The buses monitored shall include, but not be limited to, the 100BX/100NX, B12/N12, B12-AFO/NV-/N12-AFO/NV, LB12/LN12, 60BX/60NX, network equipment and microprocessor equipment power buses.

4.5.15 Each ground fault detector shall provide an alarm, which will be displayed on the local control panel as well as an indication in the Operations Control Center. The detector shall be powered by DC. Ground fault detector shall be Zytron Control Products Model GFD or Engineer approved equal. The proposed automatic ground fault detector shall be submitted to the Engineer for approval.

4.6 Relay and Equipment Racks

4.6.1 Relay racks (vital and non-vital), track circuit racks, power racks, microprocessor equipment racks, terminal racks, fuse racks, network equipment and miscellaneous racks shall be furnished by the Contractor for all instrument housings.

4.6.2 The type and size of the racks shall be as required for the purpose for which they will be used, and shall be approved by the Engineer. In general, the width of the racks and depth of the section used for the side rails shall be of the manufacturer's standard and as approved by the Engineer. The maximum rack width shall not exceed thirty-one (31) inches. The overall height of the rack shall not exceed seven (7) feet six (6) inches in height. Racks installed in new enclosures shall have overhead support. Wire entrance to racks shall be by means of overhead chase and/or conduit.

4.6.3 Swing-out type relay or equipment racks shall not be utilized.

4.6.4 Relays, track circuit equipment, microprocessor equipment or wire terminations shall not be placed less than twelve (12) inches or more than seventy-two (72) inches above the floor.

4.6.5 Terminal boards for energy buses shall be provided at the top of the rack. In general, wiring between pieces of equipment on the same rack, shall not be required to be terminated other than on the pieces of equipment. The arrangement of the terminal board shall, in general, be in accordance with the Contractor's standards, but the Engineer may require changes in the location of the terminal boards and the method of terminating wires to meet the requirements of the signal system, and the physical layout of signal equipment.

4.6.6 The Contractor shall provide means whereby each individual rack can be individually grounded to a common ground bus. Means of insulating the racks from each other and from any supports shall be provided by the Contractor and shall be as approved by the Engineer.

4.6.7 All materials, including the insulating materials described above, needed to assemble the several racks one to another to form complete units shall be furnished by the Contractor.

4.6.8 The Contractor shall submit drawings of each proposed type of rack for the approval of the Engineer.

4.6.9 The Contractor shall prepare detailed drawings showing arrangement of equipment on racks, for each type of rack and for each application, which shall be submitted, to the Engineer for approval prior to fabrication of racks.

4.6.10 New racks and supporting braces shall be installed so that each individual rack shall be insulated from each other. The Contractor shall furnish and install all equipment and material required to insulate the racks. Racks shall be grounded in accordance with manufacturer's standard.

4.6.11 The Contractor shall provide a detailed plan defining the wire and cable management to be used for all rack mounted systems. This includes, but is not limited to, how ground wires, clean and dirty wiring will be managed and what products will be employed.

4.6.12 Means shall be provided to suspend and hold cables in place and to provide slack. Each rack shall be individually grounded to a common ground bus or as required by the manufacturer's standard. Each common ground bus shall be grounded at not less than two (2) separate points. The racks shall be insulated from each other, and from the floor, all as approved by the Engineer.

4.6.13 The Contractor shall furnish and install all materials required to make the racks level and plumb. The method and manner of performing this work shall be submitted to the Engineer prior to installation of the racks.

4.6.14 The Contractor shall prepare a drawing showing the exact proposed layout of all racks and associated equipment at each instrument house and submit the layout to the Engineer for approval.

4.6.15 A minimum of 10% spare space for additional relays or other components, and 10% spare terminals, on each equipment rack shall be provided. This requirement shall not be met by utilizing the unusable space stated elsewhere in these Technical Specifications and Contract Drawings.

5.0 WIRING AND TERMINALS

5.1 Wiring

5.1.1 The Contractor shall furnish all wire, terminal and connectors in accordance with the requirements of these Technical Specification and Contract Drawings.

5.1.2 The Contractor shall size all wire in order to assure proper operation of the apparatus on the basis of equipment loads and the operating parameters for the systems described in this specification. Conductors shall be sized in accordance with Article 310 of the National Electrical Code, where applicable. In no event shall conductor size be less than that specified.

5.1.3 All wire and cable shall be less than three (3) years old at the time of delivery. The Contractor shall submit a complete list of the manufacture of each type of wire and cable complete with specifications for each type.

5.1.4 Inside wire shall be 600V rated wire, insulated with ethylene tetrafluorethylene (ETFE) fluorocarbon resin, clean stripping, continuous temperature rating of 150° C and minimum insulated wall thickness of 15 mils (.015 inches). Wires shall be tinned and sized as follows within the instrument houses and cases.

a. Vital circuits #16 AWG, 19 strands.
b. Non-vital circuits #20 AWG, 19 stranded, twist where indicated shall be one (1) turn per inch.
c. Signal Lighting circuits #10 AWG, 37 strands.
d. Switch machine motor control #10 AWG, 37 strands.
e. All power supply wiring between main buses and rack buses, #10 AWG, 37 strands.
f. All 60 or 100 Hz power supply wiring from the CIL to the field location cases and houses shall be 2c #4, 133 strands twisted 1 to 2 turns per foot.
g. All 100 Hz power supply wiring from adjacent signal locations to the field track cases shall utilize a pair in the track circuit coupling cables (6PR #14 T/S, twisted 1 to 2 turns per foot).
h. All incoming power supply wiring to the CIL houses from external signal power transformers, 3c #1/0 for 100 Hz and 3c #2 for 60 Hz utility power.
i. All incoming power supply wiring to the houses from external signal power transformers, 2c #4 for 60 or 100 Hz.
j. All power supply wiring from battery or source to all main buses, 2c #6, 133 strand twisted 1 to 2 turns per foot.
k. 1,000 volt insulated wire

1. Track circuits #10 AWG, 37 strand, black and white twisted 1 to 2 turns per foot.
2. All power supply wiring from battery or source to all main buses, 2c #6, 133 strands twisted 1 to 2 turns per foot.

5.1.5 Where load conditions or operational reliability may prohibit the use of these designated wire sizes, based on the Contractor's detailed design, the Contractor shall size the necessary wire to meet the load and reliability requirements at no additional cost to Metro-North.

5.1.6 Energy loops shall not be used. One (1) wire shall be run to the energy bus for each relay coil, or device requiring energy. Relay wires and bus links shall be arranged so that removal of individual wires does not de-energize any portion of the energy bus. When the housings, cases, or racks have been completed and tested, the Contractor shall furnish, to the Engineer, detailed drawings of the energy buses.

5.1.7 All wires shall have printed on the jacket, with permanent ink, the manufacturer, date of manufacture, plant i.d. and wire gauge at no greater than 36-inch intervals.

5.1.8 All apparatus wiring shall be neatly bundled so as to provide a clear reference to the device which the wire is connected.

5.1.9 All wall-mounted apparatus shall have the wiring fed through the plywood-mounting panel. Sufficient clearance shall be supplied for routing wires between the wall-mounted apparatus and the wall of the CIL and houses.

5.1.10 All rack-mounted apparatus shall have all wiring run in a neat bundle, and securely fastened to the rack. The Contractor shall submit the proposed method of wiring to include the wire management products to be used to manage clean, dirt and ground wiring. All wires to a specific relay or device shall be held securely and separate from adjacent relay or device wiring.

5.1.11 Twisted pair wiring configuration shall be used to reduce EMI or EMC conditions. The number of turns per inch shall be determined by the Contractor to ensure maximum benefit.

5.1.12 Sufficient slack shall be provided in all wiring or cabling adjacent to their terminals to permit movement of the equipment and to permit opening of the chassis or cabinet.

5.1.13 AC and DC Power, data, and ground wiring shall not be run in parallel or in the same plug connector.

5.1.14 Wire chassis, conduits and other wire trough supplied in houses or cases shall be of sufficient size to leave one-third of the wire space free after the full number of wires or cables required for the installation are in place.

5.1.15 The Contractor shall supply all required inter-connecting cables or wire between the vital and non-vital microprocessor system, the local control panel, and vital and non-vital relays.

5.1.16 No splices shall be made in any wire.

5.1.17 The wiring shall be cabled and held in place so as to present a neat and orderly appearance.

5.1.18 All wiring in excess of 230V shall be placed in conduit. Conduit shall be rigid steel with hot dipped galvanizing or other corrosion resistant coating.

5.1.19 All service entrance wiring shall be placed in conduit. Conduit used for service entrance wiring shall be rigid steel with hot dipped galvanizing or other corrosion-resistant coating. Wiring for signal and hotel power supply rated at less than 230V shall also be placed in metallic conduit. Electric Metallic Tubing (EMT) conduit shall be used for this application.

5.1.20 Where conduits enter threaded box openings, they shall be securely fastened to provide both a watertight seal and electrical continuity.

5.1.21 Where conduits enter non-threaded boxes, they shall be secured in place with a galvanized locknut outside the box and a galvanized locknut, plus bushing inside the box.

5.1.22 Conduit ends shall be reamed to remove all burrs. Conduits shall be properly supported. The cable termination arrangement shall be laid out by the Contractor to locate spare wire conductors of a cable on a dedicated terminal post in-line with, and grouped with, the working conductors of that cable.

5.2 Terminals for Wires and Cables

5.2.1 The Contractor shall specify each type of connector, terminal or wiring device to be used. The Contractor shall submit a complete listing of each type of connector, terminal, terminal strip, fastener, and termination hardware to the Engineer for approval. In addition, the Contractor shall specify the tooling used to attach each device.

5.2.2 Solderless, crimp-on type insulated ring eye connectors shall be used. All solderless terminals shall be in accordance with the AREMA Signal Manual of Recommended Practices, Part 14.1.1. The Contractor shall submit samples of

each solderless terminal for approval.

5.2.3 Spade lug, fork lug, and Faston style terminals and wire terminations shall not be used.

5.2.4 All signal cable terminals shall consist of a double column of vertical terminals equipped with Safetran Insulated Test Links #024620 or approved equal (insulated nut on cable side). Cables will be brought through the terminal board to the left of the terminals and house wires on the right. Test Links, nuts and washers shall be furnished, but not installed and shipped with the CIL, house or case. The Contractor shall provide a minimum of 5% spare test links, nuts and washers beyond the full complement required.

5.2.5 Terminal posts shall be provided for all signal cable conductors, including spares. Cable termination shall start top to bottom on main terminal boards. The top terminal post in each column shall be designated as number one and shown as such on circuit plans. No terminations shall be permitted within 12 inches of the bottom of the main terminal boards, racks or other installation.

5.2.6 Signal cable termination lineups shall be arranged to match the conductor assignment at the adjacent location. Where the adjacent location is an existing location, for which the new location must interface to the old, it shall be the Contractor's responsibility to insure that the cable conductor assignment of the new terminal board matches the actual existing conductor assignment of the cable to be terminated. The Contractor shall provide properly sized holes for the various conductor diameters.

5.2.7 The cable termination arrangement shall be laid out to locate spare wire conductors of a cable on a dedicated terminal posts in-line with, and grouped with, the working conductors of that cable.

5.2.8 The cable termination arrangement shall be laid out by the Contractor to leave at minimum two spare terminal post rows below track and power wire pairs where external power surges or faults can inadvertently damage adjacent circuits.

5.2.9 All terminal posts used to terminate 120V circuits, shall be provided with a protective insulator. Insulators shall be individual for each terminal post, Type 023408-7X as manufactured by Safetran Systems Corporation, or approved equal.

5.2.10 Additional 10% spare terminal posts shall be provided on all entrance racks.

5.2.11 Terminal blocks for use in the top of all electrical equipment racks shall be screw type DIN rail mounted terminal blocks as manufactured by Weidmueller Inc., Phoenix Contact, or Push Release cage clamp type DIN rail mounted terminal blocks as manufactured by WAGO, or approved equal with testing capability. The proposed terminal blocks shall be submitted to the Engineer for approval.

5.2.12 The Contractor shall only submit for review and approval cage clamp products that do not require special tools to release the clamp. Each cage clamp shall be released with a standard flat blade screwdriver on a tab outside of the connector. Thumb release, lever or quick release connecters shall not be used.

5.2.13 Screw post and Push Release style terminal blocks shall be in accordance with the recommended practices of AREMA Manual Part 14.1.2.

5.2.14 Screw post and Push Release style terminal blocks used for vital circuit applications shall be grouped together and of the single tier type, and in accordance with the recommended practice specific to vital circuit use of AREMA Manual Part 14.1.2.

5.2.15 All Screw post and Push Release terminal blocks shall be mounted on DIN 35 mounting rail.

5.2.16 End caps shall be used on the ends of all rows of Screw post and Push Release terminals.

5.2.17 The manufacturers numbering system shall be provided for all Screw post and Push Release terminals. The numbering system shall be mounted in such a way as to be clearly visible from the front. The numbering system shall not interfere with the insertion or removal of wires.

5.2.18 Screw post and Push Release terminals shall be provided with a bayonet lug or latching device, that shall open the circuit when activated, permitting circuit testing. The bayonet or latch shall be provided with a visual indicator to easily ascertain if the device is opened or closed.

5.2.19 Where solid state devices such as diodes or resistors are used in conjunction with Screw post and Push Release terminals for non-vital circuits, they shall be self-contained within the terminal block. Solid state devices used in vital circuits shall be mounted on AREMA style terminal posts.

5.2.20 Screw post and Push Release terminal blocks shall be assembled so as to permit the removal of one individual terminal block from an assembly of others without disturbing the other terminal blocks in the assembly.

5.2.21 Screw post and Push Release terminal blocks shall be provided with a method of busing an assembly of terminal blocks together. The bus strips used for this purpose shall be insulated to prevent the undesired bridging of adjacent terminals. The method shall be easy to modify by the insertion or removal of screws or plugs and shall not require the removal of any wiring when changing the configuration of a bus. The busing method for screw post and Push Release type terminals shall be submitted to the Engineer for approval.

5.2.22 All DIN rail mounted terminals, blocks, and equipment shall be inspected, and all seating devices and screw posts shall be re-tightened after delivery of the CIL, instrument house or wayside case by the Contractor.

5.2.23 All Screw post and Push Release terminals are subject to the approval of the Engineer.

5.2.24 All communication cables shall be terminated on standard communication cable blocks, incorporating integral screw in type gas surge protectors. A 25 pair block shall be provided in each house for the termination of circuits. Cable blocks shall be submitted, for approval by the Engineer.

5.2.25 All stranded copper wire shall be fitted with an approved type of terminal at all points where the wires are to be terminated on terminal binding posts.

5.2.26 The terminating means shall be:

a. A lug for terminating heavy wires or signal power wires.
b. An AMP Solistrand "Ring Tongue-Flat" terminal similar to that shown on the AMP Drawing P64-044 together with slip-on Nylon post insulator similar to that shown on AMP Drawing P64-0264, or approved equal, for terminating wires larger than No. 14 AWG to a maximum diameter over the insulation of 0.40 inches.
c. An AMP pre-insulated diamond grip-ring, nylon insulated wire terminal for terminating other stranded wires No. 22 and No.18 AWG having a maximum diameter of 0.125 inches. AMP Catalog No. 320554, or approved equal, shall be furnished for No. 8 studs and AMP Catalog No. 320571 or approved equal shall be furnished for one-quarter inch studs.

5.2.27 The terminals shall be attached to the ends of the conductor in such a manner that the flexibility of the conductor is not destroyed and the possibility of breakage at the terminal is reduced to a minimum.

5.2.28 Terminals shall be for attachment to the wire with a tool made by the manufacturer of the terminal and recommended for the terminals being furnished.

5.2.29 The tools shall be equipped with a ratchet device to insure proper compression of the terminal and which will not release until proper compression is complete. Three such tools shall be furnished.

5.2.30 Tools for crimping terminals shall be new and factory calibrated at least every six (6) months. Calibration stickers shall be required on each tool.

5.2.31 To ensure that the proper crimping tools are used, the Contractor shall set-up tool kits for each wireman identified by kit number. All tools in each kit shall be numbered. Each wireman shall be assigned a numbered kit. These kits shall be examined daily and any discrepancies shall be reported to their supervisor or foreman immediately.

5.2.32 The wiremen shall be instructed not to proceed with any wiring should there be a noticeable problem with the tools or cable. The kit number and employee's name shall be recorded on a Cable Termination Report and shall be submitted to the Engineer for review.

5.2.33 The Contractor shall submit all termination hardware to the Engineer for approval.

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6.0 IDENTIFICATION OF EQUIPMENT AND WIRE TAGGING

6.1 General

6.1.1 The Contractor shall provide tagging and equipment identification for all elements of the systems, subsystems and component provided.

6.1.2 The identification and tagging shall include, but not be limited to, all equipment, racks, shelves, cabling, wiring, devices and other elements supplied as part of the requirements of these Technical Specifications and Contract Drawings.

6.1.3 The Contractor shall provide for review and approval all nomenclature, tagging materials and procedures. Samples of each type shall be provided. The font type and size shall be selected to provide superior legibility within the pre-wired houses and cases provided for this contract.

6.1.4 All tagging and labeling shall be produced by machine. No handwritten tagging or identifications are permitted.

6.1.5 All material used in the tagging shall be permanent, indelible and smudge proof.

6.1.6 The materials shall meet all temperature and humidity requirements and have a proven record of satisfactory performance in comparable applications.

6.2 Identification Requirements

6.2.1 A black identification number shall be stenciled along the top and sides on the front and rear of the frame of each rack, denoting the row and column location. The minimum size of figures shall be one and one-half inch.

6.2.2 There shall be an identifying nameplate for each relay, rectifier, transformer, track circuit module, event recorder, network devices, vital and non-vital microprocessor or related component mounted on the instrument racks or mounting boards. Identification shall be provided on the mounting area, not on the equipment.

6.2.3 The front and back of relay plug boards as well as the relay itself shall be equipped with a tag, or other approved means of identification to indicate the nomenclature of the relay for which it is wired.

6.2.4 All apparatus, cables, cable wires and internal wiring shall be tagged.

6.2.5 For vital circuits, the Contractor shall furnish tags on every wire at each termination point showing termination designation.

6.2.6 The Contractor shall tag vital circuits to relays and all other vital circuits with a plastic, sleeve type tag, which designates terminations. Every bus shall be identified. Wires for a specific device shall be bundled together.

6.2.7 Microprocessor input and output circuits shall also be tagged with a sleeve tag in a similar manner.

6.2.8 All tagging shall have permanence and legibility. Sleeve tags shall be readable in an upright position and located on the conductor next to the terminal. All jumper wires on the same relay plugboard shall be provided with tags. Split sleeve wire tags shall not be used.

6.2.9 Sleeve tags shall be small enough to be captured by the wire terminal.

6.2.10 Cables and harnessed wire used as cables shall be identified. Cable identification tags shall be a wrap-around type fastened around the neck of the cable. The legend on the tag shall state the cable size, "TO", "NOMENCLATURE" and "FROM" destinations.

6.2.11 For non-vital circuits, color coding or equivalent means of identification of wires shall be used. The Contractor shall submit his proposed method of tagging to the Engineer for approval.

6.2.12 All apparatus including, but not limited to, relays, transformers, breakers, fuses, and energy buses shall be identified with a tag showing circuit nomenclature.

6.2.13 Jumper wires on the same component shall be provided with tags.

6.2.14 All material used for tagging shall be designed to be used in the temperature ranges specified in this specification and shall provide good aging properties.

6.2.15 The position of each device or contact shall be identified on the circuit plan. This shall include rack, row, column and terminal point. In addition, the location of all wall and rack mounted devices shall be shown on the circuit plans.

6.2.16 Apparatus and cable terminations shall be tagged with nomenclature shown on drawings. All energy bus wiring and terminals shall be labeled with the appropriate bus nomenclature (Example B12, N12, B12-AFO/NV, N12-AFO/NV, T100BX, etc.).

7.0 MISCELLANEOUS COMPONENTS AND PRODUCTS

7.1 Circuit Breakers, Fuses and Fuse Clips

7.1.1 Fuses and circuit breakers shall be of suitable capacities to protect the various pieces of signal apparatus from the effects of short circuits or overloads. Circuit Breakers for AC Power shall be rated to provide calculated protection when used at 60 Hz, 100 Hz or with de-rating applied in accordance with manufacturer's recommendation at 100 Hz.

7.1.2 Circuit fuses shall be non-renewable, and shall be of the fiber-case, time-lag, fusion type. The circuit breakers and fuses shall be the correct size and rating for circuit current interruption and shall protect the electrical equipment and circuits from short-term and long-term overloads.

7.1.3 Fuse clips shall be so constructed that they shall retain their resilience under all installation and service conditions to assure a positive contact between the clips and the fuse. Tron type fuse clips shall be provided. Fuse clips for circuits of 120V or higher shall be provided with a removable cover, which shall also serve, as a manual disconnect of the circuit.

7.1.4 Current limiting resistors shall not be used in DC branch circuits.

7.2 Printed Circuit Cards and Connectors

7.2.1 Printed circuit (PC) cards shall be of glass epoxy construction. Card material shall meet the requirements of NEMA Type FR-4. Cards shall have sufficient thickness to permit easy insertion and removal, and shall be physically keyed to protect against incorrect interchange. Circuits shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air.

7.2.2 PC cards shall be color coded by type and indexed to the back plane of the chassis to prevent insertion into incorrect card slots.

7.2.3 PC cards containing components that may be damaged in the event a plug connector or plug-in unit is removed while the equipment is energized shall be clearly marked or labeled with a warning note and means provided to remove power to the PC cards.

7.2.4 Components mounted on the PC card, weighing more than one-half ounce or with a displacement of more than one-half cubic inch, shall have a mechanical supporting attachment to the card, which is separate from all electrical connections.

7.2.5 Stacking or piggy-backing of printed circuit card sections, in order to accomplish changes or modifications to wiring or components or printed circuit cards shall not be allowed.

7.2.6 Connectors shall have plating a minimum thickness of 0.000050 inch.

7.2.7 PC cards shall be provided with LEDs to demonstrate that the card is functioning properly, diagnostic messages are portrayed, and inputs or outputs are energized.

7.2.8 PC card types shall be combined where possible to limit the number of different cards required.

7.2.9 All PC cards shall be supplied with a non-proprietary bar tag showing at a minimum the part number and manufacturer's name.

7.3 Resistors and Reactors

7.3.1 Resistors and reactors for electronic equipment shall be in accordance with the applicable requirements of AREMA Signal Manual of Recommended Practices Part 14.2.40.

7.3.2 All resistors, other than those required for electronic circuits, shall be in accordance with AREMA Signal Manual of Recommended Practices Part 14.2.15.

7.3.3 All reactors, other than those required for electronic circuits, shall be in accordance with AREMA Signal Manual of Recommended Practices Part 14.2.20.

7.4 Equalizers and Arresters

7.4.1 Equalizers shall be heavy duty. Equalizers shall be the manufacturer's standard for the application. Equalizers shall be submitted to the Engineer for approval.

7.4.2 No Lightning arresters shall be used for track circuits in electrified territory.

7.5 Hardware

7.5.1 All common steel mounting hardware exposed to the elements and used for signal equipment, cases, junction boxes, conduit, hangers, brackets, clamps, etc., shall be hot-dip galvanized, except as otherwise approved by the Engineer.

7.5.2 The hot-dip process of galvanizing shall be used. All parts shall be pickled so that all scale and adhering impurities will be removed. The zinc coating shall be of commercially pure zinc, and shall be continuous and thorough. It shall not scale or blister or be removable by any of the processes of handling or installation. The finished surface shall be free from fine line cracks, holes, or other indications of faulty galvanizing. It shall be smooth and free from adhering flux and other impurities. The edges and ends of parts shall be free from lumps and globules. Parts shall be coated with at least two ounces of zinc per square foot of galvanized surface, after all bending, cutting, drilling and final fabrication.

7.5.3 In order to avoid destruction of resilience encountered in the hot-dip process of galvanizing, all lock-washers shall be cadmium plated.

7.5.4 All nuts, bolts, and washers used for the mounting of equipment within finished enclosures shall be cadmium plated or stainless steel. As an alternate, the Contractor may submit another type of plating or non-corroding metal for the Engineer's approval.

7.5.5 Cadmium plating shall be an impervious, dense, hard, fine grained, continuous, closely adhering coating of commercially pure cadmium, free from capillaries and shall completely cover the surface of the part in a smooth, bright layer. Plating on raised or prominent portions shall show no evidence of blackness or loose crystalline structure. It shall have a minimum thickness of six ten-thousandths of an inch and shall withstand the salt spray test for at least 1000 hours or an equivalent test approved by the Engineer.

7.6 Padlocks

7.6.1 Padlocks shall be provided for all instrument houses and cases. The Contractor shall keep all instrument houses and cases locked at all times. Instrument houses and cases shall be shipped with a Contractor-installed and owned lock in place. Upon arrival at the shipping destination, the Contractor shall open all houses and cases for inspection by Metro-North and then shall install the Contractor-supplied Metro-North locks.

7.6.2 The Contractor shall also furnish each instrument house and case with a Metro-North standard high security lock. Metro-North shall provide the Contractor with the lock type prior to shipment.

7.7 Environmental Protection

7.7.1 Protection, as herein specified, for machined-finished surfaces, threaded rods and nuts and other parts that are susceptible to rusting, shall have a corrosion-preventive compound, "RUST VETO HEAVY" by E. F. Houghton,

Valley Forge, PA, or approved equal, which must have sufficient body to resist weather and rusting for at least six months. This material shall be furnished by the Contractor, for installation by Metro-North.

7.8 Diodes

7.8.1 All diodes to be furnished under this Contract shall carry a JEDEC number or shall be available from more than one manufacturer and shall be used within the published specifications for such number. All diodes shall be silicon type, unless otherwise approved by the Engineer.

7.9 Capacitors

7.9.1 Capacitors for electronic circuits shall be in accordance with the applicable requirements of AREMA Signal Manual Part 14.2.40.

7.10 Plug Connectors

7.10.1 Vital and non-vital plug connector assemblies shall be submitted to the Engineer for approval. Each plug connector assembly shall consist of the following:

a. A two-part molded plastic connector block equipped to hold an appropriate number of solderless, pin-and-socket contacts.
b. Devices for the mechanical locking and keying of the connector block halves.
c. Protective shells for both connector block halves
d. A strain relief device for the external wiring portion of the connector assembly.
e. Solderless, extractable pin-and-socket contacts.
f. Where required, embedded wire wrap terminals for the internal wiring portion of the connector block.

7.10.2 Connector Blocks

a. The connector blocks shall consist of molded dielectric plastic shaped to accept the required number and types of contact pins, contact sockets and locking, keying and mounting devices. The dielectric material shall exhibit a minimum insulation resistance of 100 megohms as measured between adjacent pairs of contacts and between the accessory hardware and the closest contacts in each connector assembly half.
b. The contact cavities shall be arranged in a rectangular grid configuration. The opening for each contact shall be uniquely

identified by a coordinate molded into both the mating and wiring faces of each part of the connector block.

c. The 28 contact, vital plug connector blocks shall provide a surface leakage distance of not less than 1/4 inch between contacts and between the contacts and any other metallic part of the connector assembly.

7.10.3 Locking and Keying

a. Each plug connector assembly shall include a device for mechanically locking the two mated parts together.
b. Mechanical devices and facilities shall also be provided to allow the mating parts of connector assemblies to be keyed in such a manner that they cannot be coupled except when in the correct position relative to each other and cannot be coupled to the mating parts of other coupler assemblies keyed in a different pattern.

7.10.4 Protection and Strain Relief

a. Each half of the plug connector block shall be protected by a metal shield, which shall extend beyond the mating surface. These two shields shall overlap when the connector halves are coupled.
b. The external wiring portion of each plug connector assembly shall be equipped with a device to grip the external wiring firmly in order to prevent strain on the plug connector contacts.

7.10.5 Pin-and-Socket Contacts

a. The pin-and-socket contacts shall be fabricated from commercial bronze or brass and plated with gold overnickel underplate. The retention springs of the pin-and-socket contacts shall be fabricated from stainless steel.
b. The contacts shall be fabricated and classified in the required selection of sizes to accept wire sizes 16 through 22 AWG.
c. Contact current rating and termination resistance shall meet the requirements of the following table with properly sized contacts applied to the wire sizes specified.

Wire Size(AWG)	16	18	20	22
Minimum Current Rating (Amperes)	13.0	10.0	7.5	5.0
Maximum Termination Resistance (Milliohms)	1.7	2.0	2.7	4.0

d. Contact termination resistance shall be measured in accordance with Method 307 of MIL-STD-202 at the rated current specified for each wire size.

7.10.6 The 28-way, vital plug connector assembly shall be required where any vital circuits are to be inter-connected and the 50-way, non-vital plug connector assembly shall be used where non-vital circuits are to be interconnected.

8.0 RELAYS AND CODE TRANSMITTERS

8.1 General

8.1.1 Contractor shall furnish vital and non-vital relays and Code Transmitters as shown on the Contract Drawings and as necessary to implement the microprocessor-based signal system. Relays shall be plug-in, rack mounted except where the application calls for a relay that is not available in a rack mount base configuration.

8.1.2 All vital and non-vital relays specified herein to be furnished under this project shall be designed, manufactured, and tested in accordance with the applicable recommended practices presented in the AREMA Signal Manual of Recommended Practices, Part 6. All relays shall be newly manufactured and not reconditioned. Relays performing the same function shall be from the same manufacturer.

8.1.3 Vital relays and code transmitters shall be shipped separately from the instrument house or case, in a sturdy corrugated cardboard carton with the drawing number and name of the relay printed on the outside of the carton. The relay carton shall be identified with the instrument location, mounting location and relay name.

8.1.4 Non-vital relays shall be protected from damage during shipment and shall be stored in a protected area until tested and installed.

8.1.5 The Contractor shall submit a detailed list of all relays and code transmitters and the application in which they are used to the Engineer for approval.

8.2 Vital Relays

8.2.1 The contractor shall furnish all vital relays.

8.2.2 All vital relays of a given type shall be furnished by a single manufacturer unless approved by the Engineer.

8.2.3 Vital relays shall be quick detachable plug-in type as manufactured by AnsaldoSTS, ALSTOM, or approved equal.

8.2.4 Vital plug-in type relays shall be rack mounted and have a transparent dust cover made of nonflammable composition, meeting the applicable requirements of AREMA Signal Manual of Recommended Practices Part 6.2.1. Each type of relay shall include a unique registration plate or pins.

8.2.5 All vital plug-in relays, except vital time-element relays, and special application relays shall be equipped with front testing facilities.

8.2.6 All commonly used vital relays shall have a minimum of six (6) front-back-dependent contacts. The Contractor shall furnish all required relays.

8.2.7 Vital relay contact assignments for final design shall be such that each vital relay-repeater combination shall have at least one (1) spare dependent front/heel/back contact, or one (1) spare independent heel/front and one (1) spare independent heel/back contact.

8.2.8 Vital relays with greater than six (6) stacks of contacts shall be used to reduce or eliminate repeater relays when required. The standard contact arrangement for these double size relays shall be eight (8) front-back dependent, four (2) front and two (2) back contacts.

8.2.9 Relays (except time-element) with a nominal operating voltage of 12V shall operate continuously and successfully without resultant damage within a voltage range of 7 to 21 volts inclusive, applied to their operating coils.

8.2.10 All relays shall be biased-neutral relays, except where application requires that they not be biased.

8.2.11 Contacts must be clearly viewed from the front of the relay without distortion.

8.2.12 Vital relay repeaters shall not be wired in multiple.

8.2.13 Plugboards for plug-in relays shall include unique indexing plate or pins and shall be equipped with self-retained contacts, which are removable by use of relay manufacturer's tool. The method of connecting a maximum of two (2) wires to contact shall be submitted to the Engineer for approval. The plugboard shall be designed so that the self-retained contact has a direct connection with the relay coil and contact prongs.

8.2.14 The Contractor shall perform factory tests on all vital relays for all mechanical and electrical performance characteristics, including pick-up and drop-away values and contact resistance. Records of all vital relays, showing serial numbers, test date and test values shall be retained by the Contractor and furnished to the Engineer. Relay testing shall be performed prior to the factory test. Relays used for the factory test shall be reinstalled in the same position that they were in during the factory test, in the field by Metro-North.

8.2.15 Biased Neutral Relays

a. Biased neutral relays shall be such that their armature will not pick up with the permanent magnet demagnetized or when no current is applied to coils or due to an interruption of the normal magnetic circuit.
b. Biased neutral relays shall be such that when 50 times the working energization is applied for two seconds, at both normal and reverse polarity, it will not affect their operating characteristics by more than two percent, and will not pick up their armature on reverse polarity.

8.2.16 Slow acting relays, either slow pick-up or slow release, shall have their slow acting characteristics obtained by the use of copper or aluminum washers or slugs applied to the relay core.

8.2.17 Vital Time-Element Relays

a. Vital time-element relays shall be of the plug-in type for nominal 10 to 16 volt DC operation. The vital time element relays shall be electronic or microprocessor-based. If external vital electronic timer relays are used, back check contacts shall be provided as standard and shall be checked within the SSAL.
b. Vital time-element relays shall have a minimum of two contacts that will close only at the end of the adjusted timing cycle.
c. The vital time element relay shall have a LED display showing the actual time settings when in operation.
d. Any interruption of input power shall cause immediate reset to the beginning of the present time cycle. The design of the microprocessor electronic timer shall be based on the premise that the degradation of any component shall result in a longer time than the present time.
e. Each vital time-element shall be provided with a time adjustment which can be sealed. When sealed, it shall be impossible to adjust the timing interval. The timing interval shall withstand repeated operation with an error of no more than 0.5 seconds when the applied voltage is between 9 and 14 volts, and ambient temperature between -40 degrees F and +160 degrees F.

8.2.18 Magnetic Stick Polar Relays, as used for "FR" series traffic circuit application, shall be US&S PP-151 or Engineer approved equal, Metro-North material reference number 314.

8.3 Code Transmitters

8.3.1 Code Transmitters shall be of the plug-in type, and designed for nominal 8 to 16 VDC operation. Code Transmitters shall be of the solid-state type. Code Transmitters shall be of the same manufacturer and share the same

backboard/rack spacing configuration as the vital relays supplied under this contract, unless otherwise approved by the Engineer.

8.3.2 Mechanical pendulum code transmitters shall not be used.

8.3.3 Code Transmitters shall operate over a temperature range of from -40 to +70 degrees C, 0 to 95% relative humidity non-condensing.

8.3.4 Code Transmitters shall provide cab signal codes with characteristics as required elsewhere in these Technical Specifications and Contract Drawings, and which shall be fully operate with the existing Metro-North 100 Hz cab signal system and vehicle cab signal equipment.

8.3.5 Code Transmitters shall generate a single code rate; either 75, 120, 180 or 270 PPM, and shall provide either high voltage (AC) or low voltage (AC or DC) output switching, as required by the circuit application.

a. High Voltage AC output switch shall be rated at 4 ampere, 150VRMS, with no more than 1.25 VRMS across the switch in the on state, independent of load.
b. Low Voltage AC or DC output switch shall be rated at 2.5 ampere, 22VRMS maximum (AC) or 32VDC maximum (DC), with a resistance of 0.5 ohms.
c. Code Transmitters shall have the equivalent of 2 Front and 2 Back contacts, with independent Heel connections.
d. Light Emitting Diodes (LEDs) shall provide an indication when each of the Front and Back outputs are energized and providing a conduction path between the Front and Heel (or Back and Heel) terminals. Different color LEDs shall indicate for the Front and Back.
e. Index plates shall prevent interchange of Code Transmitters with different code rates or output switch ratings.

8.4 Non-Vital Relays

8.4.1 Non-vital relays for signal system functions shall be as follows, except as shown otherwise on the Contract Drawings.

8.4.2 Non-vital relays shall be manufactured by Relco using the Relco S9-m base or approved equal of the plug-in type. Non-vital timer relays shall be manufactured by Macromatic part# TR60226 and SS61926 or approved equal.

8.4.3 Each non-vital relay shall be equipped with a minimum of four front-back contacts. Stationary contacts shall be bifurcated silver, palladium, or approved equal. Movable contact shall be bifurcated silver, palladium with gold overlay, or approved equal.

8.4.4 Each non-vital relay shall meet or exceed the following requirements:

a. Maximum Temperature Rise: 55 degrees C at 30 vdc.
b. Insulation Resistance: 1.5 X 10 ohms.
c. Ambient Operating Temp: Minus 40 degrees C to ±85 degrees C.
d. Dielectric Strength: 500 volts RMS, 60 Hz between all mutually insulated parts.
e. Mechanical Life: 100 million cycle operation.
f. Electric Life: 10 million operations (.05 ampere resistive load at 25 degrees C.)
g. Contact Resistance:
    1. Before Life: 100 milliohms max, at 6VDC, 100ma.
    2. After Life: 200 milliohms max, at 6VDS, 100ma.

8.4.5 Non-vital relays shall be rack mounted on DIN 35 mounting rails and shall have removable transparent front covers that will not support combustion.

8.4.6 Non-vital relays shall be provided with mounting bases, which shall be used for attaching to the DIN 35 mounting rails, and which shall also indicate through illumination of an LED or mechanical indication flag that the relay coil is energized. A contact of the non-vital relay will not be used to light the LED. A push to test feature shall be incorporated into the module. The mounting base shall be in accordance with the AREMA Manual of Recommended Practices, Part 14.1.2.

8.4.7 Non-vital relays shall be plug-in with positive latching devices, DC neutral relays with a nominal operating voltage of 12 volts. These relays shall pick up with 9 volts or more applied to their operating circuits, and must drop out when this voltage decreases below 1 volt. These relays shall operate continuously with up to a maximum of 21 volts applied to their operating circuit. Non-vital relays shall pick up in less than 25 milliseconds when energized with 9 volts, and shall drop out when de-energized from 14 volts in less than 50 milliseconds. These times shall be measured as a front contact closure or opening from the instant the switch removing the voltage opens.

8.4.8 When three (3) non-vital relays, suppressed as required are connected in parallel and operated from 12V, a non-vital relay front or back contact that breaks this load shall withstand at least ten million operations at this load without the contact resistance, measured with a 10 ma current, exceeding five (5) ohms. All non-vital relays shall be identical by type and class, or function.

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9.0 VITAL MICROPROCESSORS

9.1 General

9.1.1 The Contractor shall provide a Vital Microprocessor System (VIMS) to meet all requirements of these Technical Specifications and Contract Drawings.

9.1.2 The VIMS shall consist of, but not be limited to, chassis', cabinets, CPU circuit cards, I/O circuit cards, power supplies, cabling, terminations, serial communications links, Ethernet network links, executive software, application software, diagnostic software, remote monitoring software and all other subsystems and components related to the system.

9.1.3 The Contractor shall be responsible for integrating all components of the VIMS. The Contractor shall provide product from manufactures that provide a complete set of required circuit cards. Mixing and matching multiple vendors is not permitted.

9.1.4 The VIMS shall be applied in a zoned non-redundant configuration as defined within these Technical Specification and Contract Drawings. This application shall apply for interlockings, intermediate locations, applications that require an interface to existing locations and other applications as required. The Contractor shall only furnish systems with a proven record of in-service applications that meet these requirements.

9.1.5 The VIMS shall be rack mounted within a house-type enclosure only. Installation within a case, cabinet or other enclosure is not permitted. The house sizes and rack requirements are located elsewhere within these Technical Specification and Contract Drawings.

9.1.6 Each intermediate location or interface location shall have a single enclosure to house the VIMS.

9.1.7 The reference to "Mini vital-processor" in these Specifications shall mean a compact version of the signal supplier's standard vital processor product and shall meet all the requirements these Technical Specifications and Contract Drawings.

9.1.8 Vital Microprocessor Systems shall meet all performance requirements as defined within these Technical Specifications.

9.1.9 Vital Microprocessor System Configuration shall be as shown in the Contract Drawings. The vital microprocessor-based control system shall utilize a packet-based peer-to-peer protocol to transmit both vital and non-vital serial data messages through a redundant diverse data links over a fiber optic based

network. This will provide vital communications between the vital microprocessor based interlocking control systems installed within the interlocking CILs and the vital microprocessor based control systems installed at the Master Locations within the external network.

9.1.10 Communications protocol and system configuration shall allow any vital microprocessor connected to the network to communicate vitally with any other vital microprocessor that is also connected to the same network.

9.1.11 Each vital microprocessor control system shall be addressable and shall only communicate with other vital microprocessor control systems whose addresses have been programmed within the vital application logic for that location.

9.1.12 Contractor's design shall include system-wide communication system drawings, diagrams, and supporting tables and charts that includes information that includes, but not limited to, the assigned addresses for every device on the network(s), partner relationships between vital redundant diverse north/south networks with seamless transfer, identification of vital and non-vital network segments, subnets, gateway, and other server addressing, physical medium types, (e.g. copper, fiber), interface type (e.g. RS232, TCP/IP), link speed, interface points to the backbone, and all static and configurable parameters associated with the communication system hardware devices.

a. Information shall be presented on standard circuit plans, with minimal reliance on supporting literature or non-drawing based documents.
b. Content and format of the drawings shall be submitted to the Engineer for approval.

9.1.13 Vital zones of the interlocking, intermediate and interface locations shall be interconnected over redundant, vital fiber-optic cable links utilizing TCP/IP communications protocol over Ethernet. These vital data links shall provide for traffic direction logic, cab signal aspect selection, and all other vital signal functions between the interlockings and throughout the automatic block sections. Fiber optic cables will be provided by others.

9.1.14 Appendix D documents are representative of the type of Site Specific Application Logic (SSAL) required to be programmed and provided by the Contractor. Metro-North utilizes Nodal design techniques for the programming of the vital and non-vital Site Specific Application Logic (SSAL).

9.1.15 Contractor shall program this logic in the most efficient manner possible using the Contract Drawings as a guide for content. Networks, such as route check, home, and distant, shall be designed using network node equations. Subject to approval by the Engineer, the Contractor may deviate from the

contract typicals. Not all of the required logic is shown in Appendix D and the Contract Drawings. Contractor shall provide all logic required to implement the vital microprocessor-based interlocking control systems in accordance with this Contract.

9.1.16 Contractor shall provide a system that is immune to the effects of any electromagnetic or electrical interference generated from within or outside the signal enclosures.

9.1.17 All input and output circuit cards or other components within the microprocessor system shall be designed in a manner that they will not generate any nuisance system alarms or system resets when the input or outputs of the circuit cards or wiring to and from the card are exposed to the normal collapsing fields developed during the operation of vital relays, non-vital relays or signal line circuits. The use of protection devices external to the circuit card, special wiring or relay placement is not permitted. Location of signal equipment and normal wiring practices shall be permitted, without any restrictions, for future additions or modification of the system after delivery and commissioning.

9.1.18 Contractor shall provide a vital microprocessor-based interlocking control system that is neither a culprit nor victim to the effects of any expected electromagnetic or electrical interference generated from within or outside the signal enclosures.

9.1.19 All input and output circuit cards or other components within the microprocessor system shall be designed in a manner to which they will not generate any system false alarms or spurious data responses when the input or outputs of the circuit cards or wiring to and from the cards are exposed to expected electromagnetic fields developed during the operation of vital relays, non-vital relays or signal line circuits.

9.1.20 Protection devices external to the circuit card or to external wiring or relays shall be limited to, surge arresting devices for protection when components are exposed to conducted over-voltage or induced over-current field gradients. Location of signal equipment and normal wiring practices shall be permitted, without any restrictions, for future additions or modification of the system after delivery and commissioning.

9.1.21 Contractor shall develop methods to test and verify that the application or designs proposed meet these requirements. Contractor shall submit a test plan to be performed during the factory test to validate design, placement of relays and wiring.

9.2 Vital Hardware and Software

9.2.1 Vital software is software whose execution is required for the implementation of a vital function. As such, vital software is a combination of system executive and application software required for the implementation of vital function.

9.2.2 Contractor shall designate vital hardware as hardware, which under failure can adversely affect the safety of train movements. Further, if the safe implementation of a vital function is dependent in whole or in part on the absence of failures in the hardware circuit or device, then that hardware is vital. Vital hardware is hardware whose failure modes and characteristics can be accurately identified, predicted and exhaustively tested. Occurrences of failure modes that could have unsafe consequences are eliminated, prevented, or otherwise accounted for by design.

9.2.3 Hardware whose failure modes may adversely affect the safe implementation of a vital function but which is not designed as vital hardware shall be considered vital. Failure modes in this hardware are revealed or otherwise accounted for by means other than vital hardware design techniques. These means include, but are not limited to, software checking and comparison of independent hardware circuits.

9.2.4 A vital function is a system function of which the correct performance affects the safety of personnel, equipment, or environment. In addition, a system function of which the incorrect performance allows a hazardous situation to exist, which may adversely affect safety of personnel, equipment, or environment either immediately or subsequently shall be considered a vital function.

9.3 Non-vital Hardware and Software

9.3.1 Non-vital hardware is defined as all hardware which is not vital. Non-vital hardware shall be clearly delineated from vital hardware.

9.3.2 Non-vital software is all software which is not vital. Since execution of an error in non-vital software operating in the same processor as vital software could affect implementation of a vital function, that non-vital software shall be subjected to the same requirements as vital software.

9.3.3 Non-vital software shall be designed such that its execution cannot result in an output that is in conflict with established interlocking conditions.

9.4 Functional Design and Implementation Requirements

9.4.1 Vital control system shall be "zoned", with the interlocking partitioned into discrete zones of control. One vital microprocessor interlocking system shall be provided for each of the zones, such that all of the interlocking devices required for the implementation of routes exclusively in one zone are controlled by a separate processor based interlocking system.

9.4.2 External interlocking apparatus shall be assigned to each zone (for control and indication, as necessary) in such a way that with the system controlling a single zone unavailable, it shall be possible for all straight and diverging routes in the other unaffected zone to be established under full control of the signal system.

9.4.3 Processor based interlocking system for each zone shall be provided with vital communications between the system controlling the adjacent zone, non-vital communications with the non-vital code system/entrance-exit system, and direct interconnection to the local control panel controlling devices and indicators for unit lever controls for signals and switches in the specific zone.

9.4.4 Vital inputs of crossover switch position for those switches that share two zones, along with the track occupancy status for the adjacent zone detector track circuit over that switch, shall be independently provided to each of the vital processors in the adjacent zones. These switch position indications shall be realized utilizing external vital switch repeater ("NWPR" and "RWPR") relays, in order to provide isolation between the external line circuits and the separate vital processors.

9.4.5 Switch control shall be provided for shared crossover switches, from either of the adjacent zone processors, such that when the adjacent zone processor fails, a vital time delay equal to at least the longest time locking for signals that can be routed over the switch in the adjacent zone shall be imposed. Appropriate logic and external vital inputs shall be provided to insure that the affected signals in the adjacent zone have been held at stop for the entire time duration, and to positively check that no unsafe switch controls can occur in the failing zone. Once the release time is fulfilled, the crossover may then be controlled by the remaining healthy processor, subject to full route locking in the active zone, but in accordance only with detector locking of the switch by the appropriate track circuit or circuits from the (failing) adjacent zone, in order to allow the switch to be thrown back to the normal position. Once the crossover is normal, uninhibited train moves over the switch shall be possible in the healthy zone.

9.4.6 The vital microprocessor-based system shall consist of microprocessors, which use a closed loop feedback and independent system

diagnostics to maintain vital integrity. System outputs shall be positively monitored with independent current/voltage sensors and compared to the requested value. A vital "kill" circuit shall be used to de-energize all outputs and shut down the system when the outputs fail to correspond to the required state. All software programs shall be checked as a part of, and after power-up and continuously during operation for alterations to ensure no modifications or errors have taken place after being installed. The central processing unit shall be continually tested to ensure all instructions are being executed properly and that processor integrity is being maintained.

9.4.7 Vital processor system shall not use a multi-processor voting type scheme to evaluate the correctness of outputs.

9.4.8 Vital microprocessor-based system shall incorporate self-checking features and diagnostic tests to ensure that the equipment and program where applicable, are functioning properly. These checks shall be integral parts of both the hardware and software to provide for a secure system.

9.4.9 Vital processors shall not allow falsely permissive information to be transmitted to external devices which may result in a hazardous condition; non-vital processors and carrier systems shall minimize the possibility of false information being transmitted to external devices. In no case may false permissive information persist long enough to allow an unsafe condition to occur.

9.4.10 Transmission of false information from a non-vital to a vital subsystem shall in no way affect the safety of the system. Non-vital visual indications, such as LED lamps, shall demonstrate that the system is functioning properly; similarly, failure and diagnostic indications shall be provided. Indications shall isolate a failure to a particular function, or to the interface between two functions.

9.4.11 PROMS, EPROMS and EEPROMS used shall be checked, as part of program execution, during each cycle, to ensure they have been unaltered during processor execution. Benchmarks shall be created for blocks of memory to implement these tests. Executive and SSAL PROMS, EPROMS and EEPROMS shall be plug-in type and shall not be soldered to the board.

9.4.12 Vital microprocessor system shall interface with the non-vital logic and code system equipment described elsewhere within these Technical Specifications and Contract Drawings. If the non-vital processor should fail, then the Local Control Panel shall function as unit-lever via the vital processor.

9.4.13 Inputs shall be buffered and shall be immune to contact bouncing and shall be electrically and physically isolated from one another. Access to inputs must be unique in the sense that under failure, reading of the incorrect input circuit will not result in a falsely permissive input being utilized in vital processing.

Processor communication with each input shall vitally assure that the proper input and input state (on or off) is read. A non-vital visual indication, such as an LED lamp, shall be provided for each input on the input boards to indicate when the input is activated.

9.4.14 A falsely permissive non-vital input shall not adversely affect the safety of the vital function processing.

9.4.15 Outputs shall be electrically and physically isolated from one another. A vital means of verifying the proper state of the output shall be provided. Access to the outputs shall be unique in the sense that under failure, writing to the wrong output circuit will not result in a falsely permissive output being generated. Processor communication with each output shall vitally assure that the proper output is in the proper state (on or off). A non-vital visual indication, such as an LED lamp, shall be provided on the output boards for each output to indicate when the output is activated.

9.4.16 Output status of the processor shall be verified at least every second to ensure correspondence between actual and requested values. The system shall shutdown in the event that an output that should be off is on.

9.4.17 Communications (TCP/IP) between processors implementing vital functions shall be vital. Security protocol, including handshaking and error detection, shall be used to ensure the validity of data. Data shall default to the most restrictive state unless a valid transmission is received. Serially transmitted data between subsystems shall be updated every second to ensure the integrity of the communications link. Propagation time shall not exceed two seconds. Vital logic executing in each processor shall detect corrupted or inconsistent data received. Multiple pieces of partial products or raw data shall be used to provide a sufficient database to detect inconsistencies. Contractor shall be responsible for the furnished equipment to function as intended in the installed electrical environment, when installed as per the Contractor's plans.

9.4.18 To ensure immunity to EMI, vital data links within and outside a CIL shall use a balanced interface. Fiber optic cable shall be used for vital serial links that leave a CIL.

9.4.19 Error correction and recovery of the vital serial data link data shall not cause the propagation delay of the link to exceed two seconds.

9.4.20 Non-vital serial links shall either use CRC (minimum CRC-16) or check sum methods to provide a high level of assurance that invalid data is not accepted.

9.4.21 Vital serial links shall either use CRC (minimum CRC-16) or check sum methods to provide a high level of assurance that invalid data is not accepted.

9.4.22 Inputs shall be re-evaluated a minimum of once every second. Evaluation shall use a double scan to ensure a permissive input is valid. If two (2) successive scans do not result in the same permissive state, the data shall be treated as false. Input refresh shall vitally erase the memory location to ensure the input is fresh. Diagnostic checks shall be included in the processing of inputs to ensure the database has not been corrupted in any fashion. Checks shall be included to ensure the independence of inputs from one another.

9.4.23 User interface for programming site specific vital application logic shall be easy to use and shall only require knowledge of interlocking system design and the Boolean logic equivalents of the circuits to configure or reconfigure the interlocking control system. The use of ladder logic type notation to define the application logic is not acceptable.

9.4.24 Site-specific logic software shall define the operation of the vital interlocking system, and shall include, but not be limited to, the following control logic:

a. Route Check
b. Signal Control
c. Absolute Block Control
d. Signal Lighting
e. Signal Indication
f. Route Locking
g. Detector Locking
h. Indication Locking
i. Switch Locking
j. Switch Control
k. Switch Indication
l. Switch Correspondence
m. Switch Blocking
n. Track Blocking
o. Loss of Shunt Protection

9.4.25 Vital timing functions for interlocking locking requirements shall be field settable and adjustable, without the need to change the Site Specific Application Logic. Vital Timer Relays shall be used if required for this purpose unless the manufacturer has an approved software revision validation process that negates the need to perform system testing of the interlocking once a new application software has been installed. If vital timer boards are provided, they shall be sealed.

9.5 Start-up

9.5.1 Upon start-up of the Vital Processor System, switches may be out of correspondence due to a lapse in communications, and corresponding loss of switch requests from the non-vital code system.

9.5.2 Therefore, for a time duration of five (5) seconds following a vital processor start-up, the field switch indication input shall set and stick the corresponding non-vital switch control request.

9.5.3 When communications are restored, if the office or local panel switch request does not match the switch request in the field, the office display or local panel switch light shall flash until the switch is requested to the same position as what is set in the field or until the switch is thrown to the other position.

9.5.4 Startup of communication devices, including Ethernet switches, data servers, routers, and any other devices that require the configuration of operating parameters shall be automatic and not require manual intervention or acknowledgment of the parameters. Devices that lose connectivity to the network(s) shall not require the cycling of power or other means of device reset to reestablish a connection to the network(s).

9.5.5 Contractor shall submit a detailed description of the start-up procedure to the Engineer for approval.

9.6 Vital Software

9.6.1 Only through special application of hardware and software in which the failure modes and effects can be revealed and proven to meet defined values of probability of occurrence and outcome can a microprocessor be classified as a vital device.

9.6.2 System software of two types shall be function dependent upon each other to perform all vital and non-vital microprocessor logic.

a. Executive system software shall be provided by the Contractor that performs all functions necessary to provide for the proper and safe operation of the microprocessor unit as specified, not to include site-specific logic processing and control.
b. Application software shall be user-defined for site-specific application and interfacing with all necessary subsystems.

9.6.3 Diagnostic checks and vital processing shall only utilize data in its nonrestrictive state which has been stored in the machine for less than two (2) machine cycles or one (1) second, whichever is less. Memory locations used to

determine the proper states of inputs and outputs shall be vitally cleared or destroyed prior to being reused during each cycle to ensure the integrity of the data.

9.6.4 Background diagnostics shall continuously monitor the execution of software. Synchronized tasks shall execute properly, and asynchronous tasks shall execute in the proper order. Checks shall be included to shutdown the system in the event of a processor overload or a processor stuck in a non-terminating program or task.

9.6.5 The system software shall recognize a secure distinction between the executive software and the application software such that it shall be impossible through the implementation of the application software to subvert in any manner the vital safety functions of the executive software.

9.6.6 There shall be no data contained within executive software that will limit or prevent the microprocessor system from being reconfigured for alternative site configurations by modification of application software. Modifications or changes to application software shall not require modification or recompilation of executive software.

9.6.7 Application logic implementing non-vital functions shall be kept separate and distinct from application logic implementing vital functions. Changes to non-vital application logic shall be performed without requiring reverification and revalidation of the vital application logic.

9.6.8 Executive software shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system during in-service operation. Executive software data storage shall include a check sum or CRC to provide a method of determining data validity. Diagnostic checks shall be incorporated which verify the integrity of the executive software during operation.

9.6.9 Application software shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system during in-service operation. Application software data storage shall include a check sum or CRC to provide a method of determining data validity and verification of the software in use. Diagnostic checks shall be incorporated which verify the integrity of the application software during operation. Application logic shall be safe in and of itself without reliance on features of the executive software. If executed correctly, the logic shall not assume an unsafe state.

9.6.10 Nomenclature shall be consistent with Metro-North practices, and consistent throughout the application. Nomenclature shall distinguish I/O from internal variables. Inputs shall be distinguished from outputs and the I/O

nomenclature shall reference the logical unit on the other side of the interface, i.e., the input or output device. Variables of vital functions shall be distinguished from those of non-vital functions. New or special function designators shall be as simple as possible, but not conflict or lead to confusion with established function designations.

9.6.11 Changes in the application logic shall not require recompilation, verification and/or validation of the executive software.

9.6.12 Logic shall be as simple as possible, expressed in a high-level, structured and easily understood Boolean form. Applications logic programming shall be in accordance with Metro-North 's standards and practices.

9.6.13 Logic equations for all functions that depend on a point to point route through the interlocking (route check, signal control, aspect selection, cab signal selection, etc.), evaluating switch correspondence states to determine the required logic checks specific to the route being taken, shall utilize a node equation structure to characterize the interlocking network. An intermediate node shall be defined to occur at each facing point switch in a direction of travel that exclusively selects the next portion of the route to be taken, and which therefore determines the subsequent logic checks required beyond that point, based on switch correspondence, for the route dependent function. An exit node shall be defined to occur for each exit point, where required for the specific route dependent function, to incorporate all of the required logic checks that are specifically related to the exit track. Intermediate and exit node logic states shall be provided. Sets of logic equations for the route dependent function shall be designed as follows. An equation shall directly evaluate all logic states required to be checked that uniquely relate to the entrance point of the route, and shall evaluate the first intermediate node logic state in the direction leading from the entrance on that track. Subsequent equations for each intermediate node shall evaluate all logic states required to be checked and common to all routes passing through the intermediate node, based on normal or reverse switch correspondence, shall directly evaluate those logic states required to be checked that are unique to the specific route at that node (if any) and the next intermediate or exit node logic state that is encountered over the determined route. Finally, exit node states, where these are required, shall include those necessary logic checks common to all routes to the specific exit track. The intermediate or exit node states shall be evaluated in each equation of the set of equations for the specific route dependent functions that pass through or terminate at the nodes. Separate sets of function, intermediate node and (where required) exit node equations shall be provided for each direction.

9.6.14 Organization and adequate commenting are an inherent quality of the safety of the logic, i.e., the readability/understandability of the logic and logic organization are integral to the long-term safe operation and maintenance of the

system. Therefore, comments shall be applied liberally throughout the software. General organization of the application programming logic, in the order appearing in the program listing shall be:

a. Program administration: version level, programmer, checker, etc.
b. Machine specific requirements in the programming (e.g., compiler switches)
c. General remarks, comments, special features, etc.
d. Hardwire I/O
e. Serial I/O
f. Table and description of variable names
g. Logic equations.

9.6.15 As a minimum, specific approval of the Engineer shall be required for each instance in which the Contractor wishes to "nest" logic more than 3 levels unless required to realize the network node structure or where additional "intermediate" bits are otherwise required to perform the same function.

9.6.16 Where specific vital functions need to be verified the logic shall be organized to avoid masking of the vital function with non-vital or other logic, and a vital means of validating the logic states shall be provided. For example, switch request and request storage prevention logic shall be provided independent of switch locking, and a means shall be provided for validating the state of the locking such as provision of a vital output or read only access to the contents of the memory location.

9.6.17 A non-asserted input is not equal to a back contact of a relay, but rather an open front contact. Vital logic requiring a non-asserted input to set an internal variable shall require an inverted input to be used in setting the internal variable. Where the relay equivalent function of a back-check is determined to be required and applied in more than one equation, the logic shall be arranged such that the back-check need only be checked once. For example, the application of a ~RWC literal in the setting of a NWC variable obviates the need for ~RWC literals in signal clearing and other equations (where the NWC is used). For logic determined internal to the machine, extraneous "back checking" of logic to replicate relay logic shall be avoided. For example, the requirement to "back-check" an AS state in a "H" function is not necessary if (a) a logic condition exists which is mutually exclusive to both functions (e.g., a set "Route check" in the "H" and a clear "route check" in the "AS" function), and (b) a particular literal is not an input.

9.6.18 Loss-Of-Shunt (LOS) protection shall be provided by five (5) second timing (i.e., delayed application of an input and/or internal variable). The Five (5) second LOS shall be implemented at the track detector level. This timing shall be performed in the processor which is processing the inputs and not by a

processor removed from the input to be timed by intermediate processing units or stages. Five (5) second loss-of-shunt protection for route locking shall NOT be performed at the switch locking or route locking level.

9.6.19 The VMIS shall provide "AS" logic incorporating a two (2) track circuit reset, which shall only be effective when a minimum time delay has been satisfied with the first circuit occupied prior to occupancy of the second track circuit in the route. This time delay shall prevent the simultaneous dropping of these adjacent track circuits(as can occur for loss of signal power or a single insulated joint failure) from improperly resetting the "AS" logic and releasing a locked route in advance. The time delay for this function shall be set at 3 seconds, except where diverging routes at the maximum possible cab signal speed result in shorter transition times, the delay time shall be reduced to 2 seconds.

9.6.20 For all steady energy AC track circuits provided under this contract, as applied in both the interlocking and intermediate territories, the VMIS shall apply the required cab signal code to the rails within 250 msecs of track occupancy. This time shall be measured from the time a train passes the insulated joints and has shunted the track circuit, based on opening of the track relay front-contacts. Where timing limitations of the specific vital processor logic require, pre-conditioning of coded vital VMIS outputs shall be provided, with track relay back-contacts used for final control and/or application of coded energy to the rails upon occupancy.

9.7 Vital Hardware

9.7.1 The vital microprocessor system shall also have the ability to be expanded when the I/O capabilities have been expended for controlling devices. The expansion architecture shall be designed such that it will not adversely affect the total bit time throughput from adjacent locations. Where excessive voltage drop in a signal lighting cable would require the addition of a microprocessor for lighting purposes only, the Contractor shall design as described below, if at all possible, rather than install an additional microprocessor.

a. Use an independent common return wire for each signal lighting bulb.
b. Boost battery voltage to the lamp driver output boards keeping within the vital microprocessor's specified equipment supply range. Vital Lamp Driver output board range shall be 7 volts to 10 volts. Signal voltage shall be 8.5VDC at the filament. Losses from the signal cable lengths shall be taken into account.

9.7.2 Spare input and output board slots are required. Vital microprocessor motherboards shall allow the addition of inputs and outputs by the purchase of input/output boards and simple installation by Metro-North. A minimum of 25% of

all of the inputs and 25% of all of the outputs used at an interlocking shall be provided as spare at each interlocking.

9.7.3 The Contractor shall also provide one complete set of spare, fully tested, vital microprocessor printed circuit boards within a lockable steel cabinet, for each interlocking CIL, master location and interface location provided under this Project. The purpose of this spare set of printed circuit boards will be to minimize downtime and service testing in the event of board failure. The spare vital processor printed circuit boards shall be in accordance with the following:

a. A complete set of vital microprocessor printed circuit boards shall be provided, including processor board, input boards, output boards, lamp driver boards, power supply boards, etc.
b. The spare set of printed circuit boards shall be completely tested, including factory simulation test, and shall have the same site-specific application logic (SSAL) and executive software, installed on EPROMS, as the matching in-service printed circuit board. Check sums on the SSAL and executive software EPROMS on both the in-service printed circuit boards and the spare set of printed circuit boards shall be verified as being the same. All Executive and SSAL PROMS, EPROMS and EEPROMS shall be labeled with program revision, date, and check sum.

9.7.4 Engineer approved labels shall be provided by each input and output indication which clearly denote the respective function of each, for the ease of maintenance and troubleshooting.

9.7.5 Power for the input/output circuits shall be supplied through a vital cut-off circuit. This circuit shall be driven by a vital clock signal generated by the processor checks and diagnostics. The vital clock signal shall pass through filters tuned to prevent a false signal from energizing the relay. The signal frequency shall be chosen such that it could not be generated by any other device in the equipment housing: for example, 60 Hz power supplies or battery chargers, audio frequency overlay equipment, or harmonics of these devices. The vital cut-off circuit shall remove the vital clock signal and de-energize the vital cut-off relay.

9.7.6 Vital processors shall control several output devices, which shall be energized with 12VDC, i.e., vital signal control relays, signal lamps, etc. Output boards shall withstand without damage, the shorting of the output to ground or the opposite DC polarity. Such a short shall register an alarm to the control center.

9.7.7 The Contractor shall certify in writing that the equipment provided under this Section, including software and future software revisions, both executive application, and user-defined, shall be available and will be serviced and supported for a period of ten (10) years after Contract completion.

9.7.8 All power for the vital microprocessor inter-locking shall be properly isolated from the effects of electromagnetic interference, lightning, noise, current surges, and grounds. Surge suppressor units to further enhance this isolation are required by this Contract and shall be provided by the Contractor.

9.7.9 An Engineer-approved vital means of indexing PCBs, either mechanically or in software, shall be implemented to ensure that only the proper PCBs are inserted in card slots. In addition, PCB card edge holders or ejectors shall be color-coded.

9.7.10 All components of the system shall operate at temperatures of minus 40 degrees Centigrade to plus 70 degrees Centigrade, and humidity levels of 0 - 95% non-condensing without any external environmental controls.

9.7.11 All 'dirty' wiring (wiring not protected or isolated from the effects of electromagnetic interference, lightning, noise, current surges and grounds) shall be kept clear of the vital microprocessor as far as is practical and where that is not possible, the wiring methods shall utilize other means to protect against induced interference.

9.7.12 All monitoring equipment shall be able to be connected or disconnected from the microprocessor system while it is in operation.

9.7.13 All major assemblies, subassemblies, circuit cards and devices shall be permanently marked with the manufacturer's part identification number.

9.7.14 All ICs, PCBs, components, etc., which are subject to revision (such as PROMs) and/or are removable from assemblies, should have the revision level identified on the component.

9.7.15 Contractor shall be responsible and verify that the equipment functions as manner intended in the environment in which it is to be installed and operated.

9.7.16 Vital microprocessor card cage shall have provisions for the installation of a wire seal.

9.7.17 If a field settable vital timing board is used instead of vital timer relays, access to the timer setting of the board shall be restricted by a wire seal.

9.7.18 Chassis and cabinets shall conform to Section 10, Chassis/Cabinets of these Technical Specifications.

9.7.19 PCB construction shall comply with Section 10, Circuit Boards, of these Technical Specifications.

10.0 NON-VITAL MICROPROCESSOR-BASED SYSTEM

10.1 General

10.1.1 The Contractor shall provide Non-Vital Microprocessor systems as required by these technical Specifications and Contract Drawings.

10.1.2 Non-Vital Microprocessor system shall consist of, but not be limited to, chassis', cabinets, CPU circuit cards, I/O circuit cards, power supplies, cabling, terminations, serial communications links, Ethernet network links, executive software, application software, diagnostic software, remote monitoring software and all other subsystems and components related to the system.

10.1.3 Contractor shall furnish non-vital microprocessor logic and I/O as required at each new interlocking, upgraded interlocking, master and interface location houses as defined in these Technical Specifications.

10.1.4 Non-Vital Microprocessor Systems shall meet all performance requirements as defined in these Technical Specifications.

10.1.5 Appendix D documents are representative of the type of Site Specific Application Logic (SSAL) required to be programmed by the Contractor. Contractor shall program this logic in the most efficient manner possible using the Contract Drawings as a guide for content, not necessarily efficiency. Not all logic is shown on these documents. Contractor shall develop and implement all required logic.

10.1.6 Non-vital microprocessor code and entrance/exit logic system shall communicate with the Operation Control Center using Genisys protocols.

10.1.7 Contractor shall provide a system that is immune to the effects of any electromagnetic or electrical interference generated from within or outside the signal enclosures in accordance to these Technical Specifications.

10.1.8 All input and output circuit cards or other components within the microprocessor system shall be designed in a manner that they will not generate any system false alarms or spurious data responses when the input or outputs of the circuit cards or wiring to and from the card are exposed to expected electromagnetic fields developed during the operation of vital relays, non-vital relays or signal line circuits.

10.1.9 Protection devices external to the circuit card or to external wiring or relays shall be limited to, surge arresting devices for protection when components are exposed to conducted over-voltage or induced over-current field gradients. Relocation of signal equipment and normal wiring practices shall be

permitted, without any restrictions, for future additions or modification of the system after delivery and commissioning.

10.1.10 Contractor shall develop methods to test and verify that the application or designs proposed meet these requirements. The Contractor shall submit a test plan to be performed during the factory test to validate the design, placement of relays and wiring.

10.2 Functional Design and Implementation Requirements

10.2.1 Non-vital code system provided shall be based on solid-state microprocessor technology and shall not require any off-line storage devices for operation or start-up.

10.2.2 All software programs shall be checked after power-up and continuously during operation for alterations to ensure no modifications have taken place after being installed. The central processing unit shall be continually tested to ensure all instructions are being executed properly and that processor integrity is being maintained.

10.2.3 Non-vital microprocessor shall incorporate self-checking features and diagnostic tests to ensure that the equipment and program where applicable, are functioning properly. These checks shall be integral parts of both the hardware and software to provide for a secure system. Non-vital processors and DTS systems shall minimize the possibility of false information being transmitted to external devices.

10.2.4 Transmission of false information from a non-vital to a vital subsystem shall in no way affect the safety of the interlocking. Non-vital visual indications, such as LED lamps, shall demonstrate that the system is functioning properly; similarly, failure and diagnostic indications shall be provided. Indications shall isolate a failure to a particular function, or to the interface between two functions.

10.2.5 PROMs, EPROMs, and EEPROMs used shall be checked to ensure they have been unaltered during microprocessor execution. Benchmarks shall be established for blocks of memory to facilitate these checks.

10.2.6 Non-vital microprocessor system shall interface with the vital interlocking system described in the Vital Microprocessor Section of these Technical Specifications.

10.2.7 Non-vital microprocessor system shall interface to the Local Control Panel. The system shall perform the logic for all controlled signal system functions for entrance/exit routing and associated indications, provide simplified line-of-light type route display with indication for each discrete track circuit, and

provide for the required panel operation and alarm functionality as defined in these Technical Specifications and Contract Drawings. If the non-vital processor should fail, then the Local Control Panel shall function as unit-lever via the vital processor.

10.2.8 Inputs for the equipment shall be buffered and shall be immune to contact bouncing and shall be electrically and physically isolated from one another. A visual indication, such as an LED lamp, shall be provided on the input board, for each input, to indicate when the input is activated.

10.2.9 Outputs for the equipment shall be electrically and physically isolated from one another. A visual indication, such as an LED lamp, shall be provided on the output board for each output to indicate when the output is activated.

10.2.10 Operating programs and database definition shall be stored in nonvolatile memory so that automatic power fail/restart can be provided.

10.2.11 Non-vital code system shall perform the same functions as a conventional relay type code system. In addition, the system shall perform other functions as specified herein.

10.2.12 Non-vital code system shall include, but not be limited to, the following controls, which are listed below and shown on the Contract Drawings:

a. Route Setting
b. Switch and Signal Operation
c. Route Cancellation
d. Switch Blocking
e. Track Blocking
f. Fleeting
g. Snowmelter Control
h. Maintainer's Call
i. Absolute Block Signal Control

10.2.13 Non-vital code system shall include indication data to enable display update at the Operations Control Center. Indications shall include, but not limited to, the following, which are listed below and shown on the Contract Drawings:

a. Signal Status
b. Switch Position
c. Switch Locking
d. Route Setting
e. Traffic Direction
f. Snowmelter Status
g. Track Occupancy - Block Status

h. Maintainer's Call
i. Control from Auto or Manual
j. Fleeting Status
k. Absolute Block Signal Status
l. Intrusion
m. Vital and Non-Vital Processors Errors, Failures or Code Line Transfers
n. Fire Alarm
o. AC and DC Power Off
p. Grounds
q. Surge
r. Ethernet Switch Status
s. Fire Suppression System Fault Alarms
t. HVAC Fault Alarms
u. All other alarms and indications as may be required and that are specified in other Technical Specification sections.

10.2.14 Non-vital code and logic system shall be provided with interfaces to the vital system, in such a way as to permit the non-vital code system to be de-energized for repair and/or circuit board replacement and not affect the routes currently selected. When energized, the non-vital code system shall read all indications and establish all required internal values or sticks without requiring any interaction from the office system or local maintainer.

10.2.15 Indications to the Operations Control Center shall be positive true unless otherwise approved by the Engineer.

10.2.16 The use of repeater relays in the logic is not permitted unless approved by the Engineer.

10.2.17 The source application for the system shall be provided in a readable hardcopy and in a word processor text file. The format shall be Microsoft Word or other approved word processor.

10.2.18 Programming for the field non-vital code system shall be modular in-format. Common pieces of logic shall be represented by variable names. All networks should be modular in format and be minimized to the greatest extent possible.

10.2.19 Code System Interface shall provide for reliable operation under the following conditions:

a. Field-installed non-vital code system shall be polled in a round robin fashion once every second with a unique address. The field shall answer with a complete indication message at intervals not greater

than once in the sequential number of polls equal to the total field station count for which the station's address is correctly decoded.

b. Code charts are provided in the Contract Documents to demonstrate the control and indication nomenclature and layout. Discrete request and cancel bits for control are required, as are the appropriate output control relays. Discrete indication bits are required as indicated in the code charts.
c. Detection of any three failures in a row shall denote a failed line. The field shall derive, from these errors, a status bit for each of the two data lines. Status shall be determined from within the non-vital code system and not by an external device. Carrier detect is not a valid indication of code line status. Status bits shall operate independently of each other. The status bits shall be set (true or logic 1) when the code line is not on a failure mode. Status bits shall not be set (false or logic 0) when the code line is in a failure mode.
d. The office shall roll call and send controls on both the primary and standby data lines at the same time. The field is expected to answer each valid role call with a full indication message on both primary and standby indications data lines at the same instant.
e. The code interface shall operate over a new communications and signal network via Ethernet connections consisting of primary and standby fiber optic links between control points, master locations and Operations Control Center. The contractor shall provide data device server/Ethernet switches at control points and master locations for the purpose of interfacing the wayside locations to the new communications and signal network.
f. Interface between master locations and control points shall be over a separate set of primary and standby fiber optic links for the purpose of transmitting alarms and indications to the control points as well as performing remote diagnostics.
g. Connections between the fiber distribution panel and the data device server/Ethernet switches to the non-vital code system shall be separated into primary and standby functions and be provided by separate Ethernet cables.
h. Controls will be sent to the field in a unit-lever fashion. The method for establishing routes shall be as follows:

    1. Office roll call will pause when any controls are being sent to the field.
    2. Office will send a control to the field containing the position of each switch.
    3. Office will send the traffic request along with switches based on the route requested.
    4. The field will receive the switch and traffic request controls and test for framing errors and CRC.

5. Office roll call will resume.
6. Non-vital controls delivered to vital logic and switches/traffic are aligned.
7. Switch position and traffic directions indications are received at the office.
8. When the actual switch position is in agreement with position requested by the office, the office roll call will pause as a signal request (GZ) control is sent to the field.
9. Field will receive the control and test for parity, framing, and CRC.
10. Office roll call will resume.
11. Field will deliver the GZ controls to the appropriate output ports.
12. While the field is working on a request, the office will return to roll calling. The field shall answer the roll call each time it is called by the office even if the last GZ has not been delivered. In this manner, the office can continue to monitor the switch positioning and other indications for the field.
13. As switches move and locks are established, the indication is passed to the office through subsequent roll calls.

10.3 Non-Vital Microprocessor Software

10.3.1 Diagnostic checks shall act on current (fresh) data only. Memory locations used to determine the proper states of inputs and outputs shall be cleared or destroyed prior to being reused during each cycle to ensure the integrity of the data. Diagnostic checks shall be independent of the user application logic for the system. The diagnostic checks shall be incorporated in the executive systems software and shall operate independent of the user application software for the system.

10.3.2 Background diagnostic tasks shall run during application software wait states and shall serve to monitor and verify the integrity of the software execution. Synchronized tasks shall execute properly and a synchronized task shall execute in the proper order. Checks shall be included to shut down the system in the event of an executive microprocessor overload.

10.3.3 Compiler software shall be supplied to maintain and upgrade the non-vital application software. Compiler software shall be licensed to Metro-North for unrestricted use. Software technical support and revisions shall be provided for a minimum of ten (10) years by the Contractor without further cost to Metro-North. Executive software, compiler software and hardware shall be supported as described in the Vital Microprocessor Section. Configuration control for application logic shall also be as specified in the Vital Microprocessor Section.

10.3.4 System software shall recognize a secure distinction between the executive software and the application software such that it shall be impossible

through the implementation of the application software to overwrite or otherwise modify the executive software.

10.3.5 There shall be no data contained within executive software that will limit or prevent the microprocessor system from being reconfigured for alternative site configurations by modification of application software.

10.3.6 Executive software shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system. The executive software data storage shall include a check sum or CRC to provide a method of determining data validity. Diagnostic checks shall be incorporated which verify the integrity of the executive software during operation.

10.3.7 Application software shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system. The application software data storage shall include a check sum or CRC to provide a method of determining data validity and verification of the software in use. Diagnostic checks shall be incorporated which verify the integrity of the application software during operation.

10.3.8 A Software Verification and Validation Plan and site-specific application logic verifier as specified in the Vital Microprocessor Section shall be provided.

10.3.9 The SSAL shall also include "stuck input check" timer functions so that a call is not continuously placed on a switch, signal or other function in the event of a stuck local control panel button or a malfunctioning input point.

10.4 Non-Vital Microprocessor Hardware

10.4.1 Diagnostic indications shall isolate a failure to a particular function or the interface between the failing functions.

10.4.2 Labels and annotation shall be provided for each input and output indication which shall clearly denote the respective function for ease of troubleshooting and maintenance.

10.4.3 All components of the supervisory control system shall be in accordance with the environmental parameters described in these Technical Specifications.

10.4.4 Microprocessor equipment, including all field spare PCB cards, shall be mounted complete with all necessary accessories on standard 19 inch racks.

10.4.5 All power for the non-vital code system shall be properly isolated from the effects of electromagnetic interference, lightning, noise, humidity, current fluctuations, and grounds.

10.4.6 All 'dirty' wiring shall be kept clear of the microprocessor as far as is practical and where that is not possible, the wiring methods shall utilize other means to counter induced interference.

10.4.7 All monitoring equipment shall be able to be connected or disconnected with the non-vital code system in operation.

10.4.8 All major assemblies, subassemblies, circuit cards and devices shall be permanently marked with the manufacturer's part identification number.

10.4.9 The local control panel shall be tied directly to the input and output boards of the non-vital code system.

10.4.10 Ten (10) percent spare inputs and outputs shall be provided per chassis.

10.4.11 The Contractor shall supply the input and output circuit boards, which provide ports in multiples of eight (8). Output and input functions shall be provided on different circuit boards. Input indications are driven directly from the vital relay contacts using 12VDC power. Output to the vital relays shall be through a "source" or "sinking" output circuit board. The output source shall be the non-vital B12-AFO/NV bus.

10.4.12 All input and output circuit cards or other components within the microprocessor system shall be designed in a manner that they will not generate any nuisance system alarms or system resets when the input or outputs of the circuit cards or wiring to and from the card are exposed to the normal collapsing fields developed during the operation of vital relays, non-vital relays or signal line circuits. The use of protection devices external to the circuit card or special wiring or relay placement is not permitted. The location of signal equipment and normal wiring practices shall be permitted, without any restrictions, for future additions or modification of the system after delivery and commissioning.

10.4.13 Isolation to ground of a minimum of 2,500VDC shall be provided.

10.4.14 Each input and output circuit shall be provided with surge and lightning protection. Mounting of protection shall be submitted for the approval of the Engineer.

10.4.15 Contractor shall provide ten (10) sets of a complete detailed component level circuit board schematic for both input and output boards.

10.5 Chassis/Cabinets

10.5.1 Any unused chassis slots shall be fully covered by blank removable plates made of the same material as used in the working circuit boards. The blank slots shall provide for no gaps greater than 1/8 inch. No gaps greater than 18" shall be permitted anywhere on the chassis when closed. All chassis shall have a solid covered door on the front to protect the circuit boards and any switches or pushbuttons from accidental operation. The door shall be removable.

10.5.2 The chassis or cabinet material shall be aluminum or other non-corroding material as approved. Chassis shall be supplied with rear panels that permit easy access to rear edge connectors.

10.5.3 All backplane wiring methods and material are to be submitted for approval. This shall include, but not be limited to, wiring, connectors or motherboards. All wiring shall be twisted pairs to provide maximum isolation to E.M.I. noise. All support devices and internal chassis or cabinet elements shall be protected with an approved material to prevent wires from being cut or damaged.

10.5.4 Power for each chassis/cabinet shall be routed through a toggle switch with an indicated LED, and shall break both the DC power and neutral path. The switch shall be recessed to prevent accidental operation.

10.5.5 All wiring from each chassis or cabinet to other chassis, cabinets or other devices or sources shall be through plug-connected cables or plug-connected wiring. Each connector shall be AMP M-series or approved similar device. Each connector shall be keyed in a unique manner, be mounted on the rear of the chassis or cabinet as required and have a unique labeling method. All connectors, tooling, attachment methods and fittings shall be submitted for approval.

10.5.6 All chassis shall be lockable with a key lock and keyed alike.

10.5.7 Any ventilation screens shall be easily removable for cleaning.

10.5.8 All chassis or cabinets shall be completely covered or enclosed to prevent the entry of a rodent. A complete detail of each chassis or cabinet shall be submitted for approval.

10.5.9 Each chassis shall be grounded to the rack with a #10 AWG stranded green wire. No ground loops or series ground wires are permitted.

10.5.10 All chassis shall be flush mounted to the face of the rack unless otherwise approved.

10.6 Circuit Boards

10.6.1 All circuit boards shall have a unique serial number clearly marked on each board along with the board manufacturer's part number. All markings shall be of a permanent type.

10.6.2 Each circuit board shall have all components clearly identified by a silk screening process. All markings shall be clear and easily readable. The markings shall include, but not to be limited to, polarity, switch position numbers, resistor identifications or integrated circuit identifications.

10.6.3 Each circuit board shall be secured in the chassis by a secure manner such as captive screws or latching ejector tabs. Both the top and bottom of each board shall be secured.

10.6.4 Each circuit board shall be coated with a moisture resistant sealant after manufacture and testing. Any further work done to the board shall be re-coated.

10.6.5 Contractor shall supply a minimum of one each of any extender card required to match each type of circuit board.

10.6.6 Circuit boards shall be removable and be mounted on guide-ways or channels for ease of removal or insertion. The removal of any wire shall not be required to replace a circuit board.

10.6.7 Edge connector finger contacts of each circuit board shall provide a firm wiping action to prevent oxidation in the railroad environment. A gas tight connection shall be maintained.

10.6.8 All circuit boards shall have plated through holes.

10.6.9 All circuit boards using any indicator LED shall have the LEDs mounted on the front edge of the board. The colors of the LEDs shall be approved by the Engineer. Each LED shall be labeled on the circuit board in a permanent method.

10.6.10 Each circuit board of the same type shall be uniquely keyed. The chassis slots for circuit boards of the same type shall be keyed to match the board and reject others. The keying methods shall be modifiable and submitted for approval.

10.6.11 Circuit boards requiring an address setting, word count or slot number shall make use of dual in line circuit board switches or approved equal with a proven record of performance within the railroad environment.

10.6.12 Each circuit board and chassis slot shall be provided to withstand a minimum arc-over potential of 600 volts between conductor and ground.

10.6.13 All circuit board copper traces shall be two (2) ounce minimum.

10.6.14 All circuit boards shall have internal surge and polarity protection for power, data, control and indication inputs and outputs.

10.6.15 All circuit boards and components shall be new. The use of refurbished material is not permitted.

10.6.16 These circuit board Technical Specifications shall also apply to the vital microprocessor, and all other electronic components supplied under this Contract. Additional circuit board requirements are specified in the Miscellaneous Components and Products Section.

10.7 Non-Vital System Logic

10.7.1 When energized, the non-vital system shall read all indications and establish all required internal values or sticks without requiring any interaction from the office system or local maintainer. The Contractor's protocol shall include a detailed description of all aspects of the power-up/down sequence of the system.

10.7.2 The non-vital code and entrance exit logic system shall provide and be provided with interfaces to the vital system processors as required in Section 9.0 of these Specifications. The interface shall have the following characteristics:

a. Under normal CTC operation, controls such as switch requests and signal requests will be sent to the non-vital code and entrance-exit processor. This processor will route the request to the proper non-vital sections for execution and transfer to the vital section for further vital processing.
b. A failure of the CTC system detected by the non-vital processor will result in permitting local operation. Under normal local operation, the Local Control Panel will operate in an entrance-exit mode. Manipulations at the Local Panel will be routed to the entrance-exit logic in the non-vital processor. The switch requests and signal requests generated by the entrance-exit logic will be routed to the appropriate vital processors for further execution.

c. In the event of the failure of the Non-vital processor the local control panel shall be interfaced with the vital processor system for "unit lever" operation.

10.7.3 The Contractor shall design a system for each of the interlockings, which provides for full functionality in accordance with the Metro-North operational practices.

10.7.4 Listed below are the basic operational characteristics of the Local Control Panel for Entrance/Exit. Controls shall be generated with a positive 12 dc volts requesting the function:

a. Routes

1. Entrance selections will indicate available exit points by flashing route lights at the exit points. Note that traffic conditions are not criteria for available exit. The entrance signal will flash on request.
2. When the exit button is pressed, the exit selected remains flashing until the route is established, and will then be lit solid. The entrance signal will light steady when the GK is established.
3. Green route bands will light based on locking and switch position.
4. Center (Reverse) or top and bottom (Normal) switch segments will flash during switch movement indicating selected position, and will light steady when correspondence is established.
5. All segments of a route will light to indicate the route established.
6. To cancel a route, pull the signal lever.
7. Signal will flash until the GK indication has been removed.
8. Green route bands will go dark after time has run on the appropriate route.

b. Fleeted Signals

1. Only a cleared signal can be fleeted.
2. Once cleared, the lever is turned 90 degrees toward the direction of the traffic.
3. A requested fleet will flash the signal indicator LED at a 20 percent on and 80 percent off rate.
4. Once the fleet indication is established, the flash rate goes to 80 percent on and 20 percent off.
5. To cancel the fleet, pull the signal lever.
6. The flashing will go back to the 20 percent on and 80 percent off until the cancel fleet indication is received.
7. Then the signal will be steady green.

c. Track Blocks:

1. Track blocks can be placed into effect at any time, including when signals are cleared.
2. To establish a track block, press the appropriate "TRACK BLOCK" pushbutton. Light will flash blue until the indication has been received, then it will go steady blue.
3. To cancel a track block, press the "TRACK BLOCK" and the "MASTER CANCEL" pushbuttons at the same time.
4. The blue light will flash until the cancel indication is received. Then it will go dark.

d. Switch Control

1. Switch Manual Operation
2. When in the "AUTO" mode, the white auto light will be lit. Pressing either the normal or the reverse pushbutton will take the switch out of auto (dark "AUTO" light) and light the switch track segments in the track diagram to match the normal or reverse request.
3. Also, the current position of the switch will show with the appropriate indication lamp lit.
4. The switch will move, if not locked, and both the indication lamp and track segment will flash until the switch has completed its move.
5. Pressing the "AUTO" pushbutton will restore the switch to the auto routing and light the white lamp.
6. Switch block operates in a similar fashion as the track block.
7. Pressing the switch block will block the switch at any time. The blue lamp will flash until the indication is received. Then it will be steady blue.
8. To unblock a switch, press the "MASTER CANCEL" and the "SWITCH BLOCK" pushbuttons at the same time.
9. The switch block lamp will flash until the cancel indication is received. Then it will go dark.

e. Lamp Test

1. When a lamp test pushbutton is depressed, lamps will automatically cycle check each LED color group by illuminate each like color for 5 seconds until all colors are verified and then automatically extinguish.
2. When lamp test pushbutton is depressed during lamp testing cycle, lamp testing will stop.

10.8 Event Recorder

10.8.1 Each CIL, Slave CIL, and Master Location houses shall be provided with a microprocessor-based event recorder that shall contain solid-state memory for data storage at the field locations. It shall be a multi-channel, multi-speed system which contains self-test capability and delay time by-pass. It shall accept inputs from both the vital and non-vital processor systems.

10.8.2 All aspects of the Event Recorder system to be provided shall be submitted for review and approval by the Engineer.

10.8.3 The event recorder shall allow printing and viewing of data in the English language with a time stamp to include 0.10 second increments. Data shall be retrievable, viewable and printable in real-time or in time selectable blocks down to 0.10 second increments.

10.8.4 The retrieval software shall be Windows-based graphic front-end and menu-driven; shall permit downloading and remaining on-line while continuing to monitor events.

10.8.5 To insure identical times between data recorded on separate systems clocks, the Contractor shall propose a method by which these clocks shall be synchronized.

10.8.6 The unit memory shall be cyclical. When memory storage capacity is reached, the oldest data shall be erased and replaced with the data containing the newer information. The unit to be furnished and installed shall store all of the data needed for seven days with 600 train movements per day per track before recycling. If more than one unit is provided at a location, the clocks of all of the units shall be synchronized. The event recorder shall be provided with a time of year clock. The event recorder shall have the ability to set and recall time both locally and remotely.

10.8.7 Event Recorder nonvolatile memory battery shall be monitored and alarmed prior to failure to prevent loss of recorded data.

10.8.8 It shall be possible for Metro-North to reprogram the description associated with each data point. The Contractor shall provide all software and equipment required to accomplish all software modifications.

10.8.9 The event recorder shall have the ability to remotely "dump" all memory contents or selected blocks of data via new fiber optic network from the field locations to the Operations Control Center or any other location identified by Metro-North.

10.8.10 The Contractor shall supply all equipment and software required to connect event recorders to the diagnostic networks for remote monitoring of wayside data from the Operations Control Center.

10.8.11 Each event recorder shall be capable of monitoring a minimum of 32 different inputs corresponding to "On", "Off", or "Flashing" status. The following information, as a minimum, shall be used as inputs to the event recorder.

a. Home Relays (1 for each unit of each signal)
b. Switch (Position Normal or Reverse)
c. Each track circuit within the Interlockings
d. Each Block Indication
e. Fleeting Status
f. Vital Processor System Errors or failures
g. Track Switch Heater Control Status
h. Power Off Status
i. Switch Blocking Status
j. Each Signal Request
k. Each Switch Lock Circuit
l. Low Battery Indication
m. Each Switch Request
n. Track Blocking Status
o. Intrusion Alarm
p. Fire Alarm Indications
q. Local Control Panel Operation Status
r. Traffic Indications
s. Critical communication system Status

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11.0 SYSTEM DIAGNOSTICS

11.1 Remote Diagnostic System

11.1.1 Contractor shall provide a Remote Diagnostic System as part of this contract. Access to all vital and non-vital microprocessor systems is required. All aspects of the system to be provided shall be submitted for review and approval by the Engineer.

11.1.2 Contractor shall provide three (3) workstations to access the Remote Diagnostic System. These workstations will be located at three discrete locations within the Metro-North operating territory.

11.1.3 System provided shall permit Metro-North Maintenance and Technical personnel to remotely access all diagnostic aspects of the field systems normally available locally through a laptop or vendor specific interface. Whatever can be accessed, monitored, viewed, alarmed, controlled or changed locally shall be likewise available remotely through the Remote Diagnostic System.

11.1.4 Remote Diagnostic System shall be configured to be accessed through the Diagnostic Local Area Network and CTC & Diagnostic Wide Area Network provided as part of the Contractor's responsibility.

11.1.5 Remote Diagnostic System shall provide security levels to restrict unauthorized user access to the system and to permit various level of authorization for different functions provided.

11.1.6 Remote Diagnostic System shall provide access to all alarm conditions and failures as specified in these Technical Specifications and Contract Drawings. Additionally, the system shall be designed to permit monitoring of any aspect or variable within the system executive or site specific application. An alarm monitoring subsystem shall be provided to display all alarms from the field systems.

11.1.7 When alarm conditions are received, further diagnostic functions shall be provided to analysis the exact problem.

11.1.8 This system shall allow access to the vital and non-vital processor health, control and indication status and to invoke diagnostic and maintenance functions, including remote trouble shooting to the circuit board level.

11.1.9 Remote monitoring and diagnostic system shall consist of three workstations located within the Metro-North territory. Remote Diagnostic Workstations shall communicate with each control point via an Ethernet switch connected to the communications network. All alarm indications shall be

transmitted via the CTC system.

11.2 Remote Diagnostics Workstation

11.2.1 Remote Diagnostic Workstation shall consist of a Data Transmission System (DTS) interface, CPU, monitor, mouse pointer device, and keyboard. The workstation shall be pre-loaded with the remote monitoring and diagnostic software provided by the manufacturer of the specific vital interlocking processor, Ethernet switch and event recorder etc. being accessed.

11.2.2 The diagnostic workstation computer shall be an Intel Quad Core Xeon 3 GHz CPU or better and shall include as a minimum 4 GB of RAM (expandable to a minimum of 8 GB), a minimum 160 GB, 7,200 RPM internal hard drive, 48X speed CDROM/DVD drive, DB-9 serial port, internal Ethernet Card, a minimum of four USB 2 ports, USB optical mouse with scroll wheel, USB keyboard, all interface cables and a minimum 19" widescreen TFT flat screen monitor with VGA and DVI connectors.

11.2.3 The diagnostic workstation computers shall include pre-installed OEM's latest diagnostic and maintenance software. This software package shall be "Maintenance Management System" developed by Alstom Signaling, "Maintenance Tools" developed by AnsaldoSTS or approved equal.

11.2.4 Remote Diagnostics Workstation shall generate reports that allow printing and viewing of data in the English language with a time stamp to include 0.10 second increments. Data shall be retrievable, viewable and printable in real-time or in time selectable blocks down to 0.10 second increments.

11.2.5 Remote diagnostic Workstation shall contain graphical front end software and menu driven software routines to exercise the various subsystems in the field location to include, but not limited to, event recorders, Ethernet switches, network health and microprocessors.

11.2.6 Remote Diagnostics Workstation shall allow manual and automatic retrieval of all information stored within the standalone event recorders as well as the event recorders internal to the vital and non-vital processors at interlockings, master locations and interface houses. This information shall be stored within the internal hard drive in databases for trend analyses, data sorting, reporting, etc.

11.2.7 The health of fiber optic links shall include the links between each interlocking and master locations as well as between adjacent master locations. The health status of the Ethernet switches shall be achieved by utilizing a form 'C' contact on the switch.

11.2.8 Remote Diagnostics Workstation shall view remotely in real time these wayside signal system user interaction functions over the network.

a. Multiple microprocessor locations
b. Local Controls
c. Local Indications
d. View NV/Vital Logic
e. Full software and Hardware configuration data
f. Graphical Diagnostics software to point failures and corrective actions.

11.2.9 Remote Diagnostics Workstation shall include TracePlus/Ethernet network analysis software from Systems Software Technology, Inc., or an approved equal. The network analysis software will be used to test and/or troubleshoot the system remotely and will perform, as a minimum, the following functions:

a. Packet capture and analysis
b. Statistical traffic analysis by node, protocol, IP address, or MAC address
c. Graphical "dashboard" display of network performance that can be docked on the workstation desktop

11.2.10 The diagnostic system shall monitor the status of the interlocking, master and interface location indications and the health status of Ethernet switches and fiber optic links between each adjacent locations including, but not limited to the following:

a. Vital and Non-Vital Processors Errors
b. Fiber Optic Link Health
c. Ethernet Switch Failures
d. Fire Alarm Intrusion
e. Power Off
f. Snow Melter Status
g. Route Check
h. Signal Control
i. Absolute Block Control
j. Signal Lighting
k. Signal Indication
l. Track Occupancy - Block Status
m. Time Locking
n. Route Locking
o. Traffic Locking
p. Detector Locking
q. Indication Locking
r. Switch Locking

s. Switch Control
t. Switch Indication
u. Switch Correspondence
v. Switch Blocking
w. Track Blocking
x. Loss of Shunt Protection
y. Clear Block Signal Status

12.0 LOCAL CONTROL AND INDICATION PANELS

12.1 General

12.1.1 Local control and indication panels described in this Section are shown on the Contract Drawings.

12.1.2 A sample of a typical local control and indication panel showing all layouts and dimensions shall be delivered to the Engineer for approval prior to fabrication of the panels.

12.1.3 The sample typical local control and indication panel shall include at least one of each type of device including indicating lights, pushbuttons, switches, and mounting hardware. Samples shall include examples of colored engravings or etchings of tracks, and of each size lettering; including indicating lamps. All colors shall be submitted to the Engineer for approval. All layouts and dimensions shall be submitted to the Engineer for approval.

12.1.4 Prior to manufacture, drawings of each local control and indication panels shall be submitted to the Engineer for approval.

12.1.5 Local control and indication panel frames shall be equipped with a terminal lug for the purposes of grounding.

12.1.6 All local control and indication panel hardware and components shall be submitted to the Engineer for approval.

12.2 Local Control Panels

12.2.1 Contractor shall furnish mosaic tile type Local Control Panel (LCP) mounted in a sheet metal enclosure within the CILs to provide for field based entrance/exit routing.

12.2.2 Local Control Panel shall incorporate control buttons and levers for all controlled signal system functions and associated indications, provide simplified line-of-light type route display with indication for each discrete track circuit, and provide for the required panel operation and alarm functionality as defined in these Technical Specifications and the Contract Drawings.

12.2.3 Enclosure shall be constructed of 16 gauge painted steel. Frame shall be reinforced to provide rigidity required to maintain alignment. Accurately machined surfaces shall be provided to assure proper positioning. Steel shall be accurately rolled and have a smooth finish. Joints shall be formed to a tight fit with abutting edges flush and securely welded. Joints shall be welded their full length and dressed flush on exposed surfaces. Spot welding shall be used when

practicable in preference to screws or rivet fasteners. Holes for screws or bolts shall be drilled and countersunk. All bolts, nuts, washers and screws shall be chromate zinc plated. The finished work shall be strong and rigid and neat in appearance. Surfaces shall be smooth and free from warp and buckles.

12.2.4 Mosaic tile panel shall be attached to the enclosure by a piano hinge, to be located on one of the front side edges of the panel, which shall provide free and ready access to all parts of the interior. The grid structure to which the tiles attach shall be of sufficient rigidity to insure that that with the panel in the open position the grid remains square, with no bending or twisting, such that the mosaic tiles remain flush and fully seated. Hinge shall be placed on the side away from the house door, in order that the opened front panel does not block the house entrance. A stop mechanism shall be provided to restrain the panel in a maximum open position, which shall prevent strain on the wire harnesses and keep the open panel front clear of other obstructions in close proximity. Panel shall be located so that the panel front can swing to this full open position in an unobstructed manner. Cabinet panel shall be of such a size and weight as to permit opening and closing by a single person.

12.2.5 Local Control Panel shall consist of SACO Controls Inc. part number ST-2424GR, or approved equal, 24 x 24 mm mosaic tiles, which shall be supported by a light-weight, non-corrosive, and non-conductive thermoplastic grid. Tiles shall have grey colored background, with black colored lettering and track model lines. Tile locks shall be provided for all tiles where a device such as a pushbutton, switch or LED is mounted. Track diagram, signal and switch symbols, lettering, and identification numbering shall be configured on this panel generally as shown on the Contract Drawings. EAST shall be arranged on the right side of the panel, matching the actual railroad direction as the panel is mounted in the CIL Panel shall be equipped with pushbuttons and indicators described herein. Pushbuttons shall be wired directly to a non-vital microprocessor input circuit. Local control panel indicators shall be lit directly from a non-vital microprocessor output circuit. The entrance/exit local control function shall be implemented wholly within the non-vital microprocessor, a relay interface shall not be provided. If the non-vital processor should fail, the LCP shall become unit-lever via the vital-processor.

12.2.6 The panel, as described above, shall be mounted on the enclosure with a continuous hinge on one of the front side edges. The panel shall be wired with sufficient slack, and configured in a manner, to allow the panel to open to the maximum open (restrained) position with no damage to the wire bundles.

12.2.7 The panel shall be locked in place with a locking mechanism and key as provided by Chicago Lock Company, Keyway Lock No. 2382, and shall be keyed alike with the keys required for the vital and non-vital microprocessor equipment, subject to approval by the Engineer. Twenty-five (25) keys shall be

provided for the panel locking mechanisms.

12.3 Local Indication Panels

12.3.1 The Local Indication Panels described in this Section shall be supplied at all Master Location Houses.

12.3.2 The Local Indication Panels faceplate shall be 3/32 inch (minimum) smooth aluminum, photo engraved to depict the master location track circuit and traffic arrangement. The track circuits, traffic direction, and failure alarms shall be configured as shown on the Contract Drawings.

12.3.3 Local Indication panel indicators shall be lit directly from non-vital output cards.

12.3.4 The Local Indication Panel enclosure shall completely enclose the Local Indication Panel and be constructed of 16-gauge black painted steel. The frame shall be reinforced to provide rigidity required to maintain alignment. Accurately machined surfaces shall be provided to assure proper positioning. Steel shall be accurately rolled and have a smooth finish. Joints shall be formed to a tight fit with abutting edges flush and securely welded. Joints shall be welded their full length and dressed flush on exposed surfaces. Spot welding shall be used when practicable in preference to screws or rivet fasteners. Holes for screws or bolts shall be drilled and countersunk. All bolts, nuts, washers and screws shall be chromate zinc plated. The finished work shall be strong and rigid and neat in appearance. Surfaces shall be smooth and free from warp and buckles.

12.3.5 The photo engraved panel shall be attached to the enclosure by a piano hinge on the front side edge of the panel, and which shall provide free and ready access to all parts of the interior.

12.3.6 The panel shall be of sufficient rigidity to insure that with the panel in the open position the panel remains square, with no bending or twisting, and any pushbuttons that are mounted on the panel face remain flush and fully seated.

12.3.7 The panel in the open position shall not block the house entrance. A stop mechanism shall be provided to restrain the panel in a maximum open position, which shall prevent strain on the wire harnesses and keep the open panel front clear of other obstructions in close proximity.

12.3.8 The panel shall be located so that the panel front can swing to the full open position in an unobstructed manner. The cabinet panel shall be of such a size and weight as to permit opening and closing by a single person.

12.4 Pushbuttons

12.4.1 All backlit pushbuttons shall be Dialco part number 922-1524-525 or approved equal, lighted with an LED, with color as shown on the Contract Drawings. The Contractor shall submit this pushbutton to the Engineer for approval.

12.4.2 Route pushbuttons shall be Entec part number 5MNR59E1BS1 or approved equal and shall be located in the center of the track line at points corresponding to signal locations and are used for both "entrance" and "exits."

12.4.3 Pushbuttons and levers shall be provided as follows:

a. Route pushbuttons shall be used for both entrance and exists. The entrance button will be pushed to clear a signal, pulled to cancel a signal, or turned up to fleet a signal. The route button shall be utilized for both entrance and exit selection. The entrance signal shall flash green when an entrance is requested. The available exit pushbuttons are indicated by flashing the adjacent interlocking track section green LED indicator. When the exit pushbutton is pressed the exit selected shall remain flashing until the route is established, and then it shall be steady lit. The entrance signal shall light steady green when the signal is established.
b. The Absolute Block Pushbutton (Backlit) shall be pushed to initiate an absolute block request by momentarily depressing and releasing the button, and is momentarily pushed simultaneously with the "MASTER CANCEL" pushbutton to cancel an absolute block request.
c. Auxiliary switch control pushbuttons (Backlit), located below the track line, shall be used to manually control switches. The switch number shall be centered above the corresponding buttons labeled "NORMAL" "REVERSE" and "AUTO". The button for the desired switch position will be pushed to initiate a reverse switch call, a normal call, or a call for automatic "AUTO" operation. A separate switch block button shall be used to initiate switch blocking. The button is momentarily depressed and then released to initiate a switch block request, and is momentarily pushed simultaneously with the "MASTER CANCEL" pushbutton to cancel switch blocking.
d. Track block pushbuttons (Backlit), located in the track diagram, shall be used to prevent the movement of a train into the selected block under signal operation. The pushbutton shall be momentarily depressed and then released to initiate a track block and pushed simultaneously with the "MASTER CANCEL" pushbutton to initiate an unblock request. The limits of the track block are from the exiting signal at this location to the entrance signal of the next interlocking.

e. "MASTER CANCEL" Pushbutton, momentary operation of this pushbutton, as described above, shall cancel a request. This button is not illuminated, however shall be similar mechanically to the backlit pushbuttons.
f. "LAMP TEST" Pushbutton, this momentary pushbutton, when operated, shall allow all like colored local control panel LEDS to light for 5 seconds until all color groups are cycle tested and then automatically extinguish, whether the panel is in local operation mode or not. This button is not illuminated, but shall be similar mechanically to the backlit pushbuttons.
g. When "LAMP TEST" Pushbutton is depressed during lamp testing cycle, lamp testing will stop.

12.4.4 In order to facilitate quick replacement of pushbuttons, all contacts on each pushbutton assembly shall be connected to the plug portion of a locked, quick detachable keyed connector in order that all like units shall be interchangeable. Only the required wires shall be provided in the wiring tree and connected to the other side of the connector. The plug portion of the connector shall be an integral part of the pushbutton or lever assembly.

12.4.5 Each pushbutton assembly shall be protected by an approved dust cover. The material used in the fabrication of the dust covers shall be such that it will not support combustion.

12.4.6 Pushbuttons shall be of the unit type. The term "unit type" shall be understood to mean that each of the units may be completely and easily removed from the control panel without interfering with the operation of any other unit.

12.4.7 All pushbuttons shall be designed with circuitry to include "stuck stick protection" function so that a call is not continuously placed on a switch, signal or other function in the event of a stuck local control panel button or a malfunctioning input point. Under a "stuck button" condition the call shall time out in 3 seconds and automatically cancel request. Circuitry shall be submitted to the engineer for approval.

12.4.8 The local/remote control switch shall be located within a lock box on the side of the panel enclosure. The lock box shall be provided with a flip-down cover and hasp as well as padlock. Location shall be submitted to the Engineer for approval. Metro-North shall provide lock type during construction.

12.4.9 Toggle Switches, this two-position switch shall allow the changing of control modes at each interlocking. The switch shall be provided with the following two positions:

a. REMOTE - The position which permits the control of the respective interlocking from the Operations Control Center.
b. LOCAL - This position permits operation of the interlocking from the Local Control Panel.

12.5 Indicators

12.5.1 All illuminated indications on local control and indication panels shall be provided by means of individual light emitting diodes (LEDs) and/or the backlit pushbuttons. The LEDs shall normally be dark, except as otherwise provided in these Technical Specifications, and color shall be as shown on the Contract Drawings. Access to all lighting shall be from the front of the panel.

12.5.2 LCP Indicators

a. The line of light track indicators shall be both red and green. The entrance signal shall flash green when an entrance is requested. The available exit pushbuttons shall be indicated by flashing of the adjacent interlocking track section green LED indicator. When the exit pushbutton is pressed the exit selected shall remain flashing until the route is established, and then it shall be steady lit, a part of the established line of light route. When the signal has cleared over the route, the entrance signal LED shall light steady green and the corresponding track segments defining the route shall light steady green, forming the line of light route, based on indicated switch position. Track occupancy shall be displayed by illumination of the red LEDs for tile segments that correspond to the discrete track circuit indications, utilizing only those segments that depict the specific line of light route (as determined by the switch position indications).
b. The normal or reverse switch segments, or the center (reverse) or top and bottom (normal) crossover switch segments shall flash red during switch movement to the new requested position, in conjunction with the equivalent backlit control pushbutton LED indicator. These same indicators shall flash at any time the switch is out of correspondence. The current position of the switch shall be continuously indicated with the appropriate backlit control pushbutton LED lit, whenever the switch is in manual control.

12.5.3 Indication only toggle switch shall be provided on all local control and indication panel. This single pole toggle switch closed shall allow the lighting of the panels

12.5.4 Local Control Panel Alarm Indicators

a. There shall be red flashing LEDs, for indicating each of the following conditions:

    1. 100 Hz Power Off (Both North and South)
    2. 60 Hz Power Off (Both Normal and Auxiliary)
    3. DC Power Off
    4. AC and DC GROUND
    5. Fire Alarm
    6. Code Line A Failed
    7. Code Line B Failed
    8. Ethernet Switch Failed
    9. Surge Protection Failure
    10. Maintainer Call
    11. Intrusion Alarm
    12. All West and East Intermediate Territory AC Power Off, DC Power Off, Ground, Smoke, and Intrusion

b. Alarm indications shall be extinguished when alarm conditions are corrected.

12.5.5 Local Indication Panel Alarm Indicators

a. There shall be red flashing LEDs, for indicating each of the following conditions:

    1. 100 Hz Power Off (Both North and South)
    2. DC Power Off
    3. North Signal Line Failed
    4. South Signal Line Failed
    5. North Ethernet Switch Failed
    6. South Ethernet Switch Failed
    7. Diagnostic Ethernet Switch Failed
    8. Intrusion Alarm

b. Alarm indications shall be extinguished when alarm conditions are corrected.

12.5.6 The local control and indication panels shall be wired with single conductor, not smaller than No. 20 AWG, 19 strand wire, insulated for 600 volt service. The wiring harness shall allow clear access to all lights and pushbuttons.

12.5.7 The local control and indication panels shall be directly hard wired from the control panel to the non-vital microprocessor rack. Plug connector receptacles to receive the cable plugs interconnecting the local control and indication panels to the non-vital microprocessor rack will not be permitted.

13.0 SWITCH AND LOCK MOVEMENTS

13.1 General

13.1.1 The switch control circuits described in this section are shown in these Technical Specifications and Contract Drawings

13.1.2 Switch machines shall be US&S M-3 high voltage, with permanent magnet motors, utilizing a 3 wire motor control circuit with a gear ratio of 190. Switch machines (if required) will be procured by Metro-North.

13.1.3 The switch control logic in the vital microprocessor shall also include a timing function to remove power from the electric switch machine motor control circuit when the switch points or rods are obstructed. The use of overload relays shall not be permitted. In addition, a switch restoring feature shall be provided, such that with the switch in the unlocked state it shall operate to the position being requested upon the resetting of motor crank contacts or with movement creep. The Contractor shall submit the switch control/indication logic, time calculation and details of the proposed means to realize the restoring feature, to the Engineer for approval.

13.1.4 Switch control shall be implemented from the vital processors in the CIL, utilizing US&S's SML-110 Switch Lock and PN-150SSR Solid State Relay or approved equal, as depicted on the Contract Drawings. The switch position indications shall be provided utilizing external vital switch repeater ("NWPR" and "RWPR") relays, to provide isolation between the external line circuits and the separate (zoned) vital processors, as depicted on the Contract Drawings.

13.1.5 The Contractor shall be required to provide all instrumentation necessary to control the switch machines within the pre-wired CILs, up to and including the entrance terminals on the appropriate main terminal board. All external cable, bonding junction boxes, conduits, clamps, stranded wire, switch machines, rods, lugs, plates, hardware, wooden ties and lubrication shall be procured, installed and tested by Metro-North.

13.1.6 Resistive heater units, to be located in the motor, controller and contact compartments shall be provided for. Heater units shall be 110VAC.

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14.0 SIGNALS

14.1 General

14.1.1 The Contractor shall provide LED wayside signal units for all new signals for each new interlocking system supplied under this contract.

14.1.2 LED signal units shall be furnished under this contract for installation by others. The LED units will be installed by others in new color light Model CLS-10D dwarf signals, as manufactured by Safetran Systems. The LED units shall be provided in colors and quantities shown on the contract drawings for all new Interlockings. A minimum of 20% spare LED units shall be furnished for each color.

14.1.3 LED units shall be self-contained modules with individual LEDs wired in parallel. The units shall be designed to be driven directly from the approved vital microprocessor interlocking controller output boards without additional signal head mounted appurtenances and interface relays.

14.1.4 The Contractor shall provide a LED unit that accommodates the loss of a percentage of the LED devices without generating a microprocessor reset or lamp out condition. The complete shutdown of the LED unit is not acceptable when a percentage of the devices are lost. The Contractor shall provide detailed operational information and a first item inspection of the proposed LED unit for review and approval.

14.1.5 Vital lamp driver output boards shall operate LEDs at voltages between 9 and 16 Volts DC at a current not exceeding 3 Amps, measured at the LED, utilizing standard Metro-North signal lighting cable and maximum length.

14.1.6 The flashing signal aspects shall flash at 60 pulses per minute, with a 50% duty cycle and shall provide a flashing signal display without unnecessary alarming or processor shutdown due to inrush currents exceeding normal LED current thresholds.

14.1.7 The signal LED light-out detection scheme shall be submitted for approval and as a minimum, the LED unit light-out detection shall provide both hot and cold filament checks in accordance with the contract drawing and specification requirements. LED units shall not "strobe" or otherwise emit visible light, due to either cold filament check pulses or the internal output status checks of the vital processor system. Light-out detection shall be indicated to the Operations Control Center as shown on the Contract Drawings. All signals shall be continuously lit and the LED signal lighting circuitry shall be arranged so as to light signals red in the event of a vital microprocessor shutdown or failure as shown on the Contract Drawings.

14.1.8 The LED signal units to be furnished shall be certified to operate from direct connection to the approved vital processor without any requirement for interface equipment or relays and be considered as Class 1 vital hardware for the purposes of the Failure Mode and Effects Analysis (FMEA) of these Technical specifications.

14.1.9 Failure modes relating to shorted or damaged components (allowing current flow without light generation) shall be fully analyzed and tested to establish the necessary current thresholds to insure the capability for light output, and also to identify those component failures for which undesired light could be emitted due to normal system check pulse operation. The FMEA relating to LED compatibility shall identify the specific LED products analyzed and tested by supplier item number, OEM part number and the date/location of manufacture. This information shall be included in the documentation submitted to the Engineer within 45 days of contract Notice of Award.

14.1.10 Signals shall display the aspects indicated below:

Rule 11-B(1)	
Aspect:	Dark over Flashing Green over Dark
Name:	**Proceed Cab**
Indication:	Proceed Governed by Cab Signal Indication

Rule 11-B(2)	
Aspect:	Flashing Red over Alternate Flashing Green over Flashing Red
Name:	**Absolute Block Signal**
Indication:	Trains or Engines without Operative Cab Signals Proceed at **Slow Speed** within Interlocking Limits; **MAS not Exceeding 59 MPH** Outside of Interlocking Limits, Approaching the next Interlocking Signal Prepared to Stop.

Rule 11-B(3)	
Aspect:	Red over Dark over Red
Name:	**Stop**
Indication:	Stop Signal

14.1.11 All signal units, lenses, lens hoods, foundations, junction boxes, hardware, locks, stranded wire and external cable shall be procured by the Contractor, installed by others, and tested by Metro-North. The Contractor shall provide all hardware, terminals, lens and associated parts for the LED signals and all instrumentation within the house or case up to and including the entrance terminals on the main terminal board necessary to control the signals indicated on the Contract Drawings.

14.2 Stamford Yard Route Indicators

14.2.1 Route indicators are in service in Stamford Yard (CP-234), under control of Yardmaster.

14.2.2 The searchlight type signals are capable of displaying the following aspects:

Aspect:	Flashing White
Indication:	Permission to Proceed Over or Through Switches

Aspect:	Flashing Yellow
Indication:	Do Not Proceed; Not Lined or Routed

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15.0 TRACK CIRCUITS

15.1 General

15.1.1 The Contractor shall provide vital track circuits for applications as required by these Technical Specifications and Contract Drawings. The tracks circuit shall include all apparatus necessary to operate as designed and applied for this project.

15.1.2 This section describes requirements for 100 Hz AC Track Circuits for train detection, broken rail detection, cab signal control and cab signal aspect transmission, and for Audio Frequency Overlay (AFO) track circuits to be used for local switch release at electrically locked switch locations. Each type of track circuit and all associated equipment shall be submitted for approval of the Engineer. The submittal shall include a list of all proposed applications and locations.

15.1.3 100 Hz Track circuits described in this section are shown in the Technical Specifications and Contract Drawings.

15.1.4 AFO Track circuits described in this section are shown in these Technical Specifications and Contract Drawings. The use of AFO Track circuits is limited to Electric Lock Release.

15.1.5 Steady Energy 100 Hz AC Track Circuits, as described herein and in the Contract Drawings, shall be used for all interlocking and intermediate territory track circuits. In addition, shunt type AFO track circuits shall only be utilized for short range series type track circuits for electric switch lock release, as described herein and in the Contract Drawings.

15.1.6 All track circuit equipment shall be in accordance with the requirements of the AREMA Signal Manual of Recommended Practices Part 8.1.1, Recommended Functional/Operating Guidelines for Track Circuits and Part 8.6.1, Recommended Instructions for Vital Track Circuits and these Technical Specifications. Where a conflict occurs between the specified AREMA recommendations and these Technical Specifications, the more stringent requirement shall be used.

15.1.7 Track circuit equipment shall be mounted to provide easy access to test points, indicators, and adjustments.

15.1.8 All track circuits shall be double rail, configured as shown on the Contract Drawings.

15.1.9 AC track circuits shall have a shunting sensitivity of not less than 0.25 ohms for a properly adjusted track circuit with a minimum ballast resistance of 3 ohms per 1000 feet.

15.1.10 AC Track circuits shall have proven compatibility with electric traction rail return of 60 Hz AC, in equivalent mainline electrified environments for universal compatibility of the track circuit equipment over the entire Metro-North system.

15.1.11 Track Relays of the tuned AC Vane type shall not be utilized.

15.1.12 Cab Signal Code Rates and Speeds

Track circuit code units shall generate cab signal carrier frequency of 100 Hz ±2 Hz at the following five (5) code rates. The permissible range of these code rates, and the assigned cab signal speed-control settings for both passenger and freight trains are defined in the following table. On/off time for the cab signal code shall be 50/50:

Code	Nominal Code Rate	Range	Cab Signal Speed (PSGR / FRT)
1	0 PPM	0 PPM	15 MPH / 15 MPH
2	75 PPM	72.5 to 75 PPM	30 MPH / 15 MPH
3	120 PPM	120 to 123.5 PPM	45 MPH / 25 MPH
4	270 PPM	270 to 274.5 PPM	60 MPH / 30 MPH
5	180 PPM	180 to 184.5 PPM	MAS / MAS (Maximum Authorized Speed)

15.1.13 The signal system logic shall turn on the cab signal within two (2) cycles of the fastest cab code after occupation of the track circuit by the approaching train, not to exceed 250 msec.

15.1.14 Track code assignments shall be as shown on the Contract Drawings.

15.1.15 Steady Energy 100 Hz AC track circuits shall be in accordance with AREMA Signal Manual of Recommended Practices, Part C, Section 8.1.1 and 8.6.1. Coded 100 Hz AC track circuits shall be in accordance with the AREMA Signal Manual of Recommended Practices, Part C, Section 8.4.1.

15.1.16 AC Track circuits shall consist of conventional track transformers with a minimum rating of 400VA (except where double wound track transformer, Part N451428-0114 or approved equal, is required for the TRU-III track circuit application), heavy duty wire wound resistors, reactors, and other current limiting

devices, and termination hardware in accordance with the following:

a. Track reactors shall be in accordance with AREMA (AAR) Signal Manual of Recommended Practices, Part 14.2.20.
b. Track resistors shall be in accordance with the AREMA (AAR) Signal Manual, Part 14.2.15.
c. Terminals and binding posts shall be in accordance with these Technical Specifications and Contract Drawings.

15.1.17 Audio Frequency overlay track circuits shall be in accordance with the requirements of AREMA Signal Manual of Recommended Practices Part 3.1.23, Recommended Design Criteria and Functional Guidelines for Audio Frequency Track Circuits.

15.2 Steady Energy AC Track Circuits

15.2.1 Steady Energy AC track circuits shall be furnished for train detection, cab signal control and cab signal aspect transmission for all new interlocking and intermediate territory track circuits as described in Section 3 of these Technical Specifications and Contract Drawings (see Typical Interlocking and Master location Track Circuits drawings). Steady energy AC track circuit equipment shall be in accordance with AREMA Signal Manual, Sections 6 and 8, Relays and Track Circuits, respectively; the Contract Drawings; and as specified herein.

15.2.2 The steady energy AC track circuit unit shall drive a vital DC relay, in accordance with manufacturer's requirements, for interface to the vital processor interlocking equipment. All vital relays shall be plug-in type.

15.2.3 Steady Energy AC Track Circuits shall be 100 Hz, dual element, AnsaldoSTS type TRU-III or Engineer approved equal. The TRU-III Resonant Unit shall be part number N14000202, with Code Reset Unit, part number N34801901. The Code Reset Unit shall be the latest product line, demonstrated to reset on 270 code, as approved by the engineer. Track Relay shall be type PN-150B, part number N322500-701. Steady Energy AC track circuit components shall have a demonstrated service history of 5 or more years as applied in cab-signaled applications on equivalent mainline AC electrified commuter or intercity passenger rail environments in North America.

15.2.4 Steady energy AC track circuits shall be so designed such that the track relay shall be in the de-energized position whenever any of the following conditions exist:

a. When a shunt of 0.25 ohm resistance is connected across the running rails in any part of the track circuit, including the fouling sections of crossovers and turnouts.

b. Rail is broken, including rail within the fouling section of the turnout, or rail or switch frog removed, except when rail is broken or removed between the end of rail and track circuit connector or within the limits of rail joint bond, appliance or other protective device. Contractor shall validate that cross bonding depicted in the contract drawings will provide broken rail protection. If Contractor's design requires any changes to cross-bonding as shown, an alternative design shall be provided that complies with all Metro-North's cross-bonding criteria.
c. Fouling wires and/or code jumpers within the interlocking limits (to be installed by others) will consist of at least two conductors with separate rail connections for each conductor, so that if one of these conductors becomes disconnected or opened, the track relay will still be de-energized when the fouling section is shunted.

15.2.5 A five (5) second time delay pickup function, realized utilizing the vital microprocessor logic, shall be provided for loss of shunt protection on all interlocking track circuits. External timer relays shall not be used to provide this loss of shunt protection.

15.3 Electric Lock Switch Series AFO Track Circuits.

15.3.1 AnsaldoSTS ATT-20 Series type audio frequency overlay (AFO) shall be provided at electric switch lock locations in accordance with the Contract Drawings and as defined elsewhere in these Technical Specifications, to provide for local release of electrically locked hand throw switches.

15.3.2 The series type AFO track circuit shall consist of a single transceiver unit designed to apply a discrete audio frequency signal to one of the rails with a receiver connected to the opposite rail. The track transceiver shall provide a relay drive output to operate a vital signal relay when this discrete signal is received when the track in the immediate vicinity of the track connections is being occupied, adjustable to a maximum of 300 feet.

15.3.3 The series AFO transceiver unit shall drive a vital DC relay, in accordance with manufacturer's requirements, for interface to the vital processor interlocking equipment. All vital relays shall be plug-in type.

15.3.4 The series type AFO track circuit shall be protected against lightning and other voltage surges in rail and power supply leads when installed in conjunction with external surge protection in accordance with AREMA Manual Part 11.2.1 (Recommended General Practices for Electrical Surge Protection for Signal Systems).

15.3.5 The series type AFO track circuit shall meet surge withstand requirements in accordance with AREMA Manual Part 11.3.3 (Recommended

Design Criteria for Surge Withstand Capability of Electronic Signal Equipment for Signal Systems).

15.3.6 The transceiver shall be housed in metal enclosures suitable for shelf or backboard mounting or in metal enclosures suitable for mounting in a nineteen (19) inch Electrical Industries Association (EIA) rack.

15.3.7 All connections to external signal apparatus and DC power shall be made on AREMA terminal posts.

15.3.8 The series type AFO track circuit shall be designed to operate up to 300 feet at a specified frequency, at a minimum of 2 ohms per 1,000 ft. distributed ballast resistance. The transmitter level and/or receiver threshold shall be adjustable by field personnel to adapt to all track circuit conditions.

15.3.9 The transmitter section shall provide a single frequency audio track circuit signal at a stable amplitude.

15.3.10 The series type AFO track circuit shall be designed for operation from a nominal 13.6 volts dc and shall operate properly with power supply of 10.0 to 16.0 volts dc and a maximum ripple of 0.2 volts rms.

15.3.11 The relay drive output shall be isolated and provide a minimum of 7.5 volts dc into a load of 250 ohms, or 10 volts DC into a load of 500 to 1000 ohms.

15.3.12 The signal applied to the running rail shall be sinusoidal AC with no greater than 5% harmonic content. Bandwidth of modulated transmitter signal shall be no greater than ± 2% of fundamental frequency.

15.3.13 The series type AFO track circuit shall energize the receiver output relay with a track shunt of 0.06 ohms or less between the transmitter and receiver track connections.

15.3.14 The series type AFO track circuit shall be designed to operate in both the DC and 60Hz AC electrified environments. The AFO track circuit shall not energize the receiver output relay with any level of traction DC or AC energy applied to the receiver input.

15.4 Miscellaneous Track Circuit Hardware

15.4.1 Track transformers shall meet the requirements of AREMA Signal Manual of Recommended Practices, Part 14.2.10.

15.4.2 Track reactors shall be in accordance with the AREMA Signal Manual of Recommended Practices, Part 14.2.20.

15.4.3 Track resistors shall be in accordance with the AREMA Signal Manual of Recommended Practices, Part 14.2.15.

15.4.4 Terminals and binding posts shall be in accordance with these Technical Specifications and Contract Drawings.

15.4.5 AFO equipment track surge protection shall be Safetran heavy duty model SP-30 or approved equal.

16.0 POWER SUPPLIES

16.1 AC Power Service

16.1.1 The Contractor shall provide all necessary AC and DC power equipment, termination and distribution systems and related apparatus within the pre-wired CIL's, Slave CILs, houses cases and cabinets provided under this contract.

16.1.2 The 60 Hz and 100 Hz power feeds to the enclosures will be installed by others, as depicted in the Contract Drawings and as specified herein.

16.1.3 The Interlocking house(s) shall each be provided with separate redundant 110/220V 100 Hz Signal Power feeds and separate redundant 120/240V 60 Hz Hotel Power feed.

16.1.4 The Master Location houses shall each be provided with separate redundant 110V 100 Hz Signal Power feeds.

16.1.5 Power Transfer apparatus between main and alternate 100 Hz sources shall be provided for all CILs, Slave CILs, and Master Location houses as described below and as depicted in the typical arrangements contained in the Contract Drawings.

16.1.6 100 Hz power transfer apparatus shall be as manufactured by STATICON LTD, Scarborough, Ontario, Canada, model AC25BTS8661WM-4X or approved equal, and shall be capable of maintaining all track circuits energized through a power transfer from normal to standby or from standby to normal. Contact transfer time for normal to standby, and for standby to normal, shall not exceed 160 msec.

16.1.7 The power transfer device shall maintain the normal power contacts when supply voltage exceeds 110 volts and shall close the reverse power contacts when supply voltage is less than 100 volts. The contact rating of the power transfer device shall be noted on the circuit plan. This device shall be located in the CIL, Slave CIL (if required) and Master Location houses and housed to minimize fire hazard.

16.1.8 100 Hz power shall be distributed at 110V from the nearest CIL, Slave CIL (if required) or ML to the other cases and houses including interlocking cases, track case locations and track case master locations as specified herein and shown on the Contract Drawings.

16.1.9 The supplied 110V or 110/220V 100 Hz power may have transient surges as high as 700 volts. Primary AC surge protection for 100BX/100SX and

60BX/60SX power bus with Form C contacts to indicate failure modes to the OCC. Apparatus furnished for the power source, by the Contractor, shall include all necessary protection devices.

16.1.10 Power Transfer apparatus between main and alternate 60 Hz sources shall be provided for all Interlocking house(s) as described below and as depicted in the typical arrangements contained in the Contract Drawings.

16.1.11 60 Hz power transfer apparatus shall be as manufactured by General Electric Zenith ZTG Series, model ZTG000A0U010B or approved equal. There shall be a direct mechanical coupling to facilitate transfer in 6 cycles or less.

16.1.12 For the incoming AC power source, the Contractor shall furnish circuit breakers in accordance with the Contract Drawings. Ungrounded signal power supply shall utilize two pole common trip circuit breakers which shall interrupt both legs of all energy bus feeds and all branch circuits supplied by these buses, as depicted on the Contract Drawings and in compliance with the National Electrical Code.

16.1.13 Commercial Frequency (60 Hz) circuit breakers and Power Transfer apparatus shall be derated utilizing frequency dependent multipliers in accordance with the Manufacturer's specifications, for both the interrupting capacity and tripping performance, to provide for use at 100 Hz. The Manufacturer's derating curves and the derating multipliers utilized shall be included with the power calculations.

16.1.14 The AC power distribution transformers will be furnished by others in the vicinity of each Interlocking CIL, Slave CIL, and Master Location houses.

16.1.15 The Contractor shall furnish a complete set of signal power and hotel power arrangement drawings including the 60 Hz and 100 Hz automatic transfer scheme and equipment to the Engineer for approval. A complete set of approved drawings shall be furnished with the equipment at the time of delivery, and shall include all arrangement drawings, schematic diagrams, installation instructions, maintenance manuals, and other relevant data. Loose hardware shall be identified in a list, shown on the installation drawings, marked and packaged for easy identification in the field.

16.1.16 The Contractor shall submit power-loading calculations for each circuit provided. The calculations shall show that the equipment to be provided by the Contractor is of adequate size for the task to be performed.

16.1.17 The supplied 100 Hz power may have transient surges as high as 700 volts. Apparatus furnished for the power source, by the Contractor, shall include all necessary protection devices. Primary AC surge protection shall be

ERICO, Inc. EPD 120/240 TDF or approved equal.

16.1.18 Power Distribution Panels

a. Panelboards shall be metal-enclosed with dead-front distribution.
b. Single phase signal power and hotel power distribution panels shall be rated for 120 volt, ungrounded three wire, 60 Hz service; however, panels shall be designed for maximum system voltage of 600 volts.
c. Panelboards shall be complete with circuit breakers, copper buses, connections for incoming and outgoing cables, wiring and nameplates.
d. Electrical connections shall be bolted, with lock washers and ring tongue type, solderless connectors.
e. Distribution panel bus structure and main breakers shall have suitable current ratings. Such ratings shall be established by heat rise tests, conducted in accordance with UL standard 67.
f. The panelboard bus assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel to be as specified in UL standard 50 for cabinets. Wiring gutter space shall be in accordance with UL standard 67 for panelboards. The box shall be fabricated from galvanized steel or equivalent rust resistant steel. Each front shall include a door and have a flush, cylinder tumbler-type lock with catch and spring-loaded stainless steel door pull. Fronts shall not be removable with door in the locked position. A circuit directory frame and card with a clear plastic covering shall be provided on the inside of the door.
g. The panels shall be mounted directly to the walls of the instrument houses using fasteners as detailed on the approved installation arrangement drawings. All panels shall be mounted with sides plumb, and tops and bottoms level. Rigid electrical raceways shall be terminated inside the panel wiring troughs using approved conduit bushings. Conduits shall be supported and fixed to the wall within six (6) inches of the panel using approved hardware.

16.1.19 Circuit Breakers:

a. Breakers with inverse-time characteristics shall be secured through use of bimetallic tripping elements supplemented by instantaneous magnetic trip.
b. Breakers shall be UL and CSA listed, IEC 157-1 rated, meet NEMA standard AB1-latest edition and Federal Specification W-C-375B/GEN, when applicable.
c. Breakers shall have over center toggle-type mechanisms, providing quick-make, quick-break action.
d. Breakers shall be calibrated for operation in an ambient temperature of 40 degrees C.

e. Each breaker shall have trip indication by handle position and shall be trip free.
f. Two (2) and three (3) pole breakers shall be common trip.
g. Each breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole.
h. Breakers shall have removable lugs. Lugs shall be UL listed for copper conductors only. Breakers shall be UL listed for installation of mechanical type lugs.
i. Signal power will have double pole breakers and hotel power will have single pole breakers.

16.1.20 Wiring:

a. Equipment shall be completely wired internally.
b. Wiring shall be with no splices.

16.2 Battery Chargers and Power Supplies

16.2.1 The Contractor shall furnish 12 volt (nominal) DC shelf mounted battery chargers in the instrument houses and cases, as required in these Technical Specifications and in accordance with the Contract Drawings. Separate batteries and chargers shall be provided for Signal lighting circuits, designated B12E, grouped by distance from the CIL, which shall be separate from all other house equipment, and designed to provide between 8.5 and 10 volts measured at the signal lamps. Separate batteries and chargers shall also be provided for audio frequency overlay equipment and non-vital equipment designated B12-AFO/NV. Separate batteries and chargers shall also be provided for vital equipment designated B12. Separate batteries and chargers shall also be provided for external line circuits designated LB12. Each type of battery charger and all associated equipment shall be submitted to the Engineer for approval.

16.2.2 All 12 volt battery chargers shall be National Railway Supply Inc., Model ELC-12/20D or ELC-12/40D and ELC-12/60D, as required, or approved equal.

16.2.3 Each battery charger shall be supplied with a National Railway Supply Inc., external DC current monitor, Model 16775-00 or approved equal, which shall have an auxiliary contact to indicate the no charge condition (no DC output) and/or loss of AC power.

16.2.4 The actual operating voltage and current shall be set by the Contractor, for each application. Chargers shall operate at 60 and 100 Hz. The chargers shall be temperature compensated automatic current limiting, constant potential types. Chargers shall be current limiting to prevent damage during

overload conditions. Chargers shall be compatible with ultra-low-maintenance Nickel-Cadmium Alkaline Storage Batteries as per this specification.

16.2.5 The battery chargers and power supplies shall withstand 600 volts, 60 Hz applied for one minute between both input leads connected together and the case; between both output leads connected together and the case; between both output leads connected together, and both input leads connected together.

16.2.6 Input voltage shall be 115 VAC plus or minus 15 percent, 100 Hz, single-phase, two wire.

16.2.7 The capacity of the charger and power supplies shall be determined by the Contractor and furnished with a minimum of 125 percent over the calculated capacity.

16.2.8 Power supplies shall be designed so that the filter capacitors can be replaced without removing the supply from the rack on which it is mounted.

16.2.9 The power supplies shall be designed for continuous operations.

16.2.10 The current rating of each battery charger to be supplied shall be adequate to fully charge a completely discharged set of batteries within ten (10) hours while carrying the full current requirement.

16.2.11 Low voltage and power off alarms and indication shall be provided to the non-vital microprocessor equipment and field event recorder.

16.2.12 All semiconductors shall be silicon type with JEDEC numbers.

16.2.13 All external wiring for the power supplies and battery chargers shall be terminated on AREMA style terminal posts.

16.2.14 Protection Requirements:

a. The power supply shall be so designed that it will not be damaged by an input voltage range between zero and 140 VAC.
b. A separate output filter and high frequency bypass capacitor shall be located on the load side of the isolating diode.
c. Reverse output current protection shall be provided to prevent shorting or sagging of tandem power supplies in the event of filter capacitor failure.
d. The power supply output terminal shall contain a non-conducting device or insulated safety shield to protect personnel from electrical hazards. The device shall protect and be rated not less than 4 times the output voltage of the power supply.

16.2.15 Mechanical Requirements:

a. Power Supplies

1. The power supply shall be a panel-chassis combination with a perforated protective cover. The design shall be such as to provide natural convection cooling. Fans for cooling shall not be permitted.
2. The front mounting shall be designed to mount on a wall, a shelf, or a standard 19-inch rack space with EIA hole spacing.
3. The power supply front panel shall contain one AC input voltmeter, one output ammeter and output voltmeter. Meter accuracy shall be plus or minus 2 percent with nominal voltage readings at center scale.
4. Terminal binding posts for input and output and alarm circuits shall be provided. Each terminal shall be insulated from the frame of the unit.
5. All power supplies shall be clearly and permanently labeled with the manufacturer's name, serial number, part or model number, and the input and output rating, in such a fashion so that it is legible after mounting.

b. Secondary Surge Protectors

1. All Secondary surge protection shall be ERICO Protection Devices for Railway Signaling (EPD), as required, or approved equal.
2. Secondary surge protectors intended for application in vital signal circuits shall be designed with terminal posts spaced on 2-3/8 inch centers. Binding posts, nuts, and washers, if provided, shall conform to AREMA Manual Part 14.1.11, Recommended Design Criteria for Binding Posts, Nuts and Washers.
3. Secondary signal surge protector shall have a dielectric breakdown voltage from any circuit component to metal housing or mounting surface in accordance with AREMA Manual Part 14.2.50, Recommendations for Dielectric Requirements for Signal Equipment.
4. Secondary signal surge protector assembly, covers, and accessories shall not ignite or melt, nor cause ignition of adjacent surfaces, when surge protector is used within rated operating and surge conditions.
5. Exposed metal parts of secondary signal surge protectors shall be suitably protected against corrosion to maintain design electrical and leakage parameters.
6. Secondary signal surge protector shall meet all above requirements over a temperature range of -40°C to +70°C, and relative humidity of 0 to 95 percent, non-condensing within a signal housing.

7. Equalizers shall be heavy duty. Equalizers shall be the manufacturer's standard for the application.

c. Primary Surge Protectors

1. All Primary surge protection shall be ERICO Protection Devices for Railway Signaling (EPD), as required, or approved equal.
2. Primary surge protectors intended for application in vital signal circuits shall be designed with terminal posts spaced on 2-3/8 inch centers. Binding posts, nuts, and washers, if provided, shall conform to AREMA Manual Part 14.1.11, Recommended Design Criteria for Binding Posts, Nuts and Washers.
3. Primary AC surge protector shall have a dielectric breakdown voltage from any circuit component to metal housing or mounting surface in accordance with AREMA Manual Part 14.2.50, Recommendations for Dielectric Requirements for Signal Equipment.
4. Primary signal surge protector assembly covers, and accessories shall not ignite or melt, nor cause ignition of adjacent surfaces, when surge protector is used within rated operating and surge conditions.
5. Exposed metal parts of Primary AC surge protectors shall be suitably protected against corrosion to maintain design electrical and leakage parameters.
6. Primary AC surge protector shall meet all above requirements over a temperature range of -40°C to +70°C, and relative humidity of 0 to 95 percent, non-condensing within a signal housing.
7. Equalizers shall be heavy duty. Equalizers shall be the manufacturer's standard for the application.

16.3 Storage Batteries

16.3.1 The Contractor shall furnish ultra-low-maintenance Nickel-Cadmium Alkaline Storage Batteries and accessories for 12 volt DC supply, as necessary. All batteries proposed for this application shall have a satisfactory record of continuous service in similar operating railroad environments for a minimum of 8 (eight) years, reliably providing the originally specified standby capacity under actual and/or test circumstances throughout this period. The batteries proposed shall have a design service life in excess of 20 years at 20°C in stand-by float application, and 15 years (minimum) operating in the anticipated actual temperature environment. Batteries, racks, accessories and covers shall be submitted to the Engineer for approval.

16.3.2 The Batteries shall consist of open (vented) ultra-low-maintenance nickel-cadmium cells, and shall be certified as fully compliant with the

requirements of IEC 623, 1990 edition including amendments 1 & 2. The positive and negative electrodes of the cells shall be of the pocket-plate type. The active materials shall be retained in pockets formed from double-perforated nickel-plated steel strips. The required Storage Battery shall be made of single cells, connected in series. Battery wires shall be terminated directly on the Battery buses.

16.3.3 The Batteries shall operate in ambient temperatures from -40ºC (-40ºF) to +70ºC (+160ºF), and shall withstand prolonged float operations at 1.42 V/cell at 20°C without any loss of capacity.

16.3.4 Batteries shall be sized to provide a minimum of eight hours of standby power at the computed normal loads. The battery capacity shall be calculated at the 8-hour discharge rate to 1.10 volts per cell at a temperature of +25°C (+77°F) when tested in accordance with IEEE Standard 1106-1987, Recommended Practice for Maintenance, Testing, and Replacement of Nickel-Cadmium Storage Batteries for Generating Stations and Sub-Stations.

16.3.5 Each ultra-low-maintenance Nickel-Cadmium cell shall include the following parts:

a. One (1) positive plate group assembled with connecting strap and terminal post or posts.
b. One (1) negative plate group assembled with connecting strap and terminal post or posts.
c. A cell separator shall separate the plates from each other.
d. A container and cover shall be made of translucent polypropylene plastic.
e. One (1) connecting bolt and nut for each terminal post.
f. One (1) inter-cell connector for each pair of terminal posts.
g. One (1) set of hard PVC plastic connector insulators.
h. Necessary potassium hydroxide/lithium hydroxide electrolyte.

16.3.6 Plates (Electrodes)

a. Positive plates shall be of double-perforated nickel-plated sheet steel pockets with nickel hydrate active material. The plates shall be welded securely to a connecting plate. The pockets shall be mounted in a suitable steel frame.
b. Negative plates shall be of double-perforated nickel-plated sheet steel pockets with cadmium active material. The plates shall be welded securely to a connecting plate. The pockets shall be mounted in a suitable steel frame.
c. The positive and negative plates shall be connected in correct numbers for each size and type of battery. Each group shall be

securely fastened to their terminal posts.

d. These positive and negative plate groups, together with the separators, shall constitute the elements.

16.3.7 Terminals

a. The terminal posts shall be nickel plated and shall be of a sufficient size to withstand the maximum discharge current without overheating. The terminals of each cell shall be clearly marked by color coded washers to indicate polarity. Red washers shall be utilized for the positive pole and blue washers shall be utilized for the negative pole.
b. The terminal post shall extend through the cell container cover. They shall be so arranged that they will not turn in the cell. The assembly of the cell container cover and terminal post shall be designed to provide a tight, leak-proof unit. An effective seal shall prevent any seepage or leakage of the electrolyte, or gas release, between the cover and the terminal post.

16.3.8 Cell Separators

a. The cell separator shall consist of a woven fiber mat, which shall separate the plates from each other, allow free circulation of electrolyte between the plates, and promote recombination in order to reduce water consumption. The cell separator shall be alkaline-resistant and free of all impurities, which may injure the cell.
b. The cell separators shall be of such quality, material and design as to minimize any degradation in the dielectric, absorption, and porosity characteristics during the life of the elements.
c. The cell separators shall be of sufficient thickness and of a design to avoid the possibility of inter-plate short circuits.

16.3.9 Containers and Covers

a. The cell container shall be made of translucent polypropylene plastic. The electrolyte level of the cells shall be visible through the side walls. The plastic cell containers shall have two lines, indicating the maximum and minimum electrolyte levels, displayed on at least one side of the container.
b. The cell containers shall be of such quality and thickness as to provide strength in excess of that necessary to support the plate elements, contain the electrolyte and withstand handling in the railroad environment without deformation. The material shall be free from cracks, crazing, burrs, scratches and other flaws of a detrimental nature.
c. Containers shall be so constructed that they will rest evenly on any

manufacturers recommended mounting plane without rocking.

d. The container and cover materials shall meet the fire resistance rating of UL94 V-O, and have an oxygen index of at least 28%.

16.3.10 Vents

a. Each cell container cover shall be provided with a low-pressure filling vent with a cap or plug, removable for cell top-up.
b. The filling vents shall be of the flame arresting type, which does not allow an external gas explosion to ignite the charging gases inside the cell container.

16.3.11 Connectors

a. The inter-cell connectors shall properly fit the terminal posts and be corrosion-resisting, and may be of either flexible or solid construction.
b. The inter-cell connectors shall be appropriately sized to have sufficient capacity to deliver the discharge rate for which the cell is designed, without heating.
c. All internal cell connectors shall be welded together in order to achieve high mechanical strength and low internal electrical resistance. Pressing or bolting of internal cell connectors is not acceptable.
d. In order to protect the battery terminals from external accidental short-circuits resulting from any metallic item falling on top of the battery, insulating plastic connecting covers shall be provided. These covers shall be made of hard PVC plastic.

16.3.12 Electrolyte

a. The electrolyte shall be an aqueous solution of potassium hydroxide (KOH), in distilled or approved water for cold weather operation, approximately 1.190-1.250 specific gravity or as otherwise recommended by the manufacturer. The potassium hydroxide solution may also include a small amount of lithium hydroxide (LiOH), not less than 1.5% nor greater than 3.5% by weight.

16.3.13 Assembly and Charge

a. Each cell shall be completely assembled, sealed and charged ready for service.

16.3.14 Charging shall be accommodated in the following ways:

a. A single-level charge, by applying a minimum constant voltage of 1.43 V/cell at 20°C, with a current limitation of 0.25 A.

b. A two-level charge, by applying two consecutive voltage levels as follows:

   1. A high-rate charge, achieved by applying a minimum constant voltage of 1.45/cell at 20°C, with a current limitation of 0.25 A. Followed by a permanent trickle charge (float charge), by applying a minimum constant voltage of 1.42 V/cell at 20°C.

16.3.15 Watering Maintenance Intervals:

a. Watering Intervals shall not be less than once every year, for a battery under float conditions at 1.42 V/cell at 20°C. Watering intervals shall be approximately 5 times that of a standard "conventional" pocket plate nickel-cadmium battery.

16.3.16 Identification

a. Each cell shall contain permanent legible markings indicating the Manufacturer, Manufacturer's type number and serial number, capacity and date of manufacture or an equivalent accepted date code to identify the date of manufacture.

16.3.17 Mounting

a. Batteries shall be installed in floor-mounted steel racks within the instrument housing.

16.3.18 The Contractor shall supply all fuses, resistors, surge arresters and circuit breakers necessary to adjust voltages and protect the power supply and equipment. Dummy fuse holders for ten percent (10%) spare fuses with a minimum of one of each type and size of fuse shall be provided. Fuses shall be of the replaceable link cartridge design and shall be submitted to the Engineer for approval.

16.3.19 The Contractor shall submit to the Engineer the proposed type and manufacture for all equipment in this Section of the Specification.

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17.0 NETWORKING AND FIBER OPTIC EQUIPMENT

17.1 General

17.1.1 The Contractor shall provide all necessary network equipment, cablings and material to meet the requirements of these Technical Specification and Contract Drawings.

17.1.2 All network equipment furnished under this Contract shall comply with all requirements for a Class C environment (wayside signal enclosure) as defined by Section 11.5.1 of the AREMA C&S Manual. All such equipment shall also comply with any other environmental requirements stated elsewhere in these Specifications if those requirements are more restrictive than the AREMA Manual. The pertinent requirements of the AREMA manual shall include, but not be limited to, the following.

a. Operating Temp: -40C to +70C (-40F to +160F)
b. Relative Humidity: 95% non-condensing
c. Vibration, 5 to 20 Hz: .07: p-p
d. Vibration, 20 to 200 Hz: 1.5 g p
e. Mechanical Shock (11ms): 10 g
f. EMI (50kHz-88MHz): 150 V/m
g. EMI (88MHz-216MHz): 250 V/m
h. EMI (216MHz-1GHz): 350 V/m
i. Dielectric Strength: 2kVrms for electronic equipment

17.2 Ethernet Switches

17.2.1 All Ethernet switches furnished under this Contract shall include the following features in their as-delivered configuration, and these features shall be incorporated in the Contractor's proposed design and furnished system to meet the overall signal system performance requirements of this Specification.

a. Rapid Spanning Tree Protocol (RSTP) as defined by IEEE 802.1W, with the ability to fall back to Spanning Tree Protocol (STP) as defined by IEEE 802.1D if used in conjunction with older, non-RSTP equipment
b. Port security that includes both static Media Access Control (MAC) address access lists and IEEE 802.1X Network Access Control
c. VLAN tagging as defined by IEEE 802.1Q, including, but not limited to, the assignment of native VLAN number by port
d. Prioritization of packets according to the Priority Code Point (PCP) as defined by IEEE 802.1p and used in the 802.1Q frame, with a minimum of four Classes of Service (CoS). Devices shall be able to set the CoS based upon incoming Ethernet header, ingress port,

source/destination MAC address and/or ToS information from the incoming IP header.

e. If the minimum of four CoS are provided, they shall be assigned as follows from highest to lowest priority. If additional classes are available, vital indications shall be given a higher priority than non-vital indications.

    1. Network management (e.g. RSTP)
    2. Vital and non-vital indications
    3. Reserved for future VOIP
    4. Diagnostics

f. Multicast filtering with Internet Group Management Protocol (IGMP) snooping; port rate limiting; broadcast storm limiting
g. Remote management and monitoring including web-based, Telnet and Command Line Interface (CLI) interfaces
h. Simple Network Management Protocol (SNMP) and Remote Network Monitoring (RMON) as defined by IETF RFC1157 and RFC3577, respectively.
i. Capture, storage and upload of device configuration files, either locally or remotely, to allow replacement of devices in field without need to reprogram from scratch
j. Secure Shell (SSH) and password protection for management of devices at a minimum
k. Equipped for standard 19-inch EIA rack mounting. Mounting adapters for DIN-rail or panel-mount equipment are acceptable. Shelf mounting will not be permitted.
l. Industrial-grade terminal blocks for power and I/O connections
m. Internal DC power supplies operating at 12 VDC
n. Fully passive cooling; no fans permitted
o. A minimum of one (1) Form-C failsafe relay contact to indicate major alarms

17.2.2 Layer 2 Ethernet switches shall meet the following requirements, in addition to all other requirements of this Section.

a. Layer 2 Ethernet switches shall be comprised of the RuggedCom RS416 RuggedServer and/or the RuggedCom RS900 Ethernet Switch or approved equals, depending upon the Contractor's design. The unit(s) shall be equipped with the quantity and types of options and modules to meet requirements stated herein, as well as the requirements of the Contractor's design.
b. Layer 2 switches shall include a minimum of two (2) 10/100Base-T ports.

c. Layer 2 switches shall include a minimum of two (2) 100Base-FX optical ports with ST connectors, suitable for operation over distances up to 20 kilometers (12.43 miles) using single-mode fiber optic cable.
d. When used, the RuggedCom RS416 shall be equipped with dual power supplies, and shall be equipped with the quantity and types of serial ports to meet requirements of Contractor's design.

17.2.3 Layer 3 Ethernet switches shall meet the following requirements, in addition to all other requirements of this Section.

a. The Layer 3 Ethernet switches shall be the RuggedCom RX1500-L3-RM-12-12-L3SEL3HW-FX05-6TX01-S01-S01-XX or an approved equal.
b. Layer 3 switches shall include a minimum of six 10/100Base-T ports.
c. Layer 3 switches shall include a minimum of two 100Base-FX optical ports with duplex SC or LC connectors, suitable for operation over distances of up to 20 kilometers (12.43 miles) using single-mode fiber optic cable.
d. Layer 3 switches shall include a minimum of twelve (12) RS232/RS422/RS485 RJ45 serial ports.
e. Layer 3 switches shall be equipped with dual 12VDC power modules.

17.3 DC–to–DC Converters

17.3.1 The DC-to-DC Converter shall be a Power-One AM1301-9 or approved equivalent.

17.3.2 The use of DC-to-DC Converters shall not relieve the Contractor from the requirement, defined elsewhere in this Specification, to install separate DC surge protection for each individual piece of electronic equipment including networking devices.

17.3.3 The Contractor shall furnish and install one DC-to-DC Converter per each network device to be powered from the vital DC power bus so that complete isolation between signal and communications systems is achieved.

17.3.4 The nominal input voltage of the DC-to-DC Converter shall be 12VDC. The nominal output voltage of the DC-to-DC Converter shall be 12VDC.

17.3.5 The maximum output power of the DC-to-DC Converter shall be at least 48 W (4 A at 12 VDC for a single output).

17.3.6 The DC-to-DC Converter shall accept a minimum input voltage range of 8 VDC to 35 VDC.

17.3.7 The DC-to-DC Converter output voltage shall be regulated plus or minus 0.5 percent versus line and plus or minus 1 percent versus load at minimum.

17.3.8 The DC-to-DC Converter total output voltage noise shall not be greater than 80 mV peak-to-peak.

17.3.9 The DC-to-DC Converter efficiency shall be at least 75 percent at 15 percent of full load.

17.3.10 The DC-to-DC Converter Isolation between input and output, between input and chassis and between output and chassis shall be sufficient to pass a 2,000 VDC stress test.

17.3.11 The DC-to-DC Converter shall provide protection against load short circuits electronically, with automatic recovery to normal operating conditions upon removal of the fault. Protection shall be provided against accidental reversal of the dc input-voltage polarity during installation.

17.3.12 The DC-to-DC Converter shall meet other applicable contract requirements, including, but not limited to, an ambient temperature range of minus 40 degrees C to 70 degrees C.

17.3.13 The Contractor shall provide and install all materials and hardware required to mount the DC-to-DC Converter on equipment racks as required in Contractor's design.

17.4 Fiber Distribution Equipment (FDP)

17.4.1 The fiber distribution panel shall be from Optical Cable Corporation, either the Wall-Mount Cabinet (WTC Series), or the Rack-Mount Cabinet (RTC Series). The panel shall be fully loaded with adapter plates, splice trays, splice kits, pigtails and all other modules and/or material as required, for a complete unit to terminate the fiber optic cables with the connector types as required, in this Section, or an approved equivalent.

17.4.2 The fiber distribution panel shall be complete with sufficient termination positions and all hardware necessary (panels, adapters etc.) for terminating a minimum of 24 single-mode fiber strands, or the minimum number of strands indicated on the Contract Drawings, whichever is greater.

17.4.3 Except as noted, all fiber termination connectors shall be simplex Straight Tip / Bayonet Fiber Optic Connectors (ST / BFOC) suitable for termination of single-mode fibers by Metro-North Force Account.

17.4.4 All fiber termination connectors in the external communications enclosure at CIL houses shall be duplex Subscriber Connectors (SC) suitable for field termination of single-mode fibers by Metro-North Force Account.

17.4.5 Connections between fiber-optic networking equipment furnished and installed by the Contractor and the fiber distribution centers furnished and installed by the Contractor shall be made by the Contractor using pre-terminated, single-mode fiber jumper cables with the appropriate connectors per these Technical Specification as well as the requirements of the equipment to be connected.

17.4.6 The Contractor shall furnish sufficient Fiber Optic Patch Cords to interconnect all fiber optic communications equipment. Fiber optic patch cords shall be Corning Cable Systems LANscape or approved equal. Connectors on patch cords and pigtails shall meet the following requirements:

a. The maximum insertion loss shall not exceed 0.2 dB (.09 dB Typical).
b. The maximum return loss shall be less than -57 dB.
c. Fiber recess ± 50 nm
d. Apex offset 50 µm max.
e. Radius of curvature 10-25 mm
f. Fiber optic patch cords shall meet or exceed the optical attenuation requirements of TIA/EIA-568-B.3.
g. Connectors shall be compliant with TIA/EIA-604 Fiber Optic Connector Intermateability Standards. (FOCIS)
h. Connectors shall pass qualification testing that meets or exceeds all applicable EIA/TIA Fiber Optic Test Procedures for Temperature Shock (FOTP-3), Humidity (FOTP-5), Temperature Life (FOTP-4), Mating Durability (FOTP-21), Vibration (FOTP-11), Cable Flex (FOTP-1A), Cable Retention (FOTP-6), Cable Twist (FOTP-36) and Impact (FOTP-2).
i. The Contractor shall assure that the fiber optic patch cords are compatible with the fiber optic cable to which they are intended to connect.
j. The Contractor shall order the patch cords in lengths that allow for a neat and orderly installation.

17.4.7 All fiber-optic jumpers in the pre-wired enclosures shall be installed, for their entire length external to any racks or cabinets, in 1-inch corrugated, plenum-rated innerduct furnished by the Contractor. The innerduct shall be Carlon Plenum-Gard, part number CF4X1C, or an approved equivalent.

17.4.8 Where fiber distribution centers are mounted in external enclosures, a liquid-tight path such as a conduit or grommet shall be provided between the external enclosure and the interior of the house or case.

17.4.9 Connections between the fiber distribution centers and the outside plant provided under separate contract will be made by Metro-North Force Account.

17.5 Miscellaneous Networking and Communications Equipment

17.5.1 Each pre-wired signal house, not including Track Case Master Locations (TCML), shall be equipped with an RJ-11 wall-mounted telephone jack suitable for mounting of a mini-wall telephone, located as shown on the Contract Drawings. Each phone jack shall be wired to the 25-pair protected terminal block, specified below, in a manner suitable for two-line telephone applications.

17.5.2 Each pre-wired signal house, not including Track Case Master Locations (TCML), shall be equipped with one 25-pair protected terminal block, located in an external, wall-mounted enclosure as shown on the Contract Drawings. Each block shall be equipped for termination of 25-pairs of 20-guage solid conductors on a vertical row with quick connects or 66 clips for both the external and internal interfaces. Each block shall be furnished with individual surge protection for all 25 pairs consisting of gas-tube protector modules without heat coils. The 25-pair protected terminal block shall be an Emerson R66P25QC with Emerson 3GUVS protector modules, or an approved equal.

17.5.3 Each 25-pair protected terminal block shall be fully labeled by the Contractor, using label strips furnished by the Contractor from ICC, item number IC066LS050 cut to the appropriate length, or approved equivalent. The label strips shall be marked using labeling equipment defined elsewhere in this Section.

17.5.4 The Contractor shall furnish all Ethernet patch cables necessary for full functioning of the signal system and related networks as defined by this Specification. All Ethernet patch cables furnished by the Contractor shall comply with the following:

a. All Ethernet patch cables shall be factory manufactured and tested. Field fabrication of cables is not permitted.
b. All Ethernet patch cables shall be manufactured in full accordance with the EIA-568-B standard.
c. All Ethernet patch cables shall be manufactured with RJ-45 connectors with snagless boots at both ends. Other proposed connector types shall first be submitted to Metro-North for approval.
d. All Ethernet patch cables shall be manufactured with cable that is rated Cat5e or greater.

e. All Ethernet patch cables shall be color-coded relative to their use in either vital or non-vital networks. The Contractor shall first submit their proposed color scheme to Metro-North for approval.

17.5.5 The Contractor shall furnish all serial patch cables necessary for full functioning of the signal system and related networks as defined by this Specification. All serial patch cables furnished by the Contractor shall comply with the following:

a. All serial patch cables shall be of a "Y" configuration to allow Metro-North to install a data analyzer in parallel with the serial port to monitor serial data while the equipment is on-line and operational.
b. All serial patch cables shall be factory manufactured and tested. Field fabrication of cables is not permitted.
c. All serial patch cables shall be manufactured in full accordance with the EIA-232, 422 or 485 standards as required by their specific application. Other proposed serial interface standards shall first be submitted to Metro-North for approval.
d. All serial patch cables shall be manufactured with DB9 or DB25 connectors as required by their specific application. Other proposed serial connector standards shall first be submitted to Metro-North for approval.
e. All serial patch cables shall be color-coded relative to their use in either vital or non-vital links. The Contractor shall first submit their proposed color scheme to Metro-North for approval.

17.6 Network Cable Tagging

17.6.1 All network and telephone-related cabling furnished by the Contractor, including, but not limited to, telephone jack wire and fiber optic, Ethernet and serial jumper cables, shall be labeled by the Contractor as Specified elsewhere in this document, except that the following materials shall be used specifically for these applications.

17.6.2 The Contractor shall utilize a Contractor-owned tagging and labeling system as described herein, and additionally supply one (1) identical system to Metro-North for future additions and changes.

17.6.3 The Contractor provided labeling system shall be a Brady Model TLS2200, or approved equal, complete with:

a. Hard Case Brady Model TLS2200-HC
b. AC Adaptor Brady Model TLS2200-AC
c. Two (2) Rechargeable Battery Packs Brady Model TLS2200-BP
d. PC to Printer Cable Brady Model TLS2200-CABLE

e. Spare Quick Charger Brady Model TLSHM-QUICKCH
f. Latest Brady Software at time of purchase
g. User manuals, Tutorial and Quick Start Guide

17.6.4 The Contractor provided rack and equipment tags, labels and nameplates shall be Brady B-423 with R-6010 ribbon, or approved equal.

17.6.5 The Contractor provided cable tags and labels shall be Brady B-427 with R-4310 ribbon, or approved equal.

18.0 FIRE SUPPRESSION AND HVAC SYSTEMS

18.1 Fire Suppression System Requirements

18.1.1 The Contractor shall provide a Fire Suppression System for each CIL and Slave CIL(s) supplied under this Contract.

18.1.2 This Section covers the requirement for an automatic fire detection and fixed fire extinguishing system for all new central instrument houses provided by this Contract using Inergen™ or Argonite as the extinguishing agent.

18.1.3 Extinguishing Clean Agent Type: Inergen™ shall be a mixture of three (3) natural occurring gases; nitrogen, argon, and carbon dioxide. Argonite shall be a mixture of two (2) natural occurring gases: nitrogen and argon. No other inert agents will be considered. It shall exhibit no ozone depleting potential, nor contribute unique chemical species with extended atmospheric lifetimes. There shall be no formation of toxic decomposition byproducts from the discharge of agent on a heated surface. The agent shall be listed as acceptable for use in normally occupied spaces by the US Environmental Protection Agency, and listed in the NFPA 2001 Standard.

18.1.4 Alarm signals and systems supervision shall be accomplished by a control panel with 24-hour battery standby as listed by Factory Mutual.

18.1.5 Release of Inergen™ or Argonite extinguishing agent shall be accomplished by an electrical signal from the control panel. Discharge time of sixty (60) seconds shall be in accordance with the requirement set forth in the National Fire Protection Association Standard 2001.

18.1.6 System Consideration and Requirements: In order to insure system effectiveness and Engineer satisfaction, the Contractor shall supply and install all specified equipment and accessories for a complete, electrically supervised system as described and shown on the Contract Drawing.

18.1.7 Operating Requirements:

a. The extinguishing systems shall provide release of Inergen™ or Argonite agent based on the concept of total flooding fire protection for enclosed, normally occupied areas. A uniform extinguishing concentration shall be created within the space by the release of a predetermined amount of agent. The amount of agent required is based upon the volume of the enclosure, the ambient temperature range of 0 Degrees to plus 150 Degrees Fahrenheit and the design concentration required.

b. This system shall be sized to provide a minimum concentration by volume of thirty-four point two percent (34.2%) to a maximum concentration by volume of thirty-seven point five percent (37.5%) of agent in the protected spaces. Sizes and quantities of agent cylinders and discharge nozzles shall be determined to best provide even distribution throughout the protected areas.
c. Automatic Actuation: Electric actuation of an agent cylinder or bank of cylinders is accomplished by a single electric solenoid actuator.
d. All system components and wiring shall be new and of current manufacture and shall be installed in accordance with current NFPA Standards, National Electrical Code, or other governing body within the State of New York.
e. Ventilation and Leakage Effects: Design concentration shall be based upon shutting down the Ventilation systems at the time of first detection. Soaking times of approximately ten (10) minutes shall be required; that is, the area shall be properly sealed such that the specified agent concentrations will be maintained in the hazard area for a period of ten (10) minutes after completion of the initial agent discharge. The Contractor shall coordinate all trades to insure the integrity of the Hazard area.
f. Free venting calculations shall be performed and indicated on shop drawings so as to alert the engineers as to the required free venting area within the protected space. The Contractor shall provide any necessary modifications necessary to insure adequate free venting area.

18.1.8 System Components:

a. Agent Storage: The Inergen™ or Argonite storage cylinders shall be constructed, tested, and marked in accordance with Department of Transportation specifications. As a minimum, the cylinders must meet the requirements of DOT 3AA2300 or 3AA2015+. The cylinder assembly shall be of steel construction with a red standard finish. Each is equipped with a pressure seat-type, forged brass valve, equipped with a pressure gauge. Cylinders shall be indelibly marked with the name (or abbreviated name) of the release agent.
b. Cylinder Manifolds: The system manifold shall be constructed of Schedule 80 steel piping and Class 2000 or 3000 fittings, threaded or welded.
c. Orifice Union: The system manifold shall terminate with an orifice union. The orifice union shall be installed in the distribution piping to restrict the flow of suppression agent, thus reducing the agent pressure downstream of the union. The union shall contain a stainless steel orifice plate, which is drilled to the specific size orifice required based

on the hydraulic calculation. The orifice plate shall provide readily visible orifice identification.

d. Discharge Nozzle: Discharge nozzle shall be constructed of brass and designed to direct the discharge of the agent using stored pressure from the cylinders. System design shall specify the quantity of nozzles and orifice sizes to be used for proper flow rate and distribution.
e. Control Equipment: Provide and install an integrated system of automatic devices. The devices, along with manual stations, shall be used to activate a control panel. This panel shall process all inputs, sequence the levels of alarm, and provide for outputs to the agent storage cylinders. Auxiliary outputs shall be furnished to shut down ventilation, or annunciate on remote devices. System shall be provided with equipment battery standby power so as to provide a minimum of twenty-four (24) hours of battery power.
f. Smoke Detection System: Smoke detectors shall be located at the ceiling. Photoelectric smoke detectors shall be supplied. Maximum spacing for each smoke detector shall not exceed 250 square feet. Verification of a fire condition through the smoke detection circuit shall be accomplished by the counting zone method. This method requires that two smoke detectors on the same initiating circuit be in alarm before the agent release sequence begins. Photoelectric detectors shall be conventional detectors appropriate for the system and conditions of the location. All detectors shall have a built-in alarm LED, which shall blink indicating power and light steadily when in alarm condition.
g. Heat Detection System: Heat detectors shall be located at the ceiling. Rate-of –rise heat detectors shall be supplied. Maximum spacing for each heat detector shall not exceed 250 square feet. Any heat detector on the same initiating circuit will initiate the agent release sequence. Rate-of-rise heat detectors shall be Fenwal Inc. Series 500 or approved equal.
h. Control Panel: An Ansul Inergen, or approved equal control panel, shall be provided to detect fire conditions, sound audible alarms and automatically actuate independent fire suppression systems. The control panel shall be designed to meet the following requirements:

    1. Approved by Factory Mutual Engineering (FM)
    2. Installed per NFPA No. 70
    3. NFPA No. 75, 72, and 2001

i. The control system shall be a FM approved releasing panel and be utilized with listed or approved compatible operating devices and shall be capable of interfacing with the following devices:

1. Photoelectric Smoke Detectors
2. Rate-of Rise Heat Detectors
3. Horn/Strobe
4. Pull Station / Manual Pull Module
5. Alarm Module
6. Digital Release Module
7. Fault Module

j. The Fire Suppression Control Panel (FSCP) shall be listed as a "Releasing Device" and shall perform all the functions necessary to operate the suppression system including detection, actuation, and auxiliary system functions as outlined.

1. The FSCP shall be housed in a rack-mounted enclosure.
2. The FSCP shall be capable of operating at 12 VDC.
3. The FSCP shall provide an internal sounder to provide audible indication of status with distinctively different sounds for initiating circuit alarm, trouble condition and supervisory off normal condition.

k. The FSCP shall include the following additional features:

1. Abort options
2. Microcomputer based, circuit performance fully field programmable.
3. Power limited circuits
4. Smoke detection circuit programmable as single zone, counting zone, cross zones, or alarm verification.
5. Outputs can be disabled during service

l. Manual Release Station and Abort Station

1. Labeled manual release stations shall be supplied near the exits of each location.
2. Manual release shall be of the dual action type.
3. An abort station shall be mounted adjacent to each manual release station.
4. The abort button may be pushed and held to prevent agent discharge.

m. Power Off Relays

1. Power Off (FPO/FHPO) relay, DIN Rails, and mounting hardware shall be provided by the Contractor to disable the fans and heaters.
2. The characteristics of the FPO/FHPO shall be as follows:
   i. DIN Rail Mountable
   ii. Minimum 4 DPDT contacts

iii. Contact Rating - 5 amps each pole

n. Three (3) Form C contacts shall be provided to indicate the change of state corresponding with a system actuation. A functional test shall be performed to ensure the contacts open upon activation. The three (3) Form C contacts shall indicate the following:

1. Fire Suppression System has one (1) detector in Alarm Condition.
2. Fire Suppression System has detected a Trouble/Fault Condition.
3. Fire Suppression System Released/Discharged.

18.1.9 System Operation

a. Smoke/heat detectors shall be located at the ceiling. Should any one (1) of the smoke detectors, or any heat detector sense an alarm condition, the following shall occur

1. The LED on the detectors shall illuminate steady designating which detector is in alarm.
2. A local alarm horn/strobe light shall sound in a "slow pulse" mode.
3. The ventilation system serving the location shall shut down.
4. A signal shall be sent to the Metro-North Code System.
5. The control panel alphanumeric LCD display shall indicate alarm condition

b. Should any second detector on the counting zone, or immediately if a heat detector senses an alarm condition, the following shall occur:

1. The LED on the detector shall illuminate steady, designating which detector is in alarm.
2. The "Fire Alarm" lamp shall light on the main control panel, red.
3. A local horn/strobe shall sound a more urgent "fast pulse" signal indicating the start of a 20-second pre-discharge time delay.
4. Upon expiration of the 20-second time delay, the suppression system shall discharge, unless manually aborted.

18.1.10 Electrical Installation

a. The installation shall comply with the National Electrical Code.
b. Circuit Integrity (CI) cable shall be used in all Signal Locations. This cable shall be used for the detection system wiring, enunciator system, and where required by applicable codes.
c. Circuit Integrity (CI) cable shall be VITALink® CI as manufactured by Rockbestos-Surprenant Cable Corporation or approved equal.

d. The CI cable shall be of proper gauge and either two (2) conductor or six (6) conductor cable.
e. Control and other equipment shall be mounted with sufficient clearance for observation and testing. All fire alarm junction boxes must be clearly marked for easy identification. All mounting boxes, junction boxes, and panels shall be securely hung and fastened with appropriate fittings to insure positive grounding throughout the entire system.
f. Wiring splices shall not be permitted unless approved by the Engineer.
g. Transposing or changing color coding of wires shall not be permitted. Wire nut type connections are not acceptable. Cabling to modules shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Module terminals shall be numbered and coded. All wiring shall be checked and tested to insure that there are no grounds, opens, or shorts.

18.2 HVAC System Requirements

18.2.1 The Contractor shall provide a HVAC System for each CIL and Slave CIL(s) supplied under this Contract.

18.2.2 Heat pumps and Air-conditioning units: shall include all necessary accommodations needed for complete and efficient operation, including exterior protection from vandalism. The Units shall be BARD WA-Series or approved equal and equipped and function as follows:

a. Economizing dampers that allow ventilating air from the outside to warm or cool the house if temperature conditions are favorable.
b. The air Conditioning shall be exterior wall-mounted, self-contained units. Filters shall be accessible for changing or maintenance from inside of house.
c. Thermostatically controlled to operate from 120V/240V, 60 Hz, single-phase power.
d. The Thermostat is to be mounted at a minimum of 68" above the floor.
e. The system shall be sized with 40% increase or decrease for future expansion to maintain the interior temperature between 50 to 80 degrees F with exterior ambient temperatures between 0 to 100 degrees F. The Contractor shall submit cooling and heating calculations to the engineer for review and approval.
f. Dampers shall be provided to shut off all outside air vents if the fire suppression system is activated.
g. Be equipped with lockable hinged protective steel grids on the exterior of the enclosure to deter vandalism.

19.0 SNOW MELTER DISTRIBUTION CASE

19.1 General

19.1.1 The Contractor shall supply new Snow Melter Distribution and Control Cases as defined in these Technical Specifications and Contract Drawings.

19.1.2 The Snow Melter Distribution cases represent a discrete element in the overall wayside signal and network system to be provided by the Contractor. All requirements for pre-wired signal cases, wiring, components, terminal, submittals, testing and documentation shall be provided by the Contractor and be based on these Technical Specifications and Contract Drawings.

19.1.3 The Contractor shall provide submittals to the Metro-North Engineer on all elements of the Snow Melter Control Cases to include, but not limited to, hardware, electrical and testing.

19.1.4 The Contractor shall provide a system that has a proven record in implementation and operation within a 25 kV AC electrified rail environment.

19.1.5 The Contractor shall provide a snow melter design that is compatible with Metro-North's current systems without requiring modifications to the current system.

19.1.6 Each #20 turnout requires a 70 Amp distribution breaker to provide proper operation of the heater elements attached to the switch points and beneath the switch rods.

19.1.7 Each #15 turnout requires a XX Amp distribution breaker to provide proper operation of the heater elements attached to the switch points and beneath the switch rods.

19.1.8 Each #10 turnout requires a XX Amp distribution breaker to provide proper operation of the heater elements attached to the switch points and beneath the switch rods.

19.1.9 The heater elements are powered by 480 volt AC single phase.

19.1.10 The Contractor is responsible for furnishing all apparatus required for the proper operation of the systems supplied except were explicitly indicated in these specifications.

19.2 System To Be Furnished

19.2.1 The Contractor shall provide pre-wired Snow Melter Control cases as required to meet the requirements of these Technical Specification and Contract Drawings.

19.2.2 Contract Drawings show typical case layouts and wiring required. The details shall be provided by the Contractor.

19.2.3 The Contractor shall provide the listed below to include, but not be limited to:

a. Cases in quantities defined elsewhere.
b. Main Circuit Breakers.
c. Distribution Circuit Breakers.
d. Distribution Frames.
e. Ground Fault Interrupters.
f. Lighting.
g. Terminal Connections.
h. Fuses and terminals.
i. Transformers.
j. Current coils.
k. Case heater.
l. Control Switches and Indication Lamps.
m. Indication Relays.

19.2.4 Cables (external to the case) and heater elements (attached to the rails or ballast heaters) will be furnished and installed by others.

19.2.5 Metro-North will use the following typical cable sizes (external to the pre-wired cases):

a. Power Distribution - 500 MCM
b. Heater Element - 2c #4
c. Monitor/Control - 19c #14 or 17c composite (5 #9 - 12 #14)
d. Ground Wire - #4 solid

19.2.6 The Contractor shall immediately notify the Engineer, if the cable plant appears to be inadequate for the circuits as designed.

19.3 System Requirements

19.3.1 The pre-wired Snow Melter Distribution and Control Cases, covered by this specification, shall be used to provide for the operation of resistive heater elements attached to the running rails and installed under the operating rods on turnouts located in the interlockings.

19.3.2 The Contractor shall furnish cases with apparatus wired in place, in accordance with typical plans prepared by the Engineer.

19.3.3 The snow melter power shall be 480 Volts AC 60 Hertz. All apparatus shall be rated at 600 volts.

19.3.4 Any apparatus supplied by Contractor shall be fully compatible with existing systems. The interface supplied by the Contractor shall not require and changes in existing signal or power systems.

19.3.5 The operation of each Snow Melter Case shall be as follows:

a. Each distribution circuit breaker shall limit the operating current to the rated values for the breaker.
b. The Main circuit breaker shall be provided with a ground fault detector. The GFI shall operate the shunt trip to trip the breaker when a ground is detected. A remote indication circuit shall be activated on this event.

19.3.6 Each case shall have two (2) Power On Indication Lights, located at each side of cases.

19.4 Circuit Breakers

19.4.1 The Contractor shall supply Square D Thermal-Magnetic Molded Case Circuit Breakers for I-Line panel boards for the cases. The frames shall be rated at 100 Amps. Style FA standard interrupting shall be supplied. A separate breaker shall be supplied for each load leaving the case.

19.4.2 The breakers shall be rated for 600-volt operation.

19.4.3 All auxiliary and alarm contacts required shall be supplied.

19.5 Ground Fault Relay (GFI)

19.5.1 The GFI shall be a Square D GAT-12 self contained, combination sensing and relaying service suitable for 480-volt single-phase service application. The GFI systems shall consist of an independent sensing coil and control unit. The GFI unit shall be NEMA rated for heavy-duty industrial service

and meet UL Requirements. A GFI shall be supplied for only the main feed to the case.

19.5.2 The GFI shall have an adjustable trip set from 1 to 6 amps.

19.5.3 The GFI shall operate on 120 volt 60 cycle.

19.5.4 The GFI shall have one N.O. contact and one N.C. contact.

19.5.5 The GFI relay shall have a temperature range of 0 to 65 degrees C and -40 to +85 degree C for the sensor.

19.6 Main Breaker

19.6.1 The Main Breaker shall be Square D Thermal Magnetic Molded Case with a frame rating of 400 Amps. Model LAL 400 amp LHL26400 or approved equal shall be used.

19.6.2 A suitable NEMA enclosure complete with all terminals and wiring is required.

19.6.3 All labeling for the switch and terminals shall be supplied.

19.6.4 The operating lever shall be supplied with a locking mechanism to lock it in the off position.

19.6.5 All auxiliary and alarm contacts required shall be supplied.

19.6.6 A shunt trip operation shall be provided.

20.0 SHIPPING AND HANDLING

20.1 General

20.1.1 The Contractor shall be responsible for packaging, shipping, and delivery of all specified equipment to Metro-North Railroad. Arrangements for delivery, including specific directions, shall be made a minimum of seven days in advance by contacting the Engineer. Packaging and method of delivery shall be submitted to the Engineer for approval, prior to shipment.

20.1.2 The Contractor shall not ship any part of the new signal system that will require any modification without first obtaining permission from the Engineer. The delivery schedule shall be coordinated and approved by Metro-North.

20.1.3 Batteries specified herein shall not be shipped within the housings. They are to be shipped separately and direct from the manufacturer upon Engineer's request within 30 days of notice.

20.1.4 Foundations specified herein shall not be shipped within the housings. They are to be shipped separately and direct from the manufacturer upon Engineer's request within 30 days of notice. Detailed foundation layout plans shall be delivered to Metro-North separately.

20.1.5 The Contractor shall have a representative from their Company on site to accept and verify the shipment, as to the amount, type, and condition of the equipment when delivered.

20.1.6 Each house and case shall be shipped with a Contractor-supplied lock on each door as specified within this Document.

20.1.7 Instrument houses, cases, cabinets and all component parts shall be properly protected at the point of manufacture to prevent damage during shipment. All exterior openings shall be sealed during shipment.

20.1.8 Each instrument house and case shall be shipped complete with relay plug boards, card file assemblies, identification tags, terminals, resistors, and associated apparatus. This equipment shall be assembled within racks and shipped complete to each instrument house.

20.1.9 Relays shall be shipped separately, identified on each shipping carton by type, signal location (CIL, Slave CIL, house or case location) nomenclature and relay rack location (rack in which they are to be used).

20.1.10 PC cards shall be shipped separately in protective, anti-static packaging and labeled and identified for the rack number, card file and card file slot where they are to be installed.

20.1.11 Reliability back up equipment, where provided in accordance with these Technical Specifications, shall be shipped with the pre-wired signal enclosure or enclosures for which they are intended to be used.

21.0 TRAINING

21.1 General

21.1.1 The Contractor shall develop and provide an operation and maintenance training program for Metro-North personnel as specified herein. The training program shall include the theory of operation, adjustment, maintenance, trouble-shooting and modification of the vital microprocessor signal systems in the interlocking and automatic block territory, non-vital microprocessor code systems, track circuits, and the signal communication network and fiber/optic equipment.

21.1.2 In order to facilitate the operation and maintenance training program, a wayside vital and non-vital microprocessor signal and communication equipment training system shall be provided as part of this contract. The training system shall provide a complete representation of all hardware and software components used in the Contractor provided signal and communications systems.

21.1.3 The training system hardware shall be configured as independent equipment cabinets mounted on wheels, each cabinet representing a specific type of location. Cabinets shall be provided for two (2) interlockings and two (2) Master Locations. One of the Master Location cabinets shall be configured to incorporate Electric Lock switch I/O and functionality.

21.1.4 For training purposes, the cabinets shall be interconnected using fiber-optic and copper cables to provide a fully functional representation of a portion of automatic territory bounded by the two interlockings, including all network devices and local cabling. The training system shall include simulated CTC code line and the diagnostics system, event recording and retrieval systems, and all required peripheral devices.

21.1.5 The training system equipment cabinets and associated material shall include, but not be limited to, the following:

a. Two (2) Interlockings – Two independent equipment cabinet sets providing zoned vital processors (two zones per location), non-vital processors, local control panel, FRA test panel, I/O control and display panel (for simulated signal, track occupancy, alarm and switch machine interfaces), one complete Steady Energy AC Track Circuit representative of the new interlocking detector circuits, all required network devices, and the necessary cabinets and racks to mount and enclose each training interlocking.
b. Two (2) Master Locations – Two independent equipment cabinet sets providing zoned vital processors (two zones per location), local

indication panel, I/O control and display panel (for track occupancy, alarm and EL switch interfaces), one complete Steady Energy AC Track Circuit representative of the new automatic block signal system, all required network devices, and the necessary cabinets and racks for each training Master Location.

c. Fiber optic interconnecting cables, copper track feed and/or track circuit simulation cables, and simulator hardware and software for remote CTC and diagnostic systems testing.

21.1.6 Training of all Metro-North personnel as required herein shall be completed before any piece of the new system is placed in-service.

21.1.7 The training program specified herein shall be provided by the Contractor in a Metro-North facility appropriately close to the students that will be trained. The Engineer shall approve the location of this facility. All costs for the training instructors and courses, including shipping and handling of training materials, shall be the responsibility of the Contractor.

21.1.8 The overall training curriculum shall be based on the project specific hardware and software systems, and shall utilize the vital and non-vital microprocessor and communication network training system to be provided under this contract.

21.1.9 All aspects of maintenance, program changes and modification shall be covered in the training. Actual application listings, circuits and hardware layout shall be used as an integral component of the training. Generic courses or topics are not permitted. This shall include, but not limited to:

a. Vital Microprocessor systems
b. Non-Vital Microprocessor systems
c. Battery Chargers
d. Track Circuit Adjustments
e. Local Control Panels
f. Diagnostic System
g. Fire Suppression System
h. HVAC System
i. Ethernet Switches
j. Signal Communication Networks

21.1.10 Actual Boolean expressions for the project and circuit plans from the project shall be incorporated into the training programs. All tools (hardware and software) supplied under this contract shall be incorporated into the training curriculum.

21.1.11 The Contractor shall provide detailed training on the function, meaning and actions to be taken for all alarms warning or other human interface that the microprocessor systems (vital and non-vital) generate or produce.

21.1.12 The training shall be divided into two general categories: equipment operation and maintenance, and programming. The number and classification of Metro-North personnel to be trained in each category are listed below with the minimum hours of instruction each is to receive.

21.1.13 Personnel to receive Equipment Operation and Maintenance Training (including Microprocessor-Based Interlocking, Master Location and Code System equipment):

Personnel Classification	Approximate # of Persons	# Of Sessions	# Of Hours
Supervisory Personnel and Field Technicians	8	5	8
Maintenance Personnel (Signal and Comms)	30	3	8

Personnel to receive System Programming Training (Microprocessor-Based Interlocking and Code System):

Personnel Classification	Approximate # of Persons	# Of Sessions	# Of Hours
Supervisory Personnel	5	5	8
Programmer / Engineering & Maintenance Personnel	8	5	8

21.1.14 Class Size:

a. Class size of training consisting entirely of classroom instruction shall be of adequate size for twenty students.
b. Class size of laboratory or field training shall be limited to, five students.

21.1.15 When it is necessary that the Contractor prepare the text data required by this Section, it shall be his responsibility to ensure that the personnel preparing such data:

a. Have a thorough understanding of the operation and maintenance of the described items.
b. Are sufficiently skilled in technical writing to communicate the essential data.

21.1.16 The Contractor shall provide qualified instructors, professional training personnel, and Design Engineers who are thoroughly familiar with all subject material for each training session, and are of exceptional ability to allow the continuous extension of information to the student without a loss in expertise.

21.1.17 The Contractor shall submit the following to the Engineer for approval:

a. Training Program Plan - The plan shall be prepared in narrative form and shall be supported by such tables, charts, schedules, and graphs as are necessary to fully convey and describe the Contractor's plan for accomplishing the training set forth herein.
b. Training Program Schedule - The schedule shall show all major training activities in chart form, including submittal of instructor and student materials and training reports. The schedule shall be supported by such narrative description as is necessary to fully convey its impact and relationship to other contract events, including testing of such system equipment as is necessary for training laboratory sessions.
c. Training program location
d. Instructor's names and qualifications
e. Instructor Materials - The Contractor shall submit instructor materials, except training aids, in accordance with the training program schedule, provided that such submittals shall occur at an approved time prior to the scheduled commencement date of the first training session to which the materials apply.
f. Student Materials - The Contractor shall submit student materials in accordance with the training program schedule, provided that such submittals shall occur at an approved time prior to commencement of the first training session to which the materials apply. The student materials shall include an opaque copy of all visual training aids or approved electronic files to be used by the instructor.
g. Training Reports - The Contractor shall submit training reports in accordance with the training program schedule, provided that each report submittal shall occur at an approved time following the last day of the training session to which the report applies.

21.2 Training Plan Development

21.2.1 The Contractor shall develop a training program plan responsive in all respects to this Specification. The plan shall provide:

a. Materials - Student and instructor materials including course outlines and objectives, lesson plans, training aids, and student manuals shall be developed. All of these materials shall become the property of Metro-North at the conclusion of the training.

b. Schedules - Training schedules including dates, locations, and equipment requirements for each course to be presented shall be jointly developed with Metro-North.
c. Training Presentation - Training shall be presented to Metro-North supervisory, operation, training, and maintenance personnel. Such training shall be sufficient to ensure the transfer of all system-imposed knowledge and skills necessary to fulfill the duties required by the functions of said personnel.
d. Administration - The training program shall be administered as it relates to development, presentation, and evaluation of the effectiveness of instruction and instructional material.

21.3 Training Program Course Development

21.3.1 The Contractor shall develop courses of instruction in operation, maintenance and programming of the new vital and non-vital processor based signal and network communications systems, including, but not limited to, the following:

21.3.2 Microprocessor Operations and Maintenance - This course shall be designed to provide maintenance engineers and technicians with the knowledge and skills required to perform all operations and preventive and corrective maintenance of the microprocessor, input-output devices and other controls associated with the vital and non-vital interlocking microprocessor. Metro-North will troubleshoot the equipment down to board level failures. The course shall be designed accordingly.

21.3.3 Instruction: Classroom instruction shall be designed to cover, in detail, the functions of each processor subsystem including the interrelationships of the subsystems. Fault isolation and troubleshooting techniques shall be covered to the extent necessary in preparation for maintenance laboratory instruction and shall be designed to provide Metro-North engineering and maintenance personnel with practical experience in the performance of preventive and corrective maintenance, including routine servicing. Troubleshooting and fault isolation of simulated faults shall be provided for each subsystem.

21.3.4 Microprocessor Interlocking and Non-Vital Code System Programming - This course shall be designed to provide programmers/technicians complete instruction in the concepts and details of the system control programs, the associated system input-output techniques, the system's programming languages and techniques, devices, and other controls and displays associated with the data processor. Instruction shall be sufficient to enable programmers/technicians to make changes, additions, and deletions as well as simulate, compile, debug, burn EPROMs or upload application programs to enable modification to any of the computer programs after the system has been placed in service. Training shall be hands-on and interactive. No more than two students shall share any one workstation.

21.3.5 Network communication system training courses shall include, but not be limited to, communication system overview, theory of system operation, design tenets and expansion techniques, management & operations, installation & maintenance, trouble shooting, and proper field and shop maintenance procedures. Course objectives are to insure that Metro-North personnel will be able to install, maintain, and operate equipment, design and upgrade equipment, and integrate equipment with existing systems. The primary goal of all instruction shall be to provide Metro-North with self-sufficiency in operating all networks and equipment to be installed, into the future.

21.3.6 Network communication system training course topics shall cover the specific hardware, software and systems supplied, and shall include, but not be limited to:

a. Basic Installation
b. Configuration
c. Integration
d. Network Growth
e. Routine Maintenance
f. Adds, Moves and Changes
g. Troubleshooting and Repair
h. Physical and logical separation of the various networks, including, but not limited to, the South Vital Network, the North Vital Network, the Diagnostic Local Area Network and the Centralized Train Control and Diagnostics Wide Area Network
i. Rapid Spanning Tree Protocol and Spanning Tree Protocol
j. Virtual LAN segmentation techniques
k. Packet prioritization and class of service
l. Multicast filtering
m. Network security
n. System alarms
o. The use of DC-to-DC converters and other techniques used to isolate power system

21.3.7 Network communication system training courses shall be provided for any communications systems and/or related component not presently in use at Metro-North. Training shall also be provided for classes of systems that are in use at Metro-North, if the Contractor elects to propose a different make and/or model than is currently in use at Metro-North.

21.4 Training Program Material Development

21.4.1 Instructor Course Outline - A course outline with learning objectives shall be provided. The course outline shall provide a topic outline for each subsystem. Maintenance courses shall include a section devoted to system fault analysis and troubleshooting. The learning objectives shall be stated for each topic.

21.4.2 Instruction Lesson Plans - A set of lesson plans shall be developed for each subsystem corresponding to the topic outline, and shall contain the following information:

a. Lesson Title.
b. Time.
c. Objectives.
d. Training aids required.
e. Instructing sequence (outline).
f. Test outlines, written and oral.

21.4.3 Instructor Training Aids - Optimum use of slides and overhead transparencies or approved electronic files shall be made in the classroom instruction. Visual aids shall be developed for each topic. The number of aids shall be determined by the complexity and the amount of time allotted to the topic. Operations and maintenance laboratory instruction shall not require aids other than the wayside vital and non-vital microprocessor signal and communication equipment training system, test equipment, and associated documentation; however, the Contractor may utilize troubleshooting and fault isolation charts developed for training purposes.

21.4.4 Student Material - The primary source of student instruction material shall be the applicable system operation and maintenance manuals. In addition, the Contractor shall develop, for each course specified, student notebooks, containing such additional drawings, descriptive information, and laboratory procedures necessary to ensure that all learning objectives are met in an orderly and timely manner. Student notebook material shall be arranged by subsystems and sequenced according to the topic outline.

21.4.5 The Contractor shall provide the following equipment as part of the student material to be used during the training program. The equipment shall be

installed in the classroom in which the maintenance training sessions shall take place.

21.4.6 A complete vital and non-vital microprocessor signal system utilizing the wayside vital and non-vital microprocessor signal and communication equipment training system, shall be wired together to simulate actual field conditions. This shall consist of two (2) intermediate Master Locations and two (2) bounding interlockings in a two zone configuration.

21.4.7 A rack-mounted entrance exit style local control panel shall be provided for each of the two microprocessor interlocking systems to be representative of the field local control console for training purposes.

21.4.8 The student material listed above shall remain the property of Metro-North at completion of the training program.

21.5 Training Program Presentation

21.5.1 The Contractor shall provide training at facilities provided by Metro-North unless otherwise required. The training sessions shall be scheduled such that the personnel receiving training will be able to assume their assigned duties prior to pre-revenue testing. Maintenance laboratory training shall be conducted utilizing the wayside vital and non-vital microprocessor signal and communication equipment training system, provided under this contract.

21.5.2 In the event any other of the supplied signal equipment under this contract is required for training, the Contractor shall restore such equipment to normal operating condition at the end of each training session. Use of the system equipment for training purposes shall not void or otherwise modify any equipment warranty provision.

21.5.3 The Contractor shall be responsible to deliver training during the first, second and third shifts as indicated below:

a. First Trick – Monday through Friday 8 AM to 4 PM
b. Second Trick – Monday through Friday 4 PM to 12 Midnight
c. Third Trick – Monday through Friday 12 Midnight to 7 AM

21.5.4 The Contractor's training plans and classes shall provide for two (2) 15 minute breaks and a 30 minute lunch break for each eight (8) hour session.

21.5.5 Delay or Reduction - In the event the wayside vital and non-vital microprocessor signal and communication equipment training system equipment is not in operating condition at the schedule time for training requiring such equipment, Metro-North shall have the right to delay training sessions or reduce

the duration of training sessions.

21.5.6 Contractor Facility Training - Training normally provided by the Contractor at the Contractor's facilities shall not be construed to satisfy the training requirements specified herein.

21.5.7 Training Program Monitoring and Evaluation - The Contractor shall monitor the initial presentation (session) of each course. Such monitoring shall be performed, on a random basis, by a qualified training supervisor, in order to evaluate the effectiveness of training material and instruction. The results of the monitoring shall be analyzed and corrective action taken, if and as required. Metro-North supervisory personnel will have the right to monitor training sessions. Instructor evaluations shall be made by analysis of instructor critiques, coverage of materials in time allotted, and results of Metro-North's evaluations and critiques of the training.

21.5.8 A training report shall be prepared and submitted to Metro-North subsequent to the completion of each training session. The report shall include a summary of the results of the monitoring and evaluation as well as a record of student attendance and performance including results of oral and written tests.

21.5.9 The Contractor shall provide a digital video recording of both the operational and maintenance training at the conclusion of the training program. The video shall be supplied on DVD media in standard MPEG-2 video format using the UDF file system, in order that Metro-North can use it for future training.

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22.0 TESTING AND TEST EQUIPMENT

22.1 General

22.1.1 The Contractor shall perform inspections and tests to demonstrate that the systems, subsystems, assemblies, sub-assemblies, software, and hardware supplied under this contract are in compliance with the Technical Specifications and Contract Drawings.

22.1.2 All signal and communications equipment furnished, and all work performed under, these Technical Specifications and Contract Drawings shall be inspected and tested. This shall include, but not be limited to, all elements of the vital and non-vital signal system, and all associated vital and non-vital communications equipment performing signal system data link, non-vital diagnostic, and non-vital CTC communications functions.

22.1.3 The Contractor is responsible for providing a complete fully integrated communication and signal system for testing. A complete end-to-end test shall be provided to test each element within in the system down to the smallest bit or component. Testing parts or subsystem shall not be permitted to meet this requirement.

22.1.4 All systems shall be tested in complete, functional groups that match delivery requirements. Where communications and/or signal system interfaces are required to existing facilities, these interfaces shall be simulated in order to test the overall systems, in accordance with test plan as approved by the Engineer.

22.1.5 The Contractor shall perform all tests required under the supervision of the Engineer to ensure the proper and safe operations of all systems and subsystems and prove the adequacy and acceptability of the Contractor supplied signal system for operations.

22.1.6 The Contractor shall prepare and submit a complete, comprehensive factory and (where applicable) field inspection and testing plan for approval by the Engineer. The inspection and testing plan shall delineate activities performed by the Contractor, and activities performed by Railroad Forces where applicable. The plan shall include formats of pre-printed forms and checklists for recording data, a listing of the equipment required, and all other relevant information.

22.1.7 Upon Metro-North approval of the inspection and testing plan, and at least 60 days prior to the start of each factory or field test, the Contractor shall develop and submit to the Engineer for approval fully detailed inspection and test procedures, on a device or final site location specific basis.

22.1.8 The detailed inspection and test procedure submittal shall define all inspection and testing procedures required for system integration testing and operational testing/placing in service of a specific functional group of equipment/locations as identified in the overall test plan. For testing, the functional group shall be interconnected to form a complete vital and non-vital signal and associated communications system, including all signal system equipment, and all communication devices configured to form a complete integrated communication system and subsystems.

22.1.9 Inspections and testing shall be conducted according to these procedures submitted by the Contractor as approved by the Engineer. The Contractor's existing inspection and Factory Acceptance Test (FAT) procedures, if and where applicable, may be utilized with the approval of the Engineer.

22.1.10 The Contractor shall notify the Railroad at least twenty-one (21) days in advance of all Factory Acceptance Tests. The Railroad may, at their sole discretion, elect to be present, or send its agent, to witness the tests.

22.1.11 Metro-North and the Contractor shall agree upon final schedules for testing. No formal testing shall occur without Metro-North's prior approval, and all signal and communications system factory tests shall be scheduled at a reasonable time on normal working days (i.e. between 8 AM and 8 PM). A minimum of 25% of the test schedule, plus one full day for each delivery group shall be set aside for Metro-North's representatives to conduct unstructured tests.

22.1.12 The inspection procedures and testing procedures proposed by the Contractor shall be in full compliance with recommended practices and procedures for each equipment manufacturer, and as required to maintain all manufacturer's warranties.

22.1.13 The Contractor shall be responsible for planning and coordinating all communication systems tests with the associated signal system tests to ensure both the signal and communication systems meets the Contractor Specifications. To support this effort the Contractor is also responsible for providing all interfacing as necessary with all legacy signal and communications equipment. The Contractor shall be fully responsible for providing these communication interfaces at no additional cost or time to the contract.

22.1.14 The tests to be performed shall cause each system and subsystem to be sequenced through all of its required operations, including the imposition of failure conditions to prove that the system complies with all operational requirements.

22.1.15 The Contractor shall inspect and test all items of hardware and software that it supplies, and furnish inspection and test records to the Engineer.

22.1.16 All systems, subsystems, and components forming an integral part of a failsafe circuit or subsystem shall be individually inspected and tested.

22.1.17 All components or units, other than those related to failsafe circuits, may be tested on a sampling basis. An approved number of randomly selected components or units from the manufacturing process shall be tested to ensure the adequacy and acceptability of all components and units produced.

22.1.18 Each component and unit shall be inspected at its point of manufacture and evidence of this inspection and acceptability shall be indicated on the item where practical.

22.1.19 All vital relays shall be factory-tested in accordance with AREMA Standards.

22.1.20 The Contractor shall certify that all manufactured equipment is in conformance with nameplate ratings.

22.1.21 The Contractor shall be responsible the costs of the personnel, material, specialized tools, test equipment, interface simulators, and devices as required, for the preparation, performance and required documentation of both factory inspections and tests, and field inspections and tests.

22.1.22 When the system or any of its components does not meet the specification requirements, the Contractor shall make the necessary corrections and shall be responsible for the cost of additional tests required to prove compliance.

22.1.23 Metro-North reserves the right to witness any or all tests and inspections in the Contractor's facilities. The Contractor shall advise the Engineer a minimum of four weeks in advance of each inspection or factory test.

22.1.24 When tests require specific meter or test instrument readings, the pre-printed data sheet shall show the allowable range of values, for each part of the test. The Contractor shall verify and certify that the calibration of all instrumentation used in testing is traceable to the National Bureau of Standards. The test report shall contain a check-off system for each action and a blank space adjacent to the expected value in which to record the test readings.

22.1.25 The test report shall contain a final description sheet on which the Contractor shall record discrepancies found and action taken. This documentation shall be furnished to the Engineer.

22.1.26 The Contractor's test procedures shall contain pre-printed data sheets or inspection sheets for each test or inspection. When completed by the test personnel and checked for accuracy and completeness, the sheet shall be submitted as part of the test report.

22.1.27 All test reports shall be dated and signed by the responsible employee of the Contractor on the day the test is performed.

22.1.28 The Contractor shall not make any changes, which affect safety of operation of the approved circuit(s) as designed, without prior approval of the Engineer.

22.1.29 The Engineer will make all final determinations as to whether only a part, or the whole test, shall be re-run when any specific test does not meet the requirements specified for the test. The Contractor at no expense to Metro-North shall perform any additional tests required by the Engineer because of failure during testing. The Engineer shall make the final decision regarding shipment of any equipment, regardless of schedule requirements.

22.1.30 Any changes made after completion of test procedures shall be re-tested per the applicable test procedure.

22.1.31 The Contractor shall record and certify the results of each test as herein specified, and this test result documentation shall be furnished to the Engineer. The Contractor shall also furnish certified test results for test performed by any subcontractors when tests are required within this specification.

22.1.32 Copies of all competed inspection and test records shall be submitted to the Engineer within fourteen (14) days of the completion of the inspection or test.

22.1.33 The signal and communications equipment shall not be shipped from the factory until all required inspections and tests have been performed, demonstrating that each item of equipment conforms to the requirements of these Technical Specifications and Contract Drawings, and has been approved for shipment by Metro-North.

22.1.34 Approval of inspection and test results, acceptance of any equipment or the waiving of inspection or tests thereof, shall in no way relieve the Contractor of the responsibility to furnish complete and operational communication systems that meet the requirements of this Specification. Also, such actions shall not invalidate any claim the Railroad may make because of defective or unsatisfactory documentation.

22.1.35 Metro-North may request additional tests, at no charge, on any work not in accordance with the Technical Specifications and Contract Drawings.

22.1.36 Should any inspections or tests performed by Metro-North, or requested of the Contractor by Metro-North, indicate that specific hardware, firmware, software, or documentation does not meet the Specification requirements, the Contractor shall replace, modify or add the appropriate items necessary to correct noted deficiencies at no cost to Metro-North.

22.1.37 The Contractor shall prepare and submit for approval an EMI/RFI Construction Procedure and an EMI/RFI Test Plan and Procedure, subject to the approval of the Engineer.

22.1.38 The EMI/RFI Construction Procedure shall document, to the satisfaction of the Engineer, the developed shop practices, processes and procedures to be utilized by the Contractor during construction and manufacturing to mitigate EMI and RFI. These shall include, but not be limited to, shielding, bonding, cable routing and all other construction practices and methods to be deployed by the Contractor during construction specifically to mitigate potential sources of EMI/RFI.

22.1.39 The EMI/RFI Test Plan and Procedure shall be submitted to the Engineer for approval, which demonstrates the testing methods that shall be utilized during Factory Acceptance Testing to satisfactorily demonstrate that the constructed equipment is not susceptible to the environmental conditions of the railroad as listed within this document. Immunity to environmental conditions shall include, but not be limited to, a demonstration of immunity to the EMI created by the radio frequencies and sources as listed.

22.2 Factory Testing and Inspection

22.2.1 This Section describes the requirements for Factory Testing and Inspection of the signal and associated network communication systems to be furnished and integrated by the Contractor.

22.2.2 All components, subsystems, systems, software and hardware shall be 100 percent inspected and tested to the requirements of the approved test plan and detailed test and inspection procedures. All interior apparatus shall be interconnected and energized as required to simulate operating conditions.

22.2.3 Each wire shall be continuity checked to insure that it is terminated as required by the circuit drawing diagrams.

22.2.4 Wire counts shall be performed on each terminal to ensure that the proper number of wires are present.

22.2.5 All wire and equipment identification tags and nomenclature shall be verified for agreement with circuit drawings.

22.2.6 All relays, components, resistors, semiconductors, fuses, etc. shall be verified to confirm that all are the same as called for on the approved circuit plans, and that they are located in the proper positions.

22.2.7 All unique keying of relay bases, PCB's, etc. shall be verified as being present as called for on the approved circuit plans where it is identified as needed.

22.2.8 The tests herein described shall be performed to the greatest extent possible at the factory level. Any changes or detachment of wiring and equipment that can cause an unsafe condition shall be re-tested in the field by Metro-North. The Contractor shall notify Metro-North of the need to perform any re-testing, with specific details defining which circuits are affected.

22.2.9 The following tests shall be performed for Power Rack, Energy Distribution, and Failure Alarm Circuits:

a. The purpose of this test is to be certain that energy at all required levels is available in the Central Instrument Location (CIL) and properly distributed to equipment requiring it both in the field and in the CIL. This test shall check that no grounds, shorts, open circuits, crosses, or misplaced wiring exist in the power distribution system. Any malfunctions, lack of power, or blown fuses shall be recorded for correction and re-testing. All alarm circuits shall be tested by simulating power or equipment failure. All standby or reserve power circuitry shall be checked both for completeness and satisfactory operation.
b. This test shall include the following:

    1. Check AC power for correct voltage levels, and phasing where required.
    2. Check DC power for correct voltage levels and correct polarity.
    3. Check and adjust transformer taps where required.
    4. Check and make operational all ground detectors.
    5. Check all circuit breakers and fuses for correct size and rating.

22.2.10 Breakdown Test of Vital Circuits and Interlocking Control Circuits:

a. All vital circuits shall be tested in their entirety for the correct operation of and response to each contact on each circuit element, such as relays and contactors. Where parallel paths exist, the tests shall validate each path, and circuits shall be disconnected to ensure the proper test.

b. Where parallel paths exist in a relay circuit, the circuit shall be checked to prove that all paths are energized from the same fuse.
c. Each circuit shall be tested by simulating all operating conditions to ensure that the circuit operates in accordance with the Approved Circuit Plans and these Specifications. This shall be done by removing contact terminals from plug boards at each contact and removing wires from input points and checking to see that energized relays drop.
d. These tests shall also include the verification of correct current where resistors are used to reduce current.
e. These tests shall also include checking all tags and markings for their presence, legibility, and accuracy. Any discrepancy shall be tagged with a red paper tag fastened to the wire or device with string, and recorded on the discrepancy form.
f. Jumper wires used for temporary connections for these tests shall be of a vividly contrasting color to the rack wire, or alternatively, these wires shall be identified by a green paper tag fastened to the wire with string. These wires shall be removed at the end of the tests. The test procedure shall include documentation of jumper quantity and a check-off system to ensure that all jumpers have been removed.
g. Both ends of each wire shall be checked during these tests to be certain that their terminations are solidly applied and that they are properly held in their correct place. The corresponding line on an up-to-date set of approved plans shall be marked with blue pencil to indicate the presence of each wire in its proper position and condition, and that the tag applied to the wire has the proper nomenclature.
h. All circuit elements shall be checked in the breakdown test. This shall include relay test posts, pushbutton contacts, and switch machine contacts. All terminations shall be checked to ensure that no extraneous connections exist.
i. A contrasting colored pencil (blue) shall be used to checkmark each connection on the set of plans (included with the test submittal) to indicate that each circuit element and termination has been checked as required in this procedure. All coordinates for identifying apparatus locations shall be likewise checked.

22.2.11 The following Integrated System and Network Tests shall be performed:

a. The purpose of these tests is to confirm that the sub-system and system-wide operational performance levels are within the requirements established by the Technical Specifications, as may be amended by the Engineer, based on the Contractor's final design and all required timing and performance calculations.

1. Tests shall verify all specific timing and performance calculations provided by the Contractor at the 60% design level, as required in these Technical Specifications. These shall include, but not be limited to, tests to verify that the aggregate route clearing times, elements of the aggregate route clearing time, the upgrade and downgrade of cab code, and time to signal displaying stop aspect are being achieved in the factory test environment.

b. In accordance with the project schedule with respect to manufacture, test, shipping and installation sequencing constraints, a comprehensive factory test program shall be undertaken that involves the interconnection of all devices to provide an accurate representation of the final external network infrastructure.

   1. It is anticipated that the signal system will be tested in stages as described in these contract documents, to coincide with the project's installation and commissioning plan.
   2. The integrated test for the respective section shall include portions of the adjacent section (where required), such that overlapping system functions can be verified.

c. The Contractor shall demonstrate that the representative network infrastructure accurately emulates the network interconnections with respect to variables such as line loss, and the allocation of fibers, redundancy, and interface settings, e.g. IP, sub-nets, Virtual LANs (VLANs) for the respective section(s) under test.
d. The Contractor shall submit specific details pertaining to its method for accomplishing these tests within the overall test plan.

22.2.12 All Contractor-furnished equipment shall be operationally tested and inspected as a complete functional assembly prior to shipment to the extent possible. Each function shall be tested by simulating operating conditions. Where equipment is related to train protection, each component or subassembly shall be separately inspected and tested.

22.2.13 All printed circuit cards, relays, and other components used during the factory test shall have their locations within the instrument house or equipment rack documented during the test. These components shall be reinstalled in the same location as they were during the factory test prior to commencement of field testing.

22.2.14 The following operational tests shall be performed, including the simulation of train movements as necessary. Vital and non-vital signal system operational functionality shall be thoroughly tested, including, but not limited to, the following:

a. Testing of the proper function of all switch control and indication logic for each interlocking switch.
b. Testing of the proper logic checks of all opposing signals (not requested, at stop and not in time) in both the route check and signal logic, over all possible routes for each signal.
c. Testing of the inclusion of all switches, logically checked in the proper positions in accordance with the approved interlocking layout plan, in both the route check and signal control logic, over all possible routes for each signal.
d. Testing of the presence of all necessary traffic direction logic checks, as required, in both the route check and signal control logic, over all possible routes for each signal.
e. Testing of the proper incorporation of all required track circuits for block occupancy and, if applicable, fouling checks in the signal control logic, for each signal and over all possible routes for the interlocking.
f. Testing of the proper switch detector locking logic, incorporating the necessary track circuits and providing proper loss of shunt protection, for each switch in the interlocking, including all necessary fouling protection (in accordance with the approved interlocking layout plan).
g. Testing of the proper route locking for each switch in the interlocking, including a check that each signal that may be routed over the switch locks the switch for all possible routes.
h. Testing of the proper control and locking of traffic on signal display, under time locking and through directional route locking for all signals over all routes and considering all intermediate track circuits in each route, to each track requiring traffic locking, and at all automatic territory Master Locations in the traffic block.
i. Testing of the proper function of the interlocking signal indication locking logic.
j. Testing of the proper function of approach and/or time locking logic for each signal of the interlocking, including a check of track circuit "pick" logic, settings of time releases, and if applicable, the proper application of approach locking.
k. Testing of sectional switch release functionality, where this is possible, to provide for safely releasing switches behind a train movement.
l. Testing of the proper function of all interface circuits to adjacent territory, checked for signal system functional requirements and conformity with the signal aspect and cab signal code designs.
m. Testing of the proper function of all interlocking signal lighting circuits, checked for conformity with the signal aspect and cab signal code designs for each signal over each route in the interlocking.
n. Testing of the cab signal code selection in each track circuit, checked for conformity with the signal/cab signal code route and aspect design, for all routes in the interlocking and for all automatic territory track

circuits controlled at each Master Locations. Tests shall be made for interim and final routings sequences if staging is required.

o. Testing of the proper function of electric lock switch operation, checked for unlock functionality entering and leaving the main track, control of traffic upon unlock request, the re-pick of traffic direction upon actual train move, and a check that no cab signal aspects is transmitted until direction picked.

22.2.15 In addition to the normal operational tests to verify signal system functions such as locking, aspect control, cab code application described herein, the Contractor's test plan shall comprehensively address and include tests associated with degraded or perturbed system operation as described below.

22.2.16 The operational tests shall include, but not be limited to, the introduction of system and sub-system failures such as Master Location processor failures, interlocking processor failures, vital and non-vital communication failures, office system failures (loss of code lines), wayside apparatus failures, such as failure of track circuit to change ends, random track occupancy and bobbling track circuits. These tests shall be performed under a variety of operating conditions, including maximum communications and processor system loading.

22.2.17 The Contractor shall provide a means of verifying the interface to the office CTC system, including control and indications, through a connection to the representative network at the circuit interface point where the office will connect to the location(s) under test. The ability to modify the input and introduce noise or other network disruptions is required. Both the control and indication elements are required to be simultaneously monitored and modified in such a manner as to enable the verification of the control, and indication mapping.

22.2.18 The Contractor shall supply all required components to simulate a fully functional CTC control and indication operation. The connections to the systems under test shall be through the primary and standby network interface connections. The simulation shall provide for an identical operation as would be used by the final Metro-North CTC control office, including a means to emulate the office to field polling cycle.

22.2.19 The simulation shall test all control and indication elements as defined in the 100% Design code charts. Single and grouped controls shall be delivered to the field units, as they would be provided by the final system. Single and grouped indications shall be received by the simulator as would normally be generated by the field unit. The simulator shall display all control and indication bits for both ends of the same connection, on a dynamic basis.

22.2.20 The Contractor shall deliver, for review and approval by the Engineer, all details on how the code system simulator will operate and function including, but not limited to, the circuit plans and wiring details.

22.2.21 During non-vital testing, the introduction of system perturbations shall occur. The items taken as individual elements or in the aggregate shall not cause any system degradation. The items listed below occur within the normal railroad environment. The processing of controls and indications, during these events, shall not degrade the systems performance or cause system failures. Perturbations include, but not limited to, the following:

a. Intermittent ("bobbing") track circuits
b. Intermittent ("bobbing") switch indication
c. Intermittent and/or failed CTC code lines
d. Loss of signal power (track circuits de-energize simultaneously)
e. Loss of peripherals (Ethernet switches, modem, I/O card, Battery charger etc.)

22.2.22 The Contractor shall inspect all network communications system components upon transfer of the component from the manufacturer to the Contractor and prior to system integration and installation. An inspection plan and sample inspection reports shall be provided to Metro-North as part of the factory and field inspection and testing plan submittal. The plan shall delineate what devices are to be inspected, how the inspection is to be conducted, and proposed remediation plans for components that are damaged or otherwise do not meet the contract specifications.

22.2.23 This initial factory inspection and test of network communications system components and subsystems shall be described in the factory inspection and testing plan, as approved by the Engineer.

22.2.24 Each network communication system component shall be tested before assembly into a subsystem or communication system, in accordance with the factory detailed inspection and testing procedures as approved by the Engineer. The purpose of this testing is to ensure each component is in good working order and compliant with the contract specifications. All types of components provided under this contract are subject to a component test. However, the Contractor may propose to exempt certain components subject to the approval of the Engineer. Further, the Contractor may also propose to perform sample tests from each type of component, subject to the approval of the Engineer.

22.2.25 The network communication subsystems to be inspected and tested include, but are not limited to, the vital processor communications network, vital processor diagnostics communications network, and the non-vital processor train

control communications network. To the extent that the vital processor diagnostics communications network and the non-vital processor train control communications network are one and the same networks, the Contractor may propose, subject to the approval of the Engineer, that their respective subsystem inspections and tests be combined.

22.2.26 Each subsystem of the network communications system shall be inspected and tested prior to integration into a communications system, in accordance with the detailed factory inspection and testing procedures as approved by the Engineer. The purpose of the inspection and testing is ensure that the subsystem is properly assembled and conforms to the associated Contract drawings. The purpose of the test is to ensure the proper physical and electrical assembly and interface of components, and to detect installation deficiencies.

22.2.27 Integration of each communication subsystem, a communications system inspection and test will be conducted at the factory. The purpose of the inspection is to ensure that the system is properly assembled and conforms to the associated Contract drawings. The purpose of this test is to ensure the communication system functions as a complete unit. Further, the purpose of this test is to ensure the proper physical and electrical assembly and interface of subsystems, and to detect installation deficiencies.

22.2.28 After completion of the integrated communication systems test is completed a signal system integration test shall be performed. The purpose of this test is to ensure that the operation of the communication system properly supports operation of the signal system. This test may be combined with testing performed as part of the signal system implementation, subject to the approval of the Engineer.

22.2.29 After completion of the signal system integration test, a single point of failure test shall be performed to demonstrate that the failure of any single communications device or communications link between a communication device and other communication devices, signal devices, or legacy equipment does not adversely affect any part of the operation of the signal system. This test may be combined with integration tests performed as part of the signal system implementation, subject to the approval of the Engineer. Types of failure to be tested include, but are not limited to:

a. Device power failures.
b. Physical link interruption, i.e. cable cut or connector failure.
c. Physical device port failure.
d. Device installed with improper configuration, e.g. installing a switch without proper VLAN programming.
e. Excessive data traffic broadcasts from any port.

22.2.30 Before requesting the presence of the Railroad for a Factory Acceptance Test, the Contractor shall conduct a dry run of the entire test using the approved test procedure.

22.2.31 The vital and non-vital network communication systems shall be connected to simulate the signal system field conditions. The test shall include all reasonable functions that the communications equipment, and connected devices are expected to perform.

22.2.32 If, in the opinion of Metro-North, the tests indicate that the equipment has not been adequately assembled or tested, the test shall be rerun at no additional cost to the Railroad at a time agreed upon between the Contractor and the Railroad. The tests shall continue until the results are satisfactory to the Railroad.

22.2.33 A certified letter of completion of factory inspection and testing shall be submitted to Metro-North to indicate that all required component, subsystem, and communications systems tests have been performed and that the signal and communication system as shipped is fully operable and ready for field installation.

22.2.34 A completed "As Built" set of plans and complete documentation shall be provided within 20 days of completion of the Factory Test. Delivery authorization of the systems shall be contingent on receipt of the "As built" documentation.

22.3 Field Testing

22.3.1 Following final field installation and interconnection of the signal and communications equipment by Railroad forces, Metro-North will conduct field-testing of the signal system as a whole before putting the system in service.

22.3.2 The field tests are intended to verify the proper and safe operation of all equipment and prove the adequacy and acceptability of the complete installation.

22.3.3 Field tests shall be performed on all installed network communication systems to verify performance and insure inter-operability with all signal and communications "legacy" equipment, where applicable.

22.3.4 Field-testing shall include testing of all controls and indications from the Operations Control Center.

22.3.5 The network communication systems field tests to be performed shall cause the communication systems to be sequenced through all required

operational conditions and shall include simulated conditions, such as alarm events, to prove that the installation is in compliance with the Specifications. This shall include, but not be limited to, validation of Form C contact closure alarms from network devices activating Vital Processor external alarm inputs and corresponding indications of all such alarms at both control centers.

22.3.6 In addition, integrated field tests that include all associated signal system and legacy equipment shall demonstrate that the complete signal system is functional and free of single points of failure in the communications equipment and links. These tests may be combined with the signal system tests. The required single-point-of-failure field tests shall include all single point of failure tests performed during factory testing.

22.3.7 Contractor shall provide a technical support team of engineers during field testing and cutover. The Contractor's field test support team shall be approved by the Engineer.

22.3.8 The Contractor's field test support team shall provide support to Metro-North in the proper working and troubleshooting of contractor supplied equipment under energized field conditions of the system as a whole.

22.3.9 Selected personnel from the Contractor's support team shall observe equipment working for two days after cutover and be ready to assist Metro-North in the event that trouble-shooting is required.

22.3.10 When a deficiency or problem is identified during field testing, it shall be the Contractor's responsibility to locate and isolate the cause and initiate corrective measures so that the field testing can be completed as rapidly as possible.

22.3.11 Within fourteen (14) days after completion field testing, a certified letter shall be submitted to Metro-North to indicate specifically all corrective measures taken, and to certify that the final installed signal and communications system, including the corrective measures as incorporated, is fully operational in accordance with the Technical Specifications and Contract Drawings.

22.3.12 Within fourteen (14) days after completion field tests, the Contractor shall provide revised CAD files of the all drawings for which field modifications have been made to address deficiencies, updated to accurately depict the final field conditions.

22.4 Final System Acceptance Test

22.4.1 After the signal and communication systems have been field tested to the satisfaction of the Railroad, the Railroad will conduct a 30-day final acceptance test with all installed communication systems in operation at all applicable locations. This test shall verify that any changes that have occurred due to field installation, startup, and testing have been correctly implemented. The Contractor shall provide on-call site supervision during this period, but the Railroad will be responsible for conducting this test.

22.4.2 If, during the period of the final acceptance test a failure occurs in the signal and communication systems, its subsystems, or its components, the test shall immediately be determined a "failure" and shall be restarted to the full 30-day requirement, at the discretion of the Railroad.

22.4.3 The Railroad shall be responsible for conducting the final acceptance test. The test shall consist of operating the system utilizing standard Metro-North operating methods, consistent with the procedures described in the approved Contractor documentation, and without special test equipment or procedures. Logs and records documenting the performance of all equipment shall be maintained by Metro-North personnel. The Contractor shall be responsible for the performance and functional operation of the Contractor-supplied equipment. Qualified Contractor service technicians shall oversee all maintenance, both preventive and remedial, on the equipment. When on-site maintenance support is needed, qualified Contractor personnel shall arrive at the site within 24 hours of notification throughout the test period.

22.4.4 All reliability back up equipment used during the final acceptance test shall be drawn from the reliability back up equipment inventory. The Contractor shall repair or replace all spares used during the test. If a part is required that is not in the Metro-North's reliability back up equipment inventory due to the failure of the Contractor to recommend appropriate reliability back up equipment, the equipment shall be repaired or replaced and an additional unit placed into the reliability back up equipment inventory at no cost to Metro-North.

22.5 Factory Access

22.5.1 Metro-North's representatives shall have free entry into Contractor shops while design, factory integration and factory testing are taking place. The Contractor shall provide the Railroad's representatives, at no cost, all reasonable facilities, equipment and documentation necessary to prove that the communication systems are being produced in accordance with the Specifications.

22.5.2 Inspections by Metro-North will include visual examination of each component. Contractor documentation will also be examined to verify that it identifies and describes all equipment and reliability back up equipment as required by the Specifications.

22.6 Preventive and Corrective Maintenance

22.6.1 The Contractor shall be responsible for performing repairs and recommended preventative maintenance on all system elements during inspection, integration, factory testing, installation, field testing, and system acceptance testing. Both preventive maintenance and repair logs shall be kept and provided to the Engineer. These logs shall provide a record of the work performed on all hardware, firmware and software.

22.6.2 The repair log shall include the complete identification of the item repaired, the date/time/location the malfunction was detected, a description of the malfunction, the date/time malfunction was corrected, and a description of the corrective action taken.

22.6.3 The preventive maintenance log shall include the complete identification of the item being maintained, the date/time/location of the maintenance performed, a description of the maintenance procedures performed, and a description of any problems encountered.

22.7 Factory Test Equipment and Calibration

22.7.1 The Contractor shall supply all test equipment required for factory and field testing. The type, manufacturer and model of supplied test equipment must be approved for use in each test by Metro-North. The Contractor shall not use any test equipment provisioned for delivery to Metro-North, to support any of these tests.

22.7.2 Each piece of test equipment shall have its own permanently affixed identification number. Test equipment shall be calibrated, adjusted and maintained at prescribed intervals, or prior to use, against certified equipment having known valid relationships to nationally recognized standards. Calibration shall be traceable to the National Institute of Standards and Technology (NIST).

22.7.3 The method and interval of calibration for each item shall be defined, based on type of equipment, stability, characteristics, required accuracy, intended use and other conditions affecting measurement control.

22.7.4 When test equipment is found to be out of calibration during use, the Engineer will conduct and document an evaluation of the validity of previous inspection and test results, to determine the acceptability of items previously

inspected and tested. If it is determined that the testing and inspection is invalid, a retest shall be conducted with properly certified test equipment, and resubmitted for approval. Any additional testing shall be performed at the Contractor's expense.

22.7.5 Out-of-calibration tools and equipment shall be tagged and not used until they have been re-calibrated and verified.

22.7.6 If any tools or equipment are consistently found to be out of calibration, as determined by the Engineer, they shall be repaired or replaced by the Contractor.

22.7.7 A calibration shall be performed when inaccuracy is suspected.

22.7.8 All calibrations/certifications shall be recorded and become part of the quality assurance records.

22.8 Test Procedures

22.8.1 Test procedures for factory and field tests shall be developed and sufficiently documented by the Contractor to ensure that each test is comprehensive, representative of the functions to be exercised and repeatable in whole or in part if so desired. A draft of each test procedure shall be submitted to the Railroad for approval at least sixty (60) days before the start of the test. The Railroad will approve test procedures only if they are inclusive and thoroughly test each communications system, subsystem, or component. The test procedures shall include, but not be limited to, the following information:

a. Test Schedule
b. Responsibilities of Contractor and Railroad personnel.
c. Record keeping assignments, procedures and forms.
d. Copies of any certified test data to be supplied by the Contractor.
e. List of all documentation to be used during the test.
f. A description of test equipment or data to be supplied by the Contractor.
g. Block diagram of each hardware test configuration(s) including equipment to be supplied by the Railroad.
h. Techniques and equipment used to simulate, or substitute for, devices and conditions not available during factory and field testing.
i. Problem resolution and procedures for handling variances.
j. Provisions for retest.
k. The purpose of each test and functions to be tested.
l. The detailed procedures to be followed.
m. The test set-up and test conditions.
n. All inputs and outputs.

o. Test firmware/software descriptions and listings.
p. Expected results.
q. Acceptance criteria.

22.9 Test Documentation

22.9.1 Factory inspection and test documentation shall be the responsibility of the Contractor. The complete documentation package for the signal and associated network communication systems shall consist of the inspection records, test procedures, and test records for each required test.

22.9.2 The Contractor shall maintain a complete record of all factory and field test results. The test records shall be available to the Railroad at all times and shall be submitted by the Contractor to the Railroad upon successful completion of all testing. The test records shall be keyed to the test procedures and shall include, as a minimum:

a. The signatures of the Contractor and Railroad personnel witnessing each of the tests and re-tests.
b. Any special test conditions or actions taken.
c. Test results, and the test date.
d. Software and firmware versions.
e. All serial numbers of associated hardware.
f. Space for comments by the witnesses.

22.9.3 A variance report shall be prepared and included in the test record each time a deviation from Specification requirements is detected. The report shall include a complete description of the variance, and indicate whether the variance is to be corrected immediately, at the end of the current test session, or at some identified point in the future.

22.9.4 Once corrected, the Contractor shall document all corrective actions taken to eliminate each variance by providing sufficient information to enable the Engineer to determine the need for re-testing the equipment, for testing interactions with any previously tested equipment, and for updating documentation as a result of the corrective action. The variance is eliminated when the Contractor and the Railroad have acknowledged, by signature, correction of the variance.

22.10 Unstructured Tests

22.10.1 The Railroad shall have open access to all tools and equipment during all factory and field testing for performing any unstructured tests deemed necessary by the Railroad. These unstructured tests shall be with the cooperation and guidance of the Contractor. These tests shall be performed by

the Contractor or by the Railroad under the guidance of the Contractor. The Contractor shall assume all responsibility for their tools and equipment being utilized during these tests.

22.11 Network Equipment Test Sets

22.11.1 The Contractor shall furnish to Metro-North three (3) complete test sets for troubleshooting and maintenance of the data communications networks established under this Contract, as defined elsewhere in these Specifications.

22.11.2 The network test sets shall be Fluke Networks model number ES2-LAN-SX/I-KIT or approved equal, consisting of an EtherScope Series II mainframe with LAN option, SX SFP with Fiber option, ITO/RFC2544 option, rechargeable Li-Ion battery pack (installed), protective holster, carrying strap, carrying case, AC adapter/battery charger, wire map remote (ID #1), RJ-45 coupler, patch cable, 128MB CompactFlash® card and resource CD, LinkRunner Pro w/ Reflector, LinkRunner Pro Li-Ion battery and AC adapter/battery charger, LinkRunner Pro carrying case.

22.11.3 The Contractor shall furnish three 100Base-FX SFP modules compatible with the above test sets as well as all fiber optic jumper cables necessary to interface the test sets to devices and patch panels equipped with ST, SC and LC connectors as specified elsewhere in this Specification.

22.11.4 The network test sets furnished by the Contractor shall, at a minimum, perform the following tests and functions:

a. Throughput, latency, frame loss and back-to-back testing in compliance with IETF RFC 2544
b. Jitter and FrameBERT testing
c. Network health and utilization monitoring
d. Testing and verification of RJ-45 UTP cabling including, but not limited to, pair lengths, opens, shorts, splits, crossed, straight through, and cable ID
e. Fiber optic power measurements including, but not limited to, receive input power, transmit output power, temperature, voltage and TX bias current
f. Traffic generation, digital and analog tone generation
g. Auto-discovery of LANs, VLANs and network devices
h. Both Layer 2 and Layer 3 traceroute functions
i. Analysis of network traffic including, but not limited to, protocol mix, top senders, top broadcasters and error sources
j. Graphical display of analysis and test results

22.12 Ruggedized Laptops

22.12.1 Three (3) ruggedized laptops shall be furnished under this contract shall be the Panasonic Toughbook 30, or approved equal, and shall meet or exceed the following specifications:

a. Ruggedized: MIL-STD-810F and IP54 compliant, 3-foot drop approved, full magnesium alloy case with handle, sealed all-weather design, rain-, spill- dust- and vibration-resistant, pre-installed replaceable film for screen protection
b. Operating System: Microsoft Windows XP Professional with latest service pack
c. Intel Core 2 Duo Processor L7500 1.6 GHz w/ 4MB L2 cache and 800 MHz FSB
d. 1 GB SDRAM (DDR2) standard, expandable to 4 GB
e. 80GB hard drive, shock-mounted and quick-release
f. Display: 13.3" 1024 x 768 XGA transmissive, daylight-readable TFT active matrix color LCD without touchscreen
g. Interfaces shall include, at a minimum: Serial D-sub 9-pin, three USB 2.0 4-pin, IEEE 1394a (FireWire) 4-pin, 10/100/1000Base-T Ethernet RJ-45, 56k Modem RJ-11, PC Card Type II slot
h. WiFi 802.11 a/b/g with authentication, encryption and hardware on/off switch
i. Manufacturer-specified battery operation time of 7 hours or greater
j. Accessories to be supplied shall include, at a minimum: AC Adapter (Panasonic part # CF-AA1653AM), Battery Charger (Panasonic part # CF-VCBTB1W), Carrying Case (Panasonic part # 7540-P)

22.12.2 The Contactor shall furnish all tools and test equipment required to reprogram, maintain and operate the vital microprocessor-based Ethernet network signal system equipment and associated site-specific program.

22.12.3 The Ruggedized Laptops shall include pre-installed OEM's latest diagnostic and maintenance software. This software package shall be "Maintenance Management System" developed by Alstom Signaling, "Maintenance Tools" developed by AnsaldoSTS or approved equal.

22.12.4 The Ruggedized Laptops shall include pre-installed network analysis software as defined elsewhere in this Specification.

22.12.5 One (1) computer engineering application specific to the Contractors vital and non-vital provided applications. This shall include, but not be limited to, compliers and all other software and licenses necessary for all elements of the products provided.

22.12.6 Software verification and validation program to verify that any changes made to the site-specific application logic (SSAL) was confined to the intended logic and thereby precludes the need for a system test of the entire content of the application EPROM or EEPROM. One program set shall be provided.

22.12.7 The Contractor shall supply all special tools and equipment required for operation and maintenance of the vital microprocessor-based interlocking system to the board level. This equipment shall be provided for each Interlocking.

22.12.8 A complete list of all proposed test equipment shall be submitted to the Engineer for approval. Test equipment shall be in accordance with the requirements of these Technical Specifications.

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23.0 DOCUMENTATION

23.1 Documentation Requirements

23.1.1 The Contractor shall provide complete and detailed documentation for all systems, subsystems, components, elements, products, reports, documents and manuals provided under this contract.

23.1.2 The Contractor shall provide both hard copies and electronic copies of all documentation provided. The Contractor shall provide all necessary licensing required for Metro-North to use the documentation.

23.1.3 All project specific documentation shall be developed and supplied using Microsoft Word and Excel. All Circuit plans shall be provided using AutoCAD 2013. The Contractor shall provide any special applications required to access any provided documentation.

23.1.4 The Contractor shall provide file naming conventions and file formats that are compatible with the existing Metro-North conventions. No file conversion processing shall be permitted to meet this requirement.

23.1.5 The Contractor shall develop a version control process to manage all documents provided for this contract. The Version Control system shall be submitted for review and approval.

23.1.6 The Contractor shall limit the use of documentation provided in Adobe PDF format.

23.1.7 Software documentation shall be as specified in the Vital Microprocessor and the Non-Vital Code System Section of these Specifications. CD-ROM shall be provided which contains all the necessary source files and development tools which are necessary to recreate and maintain the system. Should the system require software revision by the Contractor, a separate disk that contains the changed executable files and documented modified source code shall be provided for each revision.

23.1.8 The Contractor shall develop a "Documentation Set". This document shall contain the latest revised versions of all documents including all software, wiring diagrams, plans, manuals, training aids and databases. This document format shall be submitted for review and approval.

23.1.9 The Contractor shall supply a complete formal standalone "Definition Document" showing the operation of all aspects of the Local Control Panel Operation, indication panels and Software Programming. The document shall define, but not be limited to, all software variables, operations, timers, formats,

functions, inputs, outputs and components. The use of application comments is not permitted to meet this requirement. The document shall be approved by the Engineer prior to manufacture or programming.

23.1.10 Software to be furnished shall include, but not be limited to, computer-aided assembly packages, compiler programs, source code and all commercial and Contractor-designed software. PROM burners shall be furnished to make the EPROMs supplied as part of the system.

23.1.11 Documentation for commercial software packages shall be furnished to Metro-North within 30 days from "Notice of Award". As-built plans shall be delivered within 30 days of shipment of apparatus. One set of corrected factory plans shall be shipped with all apparatus.

23.1.12 The Contractor shall provide six (6) sets of the plans in a 11" x 17" and CAD drawing files created in the following format:

a. AutoCAD, Version 2013
b. CAD files shall be in their native .DWG format in a PC readable file format.
c. AutoCAD files shall be delivered to Metro-North on CD-R media, 4 copies each.

23.1.13 At "Notice of Award" Metro-North will provide the latest CAD standards to the contractor that includes, but is not limited to:

a. General Drafting Standards
b. Setting
c. Layer names
d. Text styles
e. Sheet Naming and Numbering
f. General Nomenclature and Abbreviations
g. File naming conventions
h. File formats

23.1.14 The Contractor shall provide a sample CAD file based on the latest CAD standards provided by Metro-North for approval by the Engineer, not more than 15 days from "Notice of Award". The layer names, conventions, block names, text styles, CAD file names, etc., shall be submitted for approval. The Engineer shall approve the organization of the CAD files, prior to preparation of CAD drawings.

23.1.15 Corrected factory plans and as-built plans and diagrams shall be provided in the specified format with six (6) hard copies.

23.1.16 The Contractor shall follow the convention of "RED" out and "YELLOW" in utilizing colored pencils, for any marked plans.

23.1.17 The Contractor shall supply all circuit plans such that when reproduced in an 11" x 17" format all areas of the circuit detail is easily readable.

23.2 Documentation Set

23.2.1 An "Information Directory and Master Index" shall introduce the documentation set. It shall describe the contents of the manuals and contain a master index that is used in referring to topics described in manuals that make up the documentation set. The descriptions shall be brief. Also listed in this directory shall be the file names of all computer files that make up this documentation set.

23.2.2 The Contractor shall provide a system overview which contains high level functional descriptions related to the design of the system. It shall describe system intent and organization and provide all system level diagrams that describe inputs, data flow, communications and outputs.

23.2.3 The Contractor shall furnish 10 hard copies (and a copy on disk using Word format for Contractor-developed documentation) of maintenance manuals, operator/user manuals, training manuals, engineering information, adjustment procedures and all other information required for proper installation, testing and maintenance of the system supplied under this Contract.

23.2.4 Manuals to be provided by the Contractor shall provide sufficient information such that Metro-North Railroad employees not able to attend training can operate and perform maintenance on the system by use of the manuals.

23.2.5 The Contractor shall provide specifications, internal wiring plans and part lists of all products of the Contractor's own manufacture as well as purchased components. The Contractor shall provide, but not be limited to, the following for hardware maintenance.

a. Hardware overview and architecture
b. Power distribution overview and details
c. Test Procedures
d. Schematics
e. Part lists with commercial parts listed cross referenced to the manufactures parts numbers
f. Board and system configurations
g. Rack layouts
h. Printed circuit board level descriptions
i. Board function descriptions

j. Component level descriptions
k. Troubleshooting techniques
l. Diagnosis
m. Material specifications

23.2.6 Apparatus shall be cross-referenced between apparatus location and plan location. The Contractor's method of cross-referencing shall be submitted for approval.

23.2.7 The referencing number of apparatus shall be shown wherever apparatus appears on the plan and shall be in accordance with the Metro-North standard reference number tabulation table. Contractor shall update this reference table and assign new numbers to any new equipment proposed for this project and approved by the Engineer.

23.2.8 The Contractor shall provide the following quantities of other documents:

a. Eight (8) copies of submittal.
b. Three (3) paper and six (6) copies of CAD drawing files, on Compact Disc-Recordable (CD-R) media, of the as-built plans. As-built plans include, but are not limited to:

    1. Circuit and Wiring Plans
    2. Cabling Plans
    3. Structure System Charts
    4. Code Charts and Point Listings

c. Copies of all software, in an PC compatible format on Compact Disc-Recordable (CD-R) media, four (4) Copies each, including, but not limited to:

    1. High level design documents
    2. Pseudo code flow charts
    3. Source code
    4. Compiled and linked executable code
    5. Test and simulation software used during development
    6. EPROM, loader software

23.2.9 The Contractor shall submit 25 copies of Vital Relay Test and Maintenance Procedures for each type of relay supplied.

23.2.10 Metro-North shall be furnished 25 copies of all manuals, specifications of apparatus that make up the entire system furnished. This to insure proper installation, adjustment, maintenance, trouble shooting and repair, including

adjustment tables for coded track circuits.

23.2.11 The Contractor shall provide Metro-North with a complete set of all applicable Application Requirements documents for the system and components being supplied, and shall insure that these Applications Requirements have been satisfied in every regard in the design, manufacture and assembly of the system being provided. Specific compliance with the Application Requirements shall be included as a part the inspection sheets required under the Contractor's test procedures. If, at the sole discretion of the Engineer, the system or components of the system are found not to comply with the Application Requirements effective at the time of manufacture and assembly, the Contractor shall make the necessary corrections and shall be responsible for any and all costs associated with bringing the systems and components into full compliance.

23.3 Vital Microprocessor Design Documentation

23.3.1 The Contractor shall also submit a complete design description of the vital microprocessor-based interlocking control system hardware and software, including the typical Boolean programming equations. All vital and non-vital programming and vital circuit design shall be in accordance with Metro-North's Communications & Signal Department Typical Signal Circuit Engineering Operating Manual, Section 205, Vital Node Logic Philosophy and Section 206, Vital Signal Circuits, respectively. The document shall be submitted first as a high level description of the system design and then as a detailed description of the system design. This documentation shall be in general conformance to the latest issue of IEEE 1016, "Recommended Practice for Software Design Descriptions."

a. The high level description shall include:

    1. Identification of all major hardware and software components, interfaces, databases, system architecture, and sizing and timing estimates. Operational timing under peak and maximum (including future) loading conditions shall be specifically addressed.
    2. Functional descriptions of how the system design components shall work together as a system to fulfill the functional requirements. Matrixes or similar methods shall be used to demonstrate that all functional requirements of the vital microprocessor -based interlocking control system are being met.
    3. A description of the techniques which shall be utilized in the design to maintain the safety of the vital processing of the system.
    4. A description of how vital SSAL shall be generated and implemented.

5. Sizing; i.e., processor and memory utilization, expansion capability/ techniques and spare capacity, as well as the methods for how system sizing is determined.
6. The method of making modifications to the application software after operational testing. The Contractor shall have a vital method of verifying/testing modifications without requiring a complete retest of the operational testing, i.e., the Contractor shall have methodology to verify the elements of the application which change and which do not change when a modification is made. This methodology shall be explained.

b. The detailed submittal of the Design Documentation shall provide:

1. A breakdown of all major system components down to the lowest level components.
2. The functional descriptions shall be updated to describe in detail how the functional requirements of the system are to be implemented. These functional descriptions shall be provided using either a structured pseudo-coding language or design language and shall be augmented with graphical representations.
3. Detailed data and database descriptions shall be included as a Data Dictionary describing the usage, formatting, and handling of each element.
4. The detailed design document shall clearly identify which lowest level components and interfaces are vital and which are non-vital.
5. Schematics and block diagrams of hardware design.
6. SSAL expressed in a Boolean expression form, for each interlocking.

23.3.2 The Contractor shall provide a complete and detailed program printout of all application code software for each vital processor, both vital and non-vital. The program shall be modularized in a logical and easily understood manner. The software listings and block diagrams shall clearly distinguish between vital and non-vital software modules and procedures. Each module of the program shall be fully documented with plain- English explanations of its purpose and the methods by which it accomplished that task, the modules and data to which it is related, the modules of which it is a part, as well as a revision log. Nesting circuits and other software documentation will be bracketed and indented.

23.3.3 The Contractor shall provide all Verification and Validation Testing plans, procedures, and reports for approval. The Software Verification and Validation documentation shall meet the requirements of the approved SVVP.

23.3.4 A formal configuration control procedure shall be required and implemented. Configuration control prior to factory testing need not be as

rigorous as after factory testing. All ICs, PCBs, components, etc., which are subject to revision (such as PROM, EPROM or EEPROM) shall have the revision level check sums and CRC values identified on the component and cataloged from factory to in-service testing.

23.3.5 The Contractor shall furnish test equipment and submit documentation of the equipment required to perform diagnostic, functional and operational testing of the vital electronic equipment.

23.4 Software Version Control

23.4.1 Software version control conventions for Contractor-supplied software shall be established by Metro-North prior to commencement of the project. Configuration control of the system shall be auditable by Metro-North at any point in the system development. IEEE version control shall be used as general guidelines so that industry standards can be adhered to.

23.4.2 The system shall be tested and ready for service with the latest releases of the following third party software:

a. Operating systems
b. Compilers
c. Assemblers
d. Linkers
e. Software libraries used in the system
f. Network and communications software
g. Any other third-party software product that is deemed as a deliverable

23.5 Signal Circuit Design and Program Logic Submittals

23.5.1 The Contractor shall submit detailed signal circuit design drawings for approval of the Engineer in accordance with the following:

a. A non-detailed typical signal circuit design has been developed for this Project and is indicated within the Contract Documents. The Contractor shall develop the final detail signal circuit designs for this project, including the tie-in circuitry to the existing signal system.
b. Complete system-wide detailed circuit plans and software listings shall be provided showing all the termination points, relay coils and contacts, microprocessor vital and non-vital logic functions and equipment, controls, signal and communication network equipment and energy buses, complete with all interconnections and tie-in circuitry to the existing signal system.

    1. These plans shall be the controlling documents of the design and shall be developed and be under the control of the same design

group, team, manager and designer within the Contractor's organization from the start to completion of the design. It shall be the Contractor's responsibility to determine by means of a recheck of the completed system signal circuit plans that these plans provide the safety and operation required by these Technical Specifications.

2. Detailed signal circuit plans shall be submitted to and approved by the Engineer, prior to any factory wiring of racks, cases or housings.

c. The Contractor's detailed signal circuit design shall be based on the Intent of the typical signal circuit design shown in the contract drawings and described within these Technical Specifications. No modifications to the typical signal circuit design shall be made unless prior written approval is granted by the Engineer.

23.5.2 As-built or final drawings and documents shall be submitted to and approved by the Engineer, prior to tendering the system or system section for substantial completion. These drawings and documents shall include the latest revision of all previously submitted drawings and documents and shall show the final system configuration.

a. Before final acceptance of all work to be accomplished under this contract, the Contractor shall submit to Metro-North as-built drawings, shop drawings, schematic drawings, parts lists, maintenance manuals, and product literature. All project correspondence including test procedures, reports, analysis, submittals, and letters shall be submitted on CD-R media, two (2) copies each.
b. The Contractor-prepared documentation shall include, but not be limited to, the following:

1. Detail Signal and Communication system Circuit Design.
2. Equipment housing layouts.
3. Vital and non-vital microprocessor-based equipment rack layouts.
4. Terminal assignments.
5. Apparatus rack and mounting board assignments.
6. Relay contact assignments and signal circuit design drawings and diagrams.
7. Signal power design details, circuits and arrangement.
8. Local control panel design details, circuits and arrangement.
9. Four (4) copies each on CD-R media containing all ASCII files and paper copy of these files of user-defined software and application programs in the vital processor systems and non-vital processor systems.
10. Original installation disks/CD ROMs of all commercial software.

23.5.3 The Contractor shall provide final conformed 100% documents within 14 days of receiving final Engineer's comments.

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24.0 QUALITY ASSURANCE

24.1 Quality Assurance Program

24.1.1 The Contractor shall establish and maintain for this project a Quality Assurance Program as specified in Appendix A "Quality Assurance Program" these Technical Specifications.

24.1.2 Contractor shall submit their project Quality Assurance Program to the Engineer for approval.

24.2 Design-Build Quality Management System Manual

24.2.1 The Contractor shall develop and maintain for this project a Design-Build Quality Management System Manual as specified in Appendix B "Sample Design-Build Quality Management System Manual" within these Technical Specifications.

24.2.2 Contractor shall submit their project Design-Build Quality Management System Manual to the Engineer for approval.

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25.0 RELIABILITY, MAINTAINABILITY & AVAILABILITY

25.1 Scope

25.1.1 The Contractor shall develop and submit for review and approval a Reliability, Maintainability and Availability (RMA) program specific for the requirements for this Contract. The program shall focus only on the systems, subsystems, components and products provided by the Contractor for this project.

25.1.2 The Contractor shall only select systems, subsystems, components and products that will provide the highest levels of RMA performance.

25.1.3 The Contractor shall work closely with Metro-North Railroad and submit the Metro-North Railroad identified RMA deliverables.

25.1.4 The Contractor shall submit RMA deliverables as identified in this section shall be in accordance with the overall design submittals.

25.1.5 The following table identifies the RMA deliverables tied to the package schedule.

Table 1
RMA Deliverable Schedule

RMA Elements	RMA Deliverables	Design Submittal		
		60%	90%	100%
General	Organizational RMA Capabilities	✓		
	Subsystem Hierarchy Structure	✓		
Reliability	Reliability Prediction Analysis	✓	✓	
	FMECA		✓	✓
Maintainability /Accessibility	Maintainability Analysis (Corrective & Preventive Actions)		✓	✓
	Accessibility Analysis		✓	✓
	Handling Analysis			✓
	Modularity Analysis		✓	
	Diagnostic Analysis			✓

25.2 Contractor Organizational RMA Capabilities

25.2.1 The Contractor shall provide details of its capabilities in terms of the available manpower to perform the RMA activities. The qualifications of the identified personnel shall also be stated.

25.3 Reliability

25.3.1 The section outlines various reliability specific deliverables required from the Contractor. The Contractor shall be responsible to achieve the minimum reliability goals specified by the Metro-North Railroad in the contract. The assurance regarding the system's ability to achieve this goal shall be provided in the design stage through the Reliability Prediction Analysis (RPA).

25.3.2 Reliability Prediction Analysis:

a. The Contractor shall be required to prepare a Reliability Prediction Analysis (RPA). The purpose of the RPA is to provide assurance prior to manufacturing that the required subsystem level reliability requirements will be achieved and potential sources of unreliability in design are identified for reliability improvement. These requirements are identified later in this section.
b. The RPA involves calculating failure rates and MTBF's for all assemblies that make up the subsystem.
c. The basic reliability model shall be used to estimate the subsystem MTBF and the demand for maintenance and logistic support. The failure rates for the equipment of each subsystem shall be obtained from historical field performance wherever possible. The Contractor shall collect this data from the field performance of similar systems already in use under a comparable environment. This field failure data shall be used to arrive at the individual component/assembly level failure rates.
d. When historical performance data is not available, equipment failure rates may be calculated using MIL-HDBK-217, NRPD (Non-electronic Parts Reliability Data) published by the Reliability Analysis Center (RAC) or any other applicable source of failure rate data submitted and approved by the Engineer.
e. As stated earlier, when possible, the component level failure rate shall be based on historical performance of comparable equipment in an application and environmental similar to that of the project. The following data to the extent necessary to substantiate failure rates shall be furnished by the Contractor to Metro-North when approving the component level failure rates:

1. Prior application and environment.
2. Adjustment factors and related reasons used to modify historical data to project equivalent performance. (Adjustments could consider differences in application location and date of use.)
3. Equipment identification.
4. Number of failures experienced during the operating hours for which the analyses are presented.

f. The Contractor shall be required to meet or exceed the following minimum reliability requirements for entire package.

Table 2
MTBF & MTTR Values

DESCRIPTION	MTBF HOURS	MTTR HOURS
Vital Relays	2,000,000	1.0
DC Power Supplies & Rectifiers	40,000	1.0
Audio Frequency Overlay Track Circuits	75,000	0.5
AC Track Circuits	300,000	0.5
Local Control Panel Indication Circuits	100,000	1.0
DTS - Indication	500,000	0.5
DTS - Controls	500,000	0.5
DTS - Common	80,000	0.8
Vital Microprocessors	75,000	1.0
Non-Vital Microprocessors	175,000	1.0
Ethernet Switches	500,000	1.0

25.3.3 Failure Modes Effects and Criticality Analysis

a. A Failure Modes Effects and Criticality Analysis (FMECA) is required from the Contractor for all subsystems having direct safety implications or having the potential to cause service delays. Contractor will identify specific subsystems as having safety or service implications. The FMECA for existing proven designs shall be done at the assembly level looking only at the failure modes of the outputs of the assemblies. The FMECA shall identify the effects of each failure mode of each

assembly in order to predict the effect on the subsystem. Historical failure mode data shall be used where available.

b. The FMECA is expected to identify:

    1. Potential safety issues
    2. Safety category for each failure mode
    3. Potential service affecting failures
    4. Latent or hidden failures

c. The FMECA provides a basis for fault detection and diagnostic procedures. The FMECA also identifies specific safety or service related preventive maintenance actions necessary for the mitigation of undesirable failure modes. Any identified actions shall be included in the maintenance manuals.
d. Areas offering potential for improvement will be identified.
e. Where the subsystem utilizes existing proven components FMECA are to be done using assembly level failure modes. This information is required to identify possible safety and service issues in the system.

25.4 Maintainability

25.4.1 The Contractor shall take all necessary steps to ensure that the required maintainability aspects are integrated into the equipment provided under this section.

25.4.2 Preventive Maintenance (Scheduled)

a. Contractor shall prepare and submit a Preventive Maintenance (PM) task analysis for each applicable system, subsystem, component and product. The PM task analysis shall include all servicing, inspections, scheduled overhaul, or any maintenance related task required on a scheduled basis. The Contractor shall also include the frequency of PM tasks and resources required for each of the PM activities including manpower, materials etc. The elapsed time to perform specific tasks is to be defined in the analysis.
b. Safety-Critical Preventive Maintenance (SCPM) shall be identified. These are the tasks required as a means of detecting safety-significant latent or hidden failures, which would otherwise remain latent until a subsequent failure results in a potential hazardous event.
c. The SCPM tasks are a result of performing safety analyses on all required subsystems. The Failure Modes Effects and Criticality Analysis has provisions for the identification of SCPM tasks.

25.4.3 Corrective Maintenance (Unscheduled)

a. Corrective maintenance is performed to restore an item to a specified condition after the item has suffered failure or degradation below the specified performance. Mean Time To Repair (MTTR) shall be used as a measure to quantify corrective maintenance. The maintenance times are to include access time (through equipment access cover, etc.), diagnostic time, in place repair time or remove/replace time and functional test time. Access time does not include the access time related to the physical location of the equipment (e.g. traveling time and access through equipment supplied by others).
b. The Mean Time To Repair (MTTR) for various sub-systems shall not exceed values mentioned in Table 2. On overall system level (entire CIL) MTTR shall not exceed 1 hour. This is the average time required to repair once a qualified technician with proper tools and reliability back up equipment arrives on the site of failure.

25.4.4 Maintainability Analysis Reporting

a. In order to document its maintainability improvement efforts, the Contractor shall conduct and submit a detailed Maintainability Analysis (including Preventive and Corrective Maintenance) for all equipment provided under the contract. As identified in Table 1, this analysis is required at the 90 and 100% design submittal.

25.4.5 Accessibility Analysis

a. Access time is an important part of any repairable system. Access time is the time required to access the component/sub system for the purpose of repairing, testing, troubleshooting, or performing preventive maintenance. The Contractor shall design the system with the objective of minimizing the total access time. The Contractor shall at 90% and 100% design reviews provide an accessibility analysis. Methods for improving the accessibility times shall accompany the analysis.

25.4.6 Handling Analysis

a. The Contractor shall submit to the Engineer a detailed handling analysis that shall include special handling requirements required in preventive and corrective maintenance. It shall include:

    1. Identification of any special handling equipment required for transporting or installing/removing the subsystem equipment.

2. Procedures and precautions associated with transporting or installing/removing the subsystem equipment.
3. Any other handling requirements, associated with the equipment.

25.4.7 Modularity Analysis

a. A "Module" in this context is an assembly that can be removed and replaced as a unit in order to restore the equipment to operation after a failure. Dividing the equipment into modules reduces the diagnostic effort needed to identify the hardware that must be replaced to restore the equipment to operation.
b. The Modularity Analysis shall identify all Line Replaceable Units (LRUs). The Contractor shall furnish a complete list of all modules including their weight, mounting arrangements and electrical connections to the Engineer for approval.

25.4.8 Diagnostic Analysis

a. The FMECA identifies how each failure mode will be detected.
b. The diagnostics are to be tested by means of simulating faults in the subsystem.

26.0 SAFETY ASSURANCE PROGRAM REQUIREMENTS

26.1 Scope

26.1.1 The Contractor shall develop a Safety Assurance and System Performance (SASP) Program as required by these Technical Specifications and Contract Drawings.

26.1.2 The SASP shall be integrated into all phases of this Contract.

26.1.3 The SASP Program shall outline the Contractor's methods for evaluation of the signal system's design in regard to safety and to identify hazards and prescribe corrective action in a timely, cost-effective manner.

26.1.4 The SASP Program shall prescribe a formal approach to the elimination of hazards through engineering, design, education, management policy, and supervisory control of conditions and practices, and shall be in accordance with MIL-STD-882-C.

26.1.5 The SASP Program shall supplement the fail-safe design requirements of these Specifications, but shall not relieve the Contractor of fail-safe design responsibility in any way. The Contractor shall comply with the safety design; implementation and analysis requirements contained in these Specifications in the construction of all system hardware and software which either performs, or could affect the performance of, vital functions.

26.1.6 The Contractor shall designate vital hardware as hardware, which under failure, can adversely affect the safety of train movements; and/or adversely affects the operation of the Metro-North wayside or on-board signal systems or delivery of service to the Metro-North customers. Further, if the safe implementation of a vital function is dependent in whole or in part on the absence of failures in the hardware circuit or device, then that hardware is vital.

26.1.7 Class I vital hardware is vital hardware whose failure modes and characteristics can be accurately identified, predicted and exhaustively tested. The occurrences of failure modes that could have unsafe consequences are eliminated, prevented, or otherwise accounted for by design.

26.1.8 Class II vital hardware is hardware whose failure modes may adversely affect the safe implementation of a vital function, but which is not designed as vital hardware. Class II vital hardware shall be considered vital. Failure modes in this hardware are revealed or otherwise accounted for by means other than vital hardware design techniques. These means include, but are not limited to, software checking and comparison of independent hardware circuits.

26.1.9 Non-vital hardware is defined as all hardware which is not vital. Non-vital hardware shall be clearly delineated from vital hardware.

26.1.10 Vital software is a combination of system executive and application software required for the implementation of vital functions. Vital software is software whose execution is required for the implementation of a vital function.

26.1.11 Non-vital software is all software which is not vital. Since execution of an error in non-vital software operating in the same processor as vital software could affect implementation of a vital function, that non-vital software shall be subjected to the same requirements as vital software.

26.1.12 A vital function is a system function of which the correct performance affects the safety of passengers, personnel, equipment, or environment. In addition, a system function of which the incorrect performance allows a hazardous situation to exist which may adversely affect safety of passengers, personnel, equipment, or environment either immediately or subsequently shall be considered a vital function.

26.1.13 The Contractor shall also be required to establish and maintain a Software Quality Assurance Program (SQAP) as described elsewhere within the Vital Microprocessors Section of these Specifications.

26.2 SASP Program Requirements

26.2.1 The Contractor shall be responsible for the management and operation of the SASP Program. The responsibilities and functions of those directly associated with SASP policies and implementation of the program shall be clearly defined. The authority delegated to this organization and the relationship between line, staff, and interdepartmental, project, functional, and general management organizations shall be identified. It is not the intent of this Section to prescribe or imply organizational structure, management methodology, implementation procedures, or internal documentation.

26.2.2 For the purposes of these Specifications any element, either software or hardware, of the system which can affect the safety of the system shall be considered vital. Failure of any element or combination of elements of the system shall not result in an unsafe output or state of the system. Any element which does not affect the safety of the system shall be considered non-vital.

26.2.3 The Contractor shall analyze the system and identify all vital interfaces between the vital microprocessor interlocking controller, vital intermediate controller, track circuits, switch machine controllers, signal control, vehicle on-board cab signal systems and all other systems, including cab signal, signal power, and control center systems. These links shall include machine/machine

interfaces, man/machine interfaces, training, maintenance, rules and procedures.

26.2.4 The Contractor shall be responsible for the assurance of safety of the signal system. The Contractor shall provide, as part of the SASP Program, definitive and comprehensive proof, including historical and statistical data, of the safety of the train control system, in particular the vital microprocessor interlocking portions of the system.

26.2.5 Contractor shall conduct and submit to the Engineer for review and approval, a Preliminary Hazard Analysis (PHA) on each non-identical Signal (ATC) system and for the entire signal system covered by this Contract. The analysis shall identify all hazardous conditions and the faults which precipitate them as well as specify ways to prevent the occurrence of any hazardous conditions or faults identified. When faults or hazardous conditions cannot be prevented, the Contractor shall simulate the impact of the hazard upon Metro-North, and develop means to mitigate such impacts.

26.2.6 The PHA shall include, but not be limited to, the following subsystems, interfaces, and potential hazard areas:

a. Vital Microprocessor Interlocking Control
b. Vital Intermediate Control
c. Signal Lighting
d. Switch Control and Correspondence
e. Route Locking and Route Integrity
f. Traffic Locking
g. Track Circuit Interface
h. Cab Signal Code determination/output
i. Line Circuit Interface inputs/outputs
j. Vital Fiber Optic Network
k. Ethernet Switches
l. CTC/Diagnostic Fiber Optic Network
m. Interface between Control Center Systems, including office and field non-vital code system interface and operating personnel

26.2.7 Hazard Severity Categories: Hazard severity categories are defined to provide a qualitative measure of the worst potential consequences resulting from personnel error, environmental conditions, design inadequacies, procedural deficiencies, system, subsystem or component failure or malfunction as follows:

a. Category IV – Negligible
   Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies will not result in personal injury, or system damage.

b. Category III – Marginal
   Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies can be counteracted or controlled without personal injury or major system damage.
c. Category II – Critical
   Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies will cause personal injury or major system damage.
d. Category I – Catastrophic
   Hazardous conditions such that human error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies will cause death or serious injury to human beings or major system loss.

26.2.8 The Contractor shall provide and submit to the Engineer for review and approval, analysis and verification that the translation of the functional requirements of these Specifications to application software meets the design and implementation requirements of the Vital Microprocessors and Non-Vital Microprocessor-based Code System interface portions of these specifications, and if implemented correctly and without failure produce safe system operation.

26.2.9 The Contractor shall perform and submit to the Engineer, a Fault Tree Analysis (FTA) identifying all vital functions performed by the signal system, including all interlocking functions and signal functions implemented in either software or hardware. The faults identified in the PHA shall be used as the initiation point. The analysis shall begin at the faults and shall branch through all software and hardware to identify those components that affect the safe operation of the system.

26.2.10 The Contractor shall provide and submit to the Engineer, a complete safety analysis of the signal system. The safety analysis shall demonstrate how and to what degree the safe implementation of each vital function is assured. The Contractor shall analyze each portion of the system with regard to those factors in the Contractor's design upon which the safe implementation of the vital functions is dependent.

26.3 SASP Program Tasks and Procedures

26.3.1 The SASP Program shall specifically describe the procedures and activities which the Contractor shall follow in order to assure an acceptable level of SASP. The SASP shall describe the Contractor organizations(s) involved in the execution of each activity, describe how each task is to be performed, provide a schedule identifying the schedule for each task, and describe the output products of each task including identification of deliverable data. These

tasks shall include, but not be limited to, the following:

a. Identify hazards and take measures to mitigate the effects on SASP to an acceptable level. The goal shall be to eliminate and/or control the identified hazards. Hazards which cannot be eliminated through design are to be controlled by providing safety devices, warning devices, and adequate training and procedures.
b. Identification and correction of safety-related hazards as early in development as possible.
c. Preparation of a Preliminary Hazard Analysis.
d. Preparation of a Fault Tree Analysis.
e. Identification of vital functions and vital system components.
f. Traceability and control of hazards though all phases of development.
g. Preparation of a System and Subsystem Hazard Analysis which identifies and analyzes hazards associated with each individual system or subsystem, its elements, and internal interfaces, for each individual and non-identical system within the entire signal stem, including all interlocking systems, track circuit, switch machine controllers, cab signal, control center system and non-vital code systems.
h. Preparation of an Interface Hazard Analysis which identifies and assesses hazards between systems within the signal system, including all interlocking systems, track circuit, switch machine controller, cab signal, control center systems, and non-vital code systems.
i. Preparation of an Operating and Support Hazard Analysis which identifies and analyzes hazards associated with personnel and procedures during production, installation, testing, training, operations, maintenance, and emergencies.
j. Eliminate the evoking of any false proceed commands or false proceed signal aspects from the system.
k. Minimize the number of false restrictive or stop commands and false stop signal aspects.
l. Evaluate design changes and the impact these changes will have on the safety of the complete signal system, including all interlocking systems, track circuit, switch machine controller, cab signal, control center systems and non-vital code systems.

26.3.2 The Contractor shall provide and submit to the Engineer, for review and approval, a definitive and comprehensive demonstration of the safety assurance of the signal system including the interlocking, track circuit, switch machine controller, cab signal, control center and non-vital processor-based portions of the system. The Contractor shall analyze each portion of the signal system with regard to those factors in the Contractor's design upon which the safe implementation of vital functions is dependent. The minimum requirements of this analysis shall be as follows:

a. Safety assurance of vital application logic: The Contractor shall submit verification that the vital and non-vital logic implemented within the vital microprocessor application software produces safe system operation if implemented correctly and in absence of failure. This is to include vital microprocessor interlocking control, intermediate microprocessor control, track circuit systems, signal control, cab signal control, switch machine controller, including audio frequency overlay track circuits.
b. Safety assurance of vital hardware: The Contractor shall perform analysis on all hardware identified as Class I and Class II vital hardware. A Failure Mode and Effects Analysis (FMEA) shall be performed and submitted to the Engineer, on Class I vital hardware in accordance with MIL-STD-1629, and showing as the minimum:

26.3.3 All failure modes of all components shall be analyzed and tested by being induced or simulated on the physical hardware circuit. All failure modes specifically associated with the final fabricated form of the hardware, e.g., trace and component separation, shall be analyzed on the circuit fabricated in final form.

26.3.4 The FMEA shall classify all failure modes as self-revealing or non-self-revealing.

26.3.5 The FMEA shall show that no single failure mode produces an unsafe condition.

26.3.6 The FMEA shall show that all combinations of failures produce no unsafe condition, other than combinations of independent, self-revealing failures.

26.3.7 The FMEA shall show that if any unsafe condition results from the combination of two or more failures, that those failures are all self-revealing and wholly independent.

26.3.8 Vital Class I hardware shall be shown to have no failure mode that has an unsafe effect on the implementation of vital functions.

26.3.9 Vital Class II hardware for which all failure modes cannot accurately be identified, predicted, and exhaustively tested but under failure affects the safe implementation of vital functions shall be analyzed as follows:

a. All vital Class II hardware failures shall be shown to be detectable and once detected, subsequent action assures that no unsafe effect is produced.
b. Designs which incorporate self-checking shall be analyzed to show:

1. All failures that could adversely affect the safe implementation of vital functions have been anticipated.
2. Mechanisms incorporated to detect the occurrence of each failure are effective in revealing the failure.
3. The revealing of failures in no way compromises the safe state of the system
4. The mechanisms to reveal failures and the subsequent system reaction to the occurrence of the failure cannot be compromised by the failure itself, or any subsequent failure or combination of failures, or by unrevealed errors in the software.
5. Designs which incorporate checked redundant comparison shall be analyzed to show all failures that could adversely affect the safe implementation of vital functions have been revealed by detecting differences in the points of comparison of the systems.
6. Designs which incorporate checked redundant comparison shall be analyzed to show the comparison mechanisms incorporated to detect the occurrence of each failure has no mode of failure that could compromise its ability to detect differences between the systems.
7. Designs which incorporate checked redundant comparison shall be analyzed to show the revealing of failures in no way compromises the safe state of the system.
8. Designs which incorporate checked redundant comparison shall be analyzed to show the mechanisms to reveal failures and the subsequent system reaction to the occurrence of the failure cannot be compromised by the failure itself, or any subsequent failure or combination of failures, or by errors in the software.

c. Safety Assurance of Non-Vital Hardware: The Contractor shall submit an analysis for all non-vital hardware proving that operation of or failure within that hardware has no effect on the safe implementation of any vital function.
d. Safety Assurance of Vital Software: The Contractor shall perform and submit an analysis on all vital software using a well-structured, systematic, and comprehensive methodology. The analysis shall show that the logic, structure, algorithms, and coding of all vital software, including its subsequent translation into machine-readable language, contain no errors that can adversely affect the vital implementation of any vital function.
e. Safety Assurance of Non-Vital Software: The Contractor shall provide and submit an analysis for all non-vital software executed by the same processing equipment as vital software. The non-vital software analysis shall be similar in form to that of the vital software analysis and shall meet the same requirements.

f. For vital relay based equipment, a circuit analysis shall be performed and submitted by the Contractor, to assure that the implemented logic is correct and that the implementation of the relays is correct. An analysis of the application logic shall be performed by the Contractor to assure that the implemented logic is correct and no additional functionality is included. This is the accepted proof-of-safety for the vital relay equipment.
g. Operating and Support Hazard Analysis (OSHA) shall be performed and submitted to evaluate activities for hazards or risks introduced into the system by operational and support procedures. Additionally, operational and support procedures introduced to mitigate other identified hazards and risks shall be evaluated for adequacy.

26.4 SASP Program Objectives

26.4.1 The Contractor's objectives shall be in consonance with the SASP objectives.

26.4.2 The primary objective of the SASP Program shall be to assure the safety of the system. This shall be met through the implementation and management of a comprehensive program to identify and eliminate hazards, whether actual or potential, which adversely affect the safety of the system. These are hazards which could result in injury or loss of life, unrefurbishable property damage, or loss of a portion of the signal system. This applies both directly and indirectly, e.g., whether the injury, damage, or loss was to be caused directly by train control system malfunction or indirectly by the resultant unsafe operation of one or more trains.

26.4.3 The secondary objective of the SASP Program shall be to minimize the extent of damage to equipment and property due to any malfunction of the signal system or the trains themselves which cannot be fully mitigated or eliminated.

26.5 Submittals

26.5.1 The Contractor shall provide the following Safety Assurance submittals during the course of the Contract for approval of the Engineer. These submittals shall be separately identified as "safety related submittals" by the Contractor. The required submittals include:

a. Description of the Safety Assurance Concept(s): The Contractor shall provide a complete and well-structured description of the safety assurance concept(s) under which the vital microprocessor interlocking controllers, intermediate microprocessor controllers, signal control, cab signal control, switch machine controllers, and audio frequency overlay track circuits performing vital functions shall be designed and

implemented. This shall be submitted with proposal. The description of each concept shall indicate, clearly and in detail, how vital functions are performed such that failures in hardware and/or errors in software will not result in a more permissive condition or action than the overall system conditions safety permit. Included in this submittal shall be identification of fundamental assumptions made with regard to the assurance of SASP.

b. Description of Factors Upon Which Safety Assurance Is Dependent - The Contractor shall identify and provide a complete description of all individual factors upon which the safety assurance of the system is dependent. The Contractor shall include, as a minimum, all factors from the following list that are applicable:

1. Dependence upon the software being 'error-free', i.e., being free of software errors that could adversely affect the safe implementation of a vital function.
2. Dependence upon software functions, logic, or coding being present, i.e., dependence upon portions of the software not being omitted.
3. Dependence on the completeness and/or correctness of software data structures, constructs, or tabular application data.
4. Dependence on the absence of hardware failure in defined modes in circumscribed portions of the system.
5. Dependence on the self-revealing characteristics of hardware circuits or components under failure.
6. Dependence on the comparison of two independent processes to validate a permissive decision, condition, or action; the frequency with which the comparison is made; and the depth in the decision-making process at which the comparison is made.
7. Dependence upon the degree to which two or more hardware and/or software systems or processes are independent.
8. Dependence upon the accuracy and completeness of the set of anticipated hardware failure modes that are tested to reveal hardware failures.
9. Dependence upon the absence of electrical noise or disruption in signals being measured or monitored, or in logical processing.
10. Dependence upon the performance of a function, the execution of a software component, or any positive action being performed.
11. Dependence on test intervals or periodic maintenance.

26.5.2 Description of Safety Assurance Techniques - The Contractor shall provide a complete description including examples and details, of the techniques to be used to assure that each factor upon which the safety assurance of the system depends is effectively and comprehensively satisfied.

26.5.3 Description of Methods of Analysis - The Contractor shall provide a description of the individual analysis methods to be used to confirm the safety of the system, including a statement of the extent to which each analysis method is effective, and verification of that effectiveness. The description shall also indicate the specific high-level system components, hardware and software, to which each analysis method is applied. The analysis methods shall conform to the analysis requirements herein specified.

26.5.4 Application Logic Analysis - The Contractor shall provide documented analysis showing the translation of the functional requirements into a set of logical constructs and including the verification of the safety of the logic.

26.5.5 Vital Hardware Analysis - The Contractor shall provide analysis of the safety of the vital hardware and shall comply with the requirements of this Section.

26.5.6 Non-Vital Hardware Analysis - The Contractor shall provide analysis of the non-vital hardware and shall comply with the requirements of this Section.

26.5.7 Vital Software Analysis - The Contractor shall provide analysis of all vital software contained in the systems and shall comply with the requirements of this Section.

26.5.8 Non-Vital Software Analysis - The Contractor shall provide analysis of all non-vital software contained in the systems and shall comply with the requirements of this Section.

26.5.9 Relay Circuit Analysis - The Contractor shall provide analysis of the vital relay based circuits and shall comply with the requirements of this Section.

26.5.10 The Contractor shall submit monthly SASP Reports. These reports shall include descriptions of hazards detected and progress in implementing corrective measures to eliminate or reduce the seriousness of hazards within the signal system. The discussion of hazards in this section of the report is intended to be limited to hazards, or safety-related design problems, of an unexpected or unusual nature. It is not intended that the monthly safety report contain a comprehensive discussion of all hazards related to transit operation in general. The monthly report shall include an interface section which identifies hazards to the signal system which are best corrected external to the signal system such as by changes in rules, procedures, training or maintenance. The interface section shall also identify external hazards which shall be corrected in the signal system, such as protection against mismanipulation of controls, failure of incoming power, etc.

26.5.11 The Contractor shall submit separate monthly reports evaluating the impact of design changes on the safety of the signal system, after the design has been accepted and approved.

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27.0 CONTRACT DATA REQUIREMENTS LIST (CDRL)

The following table lists the required Contract Data deliverables, including the required delivery schedule relative to Contract award, with cross references to the applicable section of these Technical Specifications that describes the required submittal. While it is intended to be complete, lack of inclusion in this listing does not relieve the Contractor of the obligation to provide any deliverable required elsewhere in these Technical Specifications. Submittals of this Contract Data shall reference the CDRL item numbers as tabulated below, and shall be assigned a date and numbered revision level, including a brief revision history, in order to provide for the subsequent tracking of revised submittal documents.

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
1	Proposal Requirements	2.1.3 2.4	With Proposal
2	Proposal Requirements	2.2 2.2.1	With Proposal
3	Security Sensitive Information Handling Protocol	2.2.2	With Proposal
4	ANSI /ASQC ISO 9001-2000 Quality Standard Certificate	2.2.3	With Proposal
5	Complete hardware and software technical information and descriptions of the proposed system	2.2.4	With Proposal
6	Description of vital and non-vital interfaces	2.2.5	With Proposal
7	Cutover Support Description	2.2.6	With Proposal
8	Complete signal communications network design definition	2.2.7	With Proposal
9	Proof of similar work completed by contractor	2.2.8	With Proposal
10	Reliability back up equipment list	2.2.10	With Proposal
11	Detailed Staffing Plan	2.2.12	With Proposal

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
12	Confidentiality Statement	2.3.37	With Proposal
13	Complete Submittal List	2.3.39	30 days after Notice of Award
14	Specifications, descriptions, plans, and diagrams	2.3.43	30 days after Notice of Award
15	Failure Mode Effects Analysis (FMEA) for all lightning arresters and surge protection equipment	2.3.45	45 days after Notice of Award
16	Systems Designs for Stages 1 through 7.	2.3.46	Per Appendix "E" Schedule
17	60% Design Documents for Stages 1 through 7.	2.3.51	Per Appendix "E" Schedule
18	90% Design Documents for Stages 1 through 7.	2.3.52	Per Appendix "E" Schedule
19	100% Design Documents for Stages 1 through 7.	2.3.53	Per Appendix "E" Schedule
20	Final, Conformed 100% Design Documents for Stages 1 through 7.	2.3.54	14 days after engineers final comments
21	Work Plan	2.4.4	10th day of each month
22	Listing and organization of support personnel	2.5.2	With Proposal
23	Principle staff assignments, responsibilities and resumes	2.5.3	With Proposal
24	Delivery of Signal Batteries	3.1.28	Within 30 days of engineers request
25	Size of each house or case and a detailed floor and wall layout	3.1.31	With the 60% Submittal.
26	Adequacy of express cable plant and standard Metro-North Cables.	3.1.54	90 Days from Contract Award

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
27	Notify if interface design is not compatible with the intended new system design	3.1.55 3.1.56 3.1.57	90 Days after Notice of Award
28	Interface Certification Letter	3.1.58	With 100% design submittal
29	Material Composition Description	3.1.62 3.1.63	As required
30	Engineering Calculations	3.2.1	45 days from Contract Award (60% Submittal)
31	Timing and performance calculations	3.2.16 3.2.17	With 60% design submittal
32	Details and assumptions for timing and performance calculations	3.2.19	With 60% design submittal
33	Detailed, complete signal location packages	3.3.8	As required
34	Interface designs	3.3.11	As required
35	Proposed new material reference numbers	3.3.13	At Notice of Award
36	Detailed Plans	3.3.22 through 3.3.29	With design submittals
37	Detailed Interface	3.3.28 3.3.29	With design submittals
38	Computer Engineering Application	3.3.38, a	Per Appendix "E" Schedule
39	Portable Diagnostic System Test Set	3.3.38, b 3.3.38, c	Per Appendix "E" Schedule
40	Wayside Vital, Non-Vital Microprocessor and Communication System Training System	3.3.38, d	Per Appendix "E" Schedule

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
41	Reliability Back up Equipment	3.3.38, e	Per Appendix "E" Schedule
42	System, Subsystem and Component Training	3.3.38, f	60 days prior to training
43	Factory Test Documentation	3.3.38, i 3.3.38, j	10 days prior to Shipping
44	Custom Device Configuration	3.4.18	With design submittals
45	Custom Configuration Files – Electronic Versions, Native Format	3.4.20	Per Appendix "E" Schedule
46	Grounding Faults Corrective Action	3.4.21	As required
47	Product Safety Plan Defined in 49 CFR 236 907 for New or Modified Products	3.6.7	As required
48	Detailed Plan for Each Cutover Stage	3.7.6	105 days from Contract Award (90% Submittal)
49	Full Plan Set for Each Cutover or Stage for Tie In's	3.7.8	105 days from Contract Award (90% Submittal)
50	Signal Enclosure Shop Drawings	4.1.3	30 Days Prior to Fabrication
51	Paint and Primer for Inside of Signal Enclosures	4.1.16	30 Days Prior to Fabrication
52	Signal Enclosure Ventilator Openings	4.1.17	30 Days Prior to Fabrication
53	Maximum Weight of Each Instrument House	4.1.18	30 Days Prior to Fabrication
54	Instrument House Lifting and Placement Methods	4.1.20	30 Days Prior to Fabrication
55	Main Terminal Board Structural Design, Mounting Methods and Layout	4.1.28, a	30 Days Prior to Fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
56	Apparatus boards and shelves structural design, spacing, mounting methods and layout	4.1.28, b	30 Days Prior to Fabrication
57	Details concerning the work space behind apparatus boards, wire chases, wire management and tagging mounting hardware, overhead cable trays and all other related material	4.1.28, c	30 Days Prior to Fabrication
58	Insulating Materials, Installation Details and Fire Retardant Paint	4.1.31	30 Days Prior to Fabrication
59	Signal enclosure precast concrete foundation delivery authorization	4.1.32	30 days prior to fabrication
60	Signal enclosure foundation layout plan	4.1.33	30 Days Prior to Fabrication
61	Signal enclosure proposed locking arrangement, hinge configuration, door swing and location of doors	4.2.10	30 Days Prior to Fabrication
62	Signal enclosure lighting arrangements	4.2.24	30 Days Prior to Fabrication
63	Signal Enclosure Intrusion Detection Device	4.2.30	45 days from Contract Award (60% Submittal)
64	Signal Enclosure Intrusion detection energy distribution design	4.2.31	45 days from Contract Award (60% Submittal)
65	Signal enclosure smoke detectors	4.2.33, a	30 Days Prior to Fabrication
66	Signal enclosure ventilation system design	4.2.34	30 Days Prior to Fabrication
67	Signal enclosure wall-mounted plan holder	4.2.37	30 Days Prior to Fabrication
68	Signal case cable chutes, number and size	4.3.13	30 Days Prior to Fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
69	Signal case wall-mounted plan holder	4.3.15	30 Days Prior to Fabrication
70	Grounding plan for signal system provided	4.5.2, a through 4.5.2, i	45 days from Contract Award (60% Submittal)
71	Battery charger and electronic device rating	4.5.10	45 days from Contract Award (60% Submittal)
72	AC and DC Surge Protection Devices	4.5.13	45 days from Contract Award (60% Submittal)
73	Automatic ground fault detector	4.5.15	45 days from Contract Award (60% Submittal)
74	Size and type of racks	4.6.2	45 days from Contract Award (60% Submittal)
75	Rack ground insulation design	4.6.6	45 days from Contract Award (60% Submittal)
76	Rack type design	4.6.8	30 Days Prior to Fabrication
77	Rack equipment arrangements	4.6.9	45 days from Contract Award (60% Submittal)
78	Wire and cable management plan for all rack equipment	4.6.11	30 Days Prior to Fabrication
79	Rack cable installation plan, rack ground plan, common ground plan	4.6.12	30 Days Prior to Fabrication
80	Rack leveling and plumbing methods	4.6.13	30 Days Prior to Fabrication
81	Rack layout and associated equipment designs	4.6.14	45 days from Contract Award (60% Submittal)

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
82	Submit complete List of Each Type of Wire and Cable	5.1.3	30 Days Prior to Fabrication
83	Energy Bus Design	5.1.6	45 days from Contract Award (60% Submittal)
84	Complete list of each type of connector, terminal, terminal strip, fastener and termination hardware	5.2.1	30 Days Prior to Fabrication
85	Solderless terminal samples	5.2.2	30 Days Prior to Fabrication
86	Top of rack terminal blocks	5.2.11	30 Days Prior to Fabrication
87	Cage clamp products	5.2.12	30 Days Prior to Fabrication
88	The busing method for screw post and Push Release type terminals	5.2.21	30 Days Prior to Fabrication
89	Screw post and Push Release terminals	5.2.23	30 Days Prior to Fabrication
90	Cable blocks	5.2.24	30 Days Prior to Fabrication
91	Cable termination report	5.2.32	30 Days Prior to Fabrication
92	Cable termination hardware	5.2.33	30 Days Prior to Fabrication
93	Nomenclature, tagging materials and procedures	6.1	30 Days Prior to Fabrication
94	Proposed method of tagging for non-vital circuits	6.2.11	30 Days Prior to Fabrication
95	Equalizer submittal	7.4.1	30 Days Prior to Fabrication
96	Hardware plating or non-corroding metal alternate	7.5.4	30 Days Prior to Fabrication
97	Salt spray test methods	7.5.5	30 Days Prior to Fabrication
98	Corrosion Preventive Compound	7.7.1	30 Days Prior to Fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
99	Diode type and identifiers	7.8.1	30 Days Prior to Fabrication
100	Vital and non-vital plug connector assemblies	7.10.1	30 Days Prior to Fabrication
101	Vital relay type and manufacturer	8.2.2 8.2.3	30 Days Prior to Fabrication
102	Method of connecting a maximum of two (2) wires to contact	8.2.13	30 Days Prior to Fabrication
103	Magnetic stick polar relays	8.2.18	With the 60% Submittal
104	Code transmitters and their application	8.3.1	With the 60% Submittal
105	Non-vital relays and non-vital timer relays	8.4.2	With the 60% Submittal
106	Mini vital processor submittal	9.1.7	With the 60% Submittal
107	system-wide communication system drawings, diagrams, and supporting tables and charts	9.1.12	With the 60% Submittal
108	Deviations from contract typical networks	9.1.15	With the 60% Submittal
109	Factory Test Plan to validate the vital design and placement of relays and wiring	9.1.21	60 days prior to Factory Test
110	Start-up procedure for configurable devices	9.5.5	At the beginning of software Development
111	Application Logic Submittal	9.6 9.7	Before the 90% Submittal
112	Logic nesting beyond 3 levels	9.6.15	At the Beginning of Software Development
113	Input / Output labels for vital circuit indication	9.7.4	With the 60% Submittal

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
114	Equipment and software availability and support certification	9.7.7	At the beginning of software Development
115	Vital means of indexing printed circuit boards	9.7.9	At the beginning of software Development
116	Factory Test Plan to validate the non-vital design and placement of relays and wiring	10.1.10	60 days prior to Factory Test
117	Logic states of control center indications	10.2.15	With the 60% Submittal
118	Repeater relays in vital logic	10.2.16	With the 60% Submittal
119	Source application program format	10.2.17	With the 60% Submittal
120	Software Verification and Validation Plan and site-specific application logic verifier	10.3.8	At the beginning of software Development
121	Mounting of surge and lightning protection devices	10.4.14	30 Days Prior to Fabrication
122	Detailed component level circuit board schematic for both input and output boards	10.4.15	30 Days Prior to Fabrication
123	Chassis connectors, tooling, attachment methods and fittings	10.5.3 10.5.5	30 Days Prior to Fabrication
124	Complete detail of each chassis or cabinet	10.5.8	30 Days Prior to Fabrication
125	Chassis mounting	10.5.10	30 Days Prior to Fabrication
126	Extender cards	10.6.5	30 Days Prior to Fabrication
127	Circuit board keying methods	10.6.10	30 Days Prior to Fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
128	Non-vital logic power up/power down sequence	10.7.1	With design submittals
129	Interlocking functionality	10.7.3	With design submittals
130	Event recorder system	10.8.2	With design submittals
131	Clock synchronization method	10.8.5	With design submittals
132	Equipment and software required for vital and non-vital software modification	10.8.8	With design submittals
133	Remote diagnostic system design details	11.1.1	With design submittals
134	Remote diagnostic workstations	11.1.2	Per Appendix "E" Schedule
135	Local control and indication panel sample	12.1.2 12.1.3	60 days prior to fabrication
136	Drawings of each local control and indication panels	12.1.4	With design submittals
137	Local indication panel hardware and components	12.1.6	30 Days Prior to Fabrication
138	Local control panel mosaic tiles	12.2.5	30 Days Prior to Fabrication
139	Keys for the LCP and vital and non-vital microprocessor equipment cabinets	12.2.7	Prior to delivery
140	Backlit pushbutton	12.4.1	30 Days Prior to Fabrication
141	LCP route pushbuttons	12.4.2	30 Days Prior to Fabrication
142	Stuck stick protection circuitry and logic	12.4.7	With design submittals
143	Switch control logic, time calc. and restore feature	13.1.3	30 Days Prior to Fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
144	FEMA relating to LED Signals	14.1.4	With 60% design submittal
145	Signal L.E.D. light out detection scheme	14.1.7	With design submittals
146	Signal L.E.D. operational certification	14.1.8	With design submittals
147	FEMA for L.E.D. compatibility	14.1.9	45 days After Notice of Award
148	Each type of track circuit and wheel counters and their proposed application and location	15.1.2	30 Days Prior to Fabrication
149	Power transfer apparatus	16.1.6	30 days prior to fabrication
150	Signal Power and Hotel Power Arrangement Drawings	16.1.13	30 days Prior to fabrication
151	Power load calculations for each circuit	16.1.16	30 days Prior to fabrication
152	Heat rise test results and certification	16.1.18, e	Prior to delivery
153	Power Distribution Panel Installation Drawings	16.18, g	30 Days Prior to Fabrication
154	Battery Chargers.	16.2.1 16.2.2	30 Days Prior to Fabrication
155	Battery charger and power supply capacity	16.2.7	30 Days Prior to Fabrication
156	Secondary surge suppressors	16.2.15, b, 1	30 Days Prior to Fabrication
157	Primary surge suppressors	16.2.15, c, 1	30 Days Prior to Fabrication
158	Storage Batteries	16.3.1	30 Days Prior to Fabrication
159	Fuses	16.3.18 16.3.19	30 Days Prior to Fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
160	Ethernet switch design	17.2.1	With design submittals
161	Layer 2 Ethernet Switch	17.2.2	30 Days Prior to Fabrication
162	Layer 3 Ethernet Switch	17.2.3	30 Days Prior to Fabrication
163	DC-to-DC converter	17.3.1	30 Days Prior to Fabrication
164	Fiber Distribution Panel	17.4.1	60 days Prior to fabrication
165	Fiber optic patch cords	17.4.6	60 days Prior to fabrication
166	Fiber optic patch cord connecter qualification	17.4.6, h	60 days Prior to fabrication
167	Fiber optic jumpers and prewired enclosures	17.4.7	60 days Prior to fabrication
168	25-pair protected terminal block	17.5.2	60 days Prior to fabrication
169	Label strips	17.5.3	60 days Prior to fabrication
170	Ethernet patch cables	17.5.4, a through 17.5.4,e	60 days Prior to fabrication
171	Serial patch cables	17.5.5, a through 17.5.5,e	60 days Prior to fabrication
172	Tagging and labeling system	17.6.2 17.6.3 17.6.3, a through 17.6.3, g	60 days Prior to fabrication
173	Rack and equipment tags	17.6.4	60 days Prior to fabrication
174	Cable tags and labels	17.6.5	60 days Prior to fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
175	Extinguishing Clean Agent Type	18.1.3	With design submittals
176	Free venting calculations	18.1.7, f	With design submittals
177	Heat detectors	18.1.8, g	With design submittals
178	Control panel	18.1.8, h	With design submittals
179	Control system	18.1.8, i	With design submittals
180	Functional test of form C contacts	18.1.8, n	Factory Test
181	Heat pumps and air-conditioning units	18.2.2	60 days Prior to fabrication
182	Heating and cooling calculations	18.2.2, e	With design submittals
183	Snow melter control cases	19.1.3	With design submittals
184	Snow melter cable plant adequacy	19.2.6	With design submittals
185	Main breaker	19.6.1	With design submittals
186	Packaging and method of delivery of all specified equipment	20.1.1	30 days prior to shipment
187	Delivery Schedule	20.1.2	30 days prior to shipment
188	Battery shipment	20.1.3	30 days prior to shipment
189	Foundation layout plans	20.1.4	60 days Prior to fabrication
190	Wayside vital and non-vital microprocessor signal and communication equipment training system	21.1.2	60 days prior to training

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
191	Proposed Metro-North Training location	21.1.6	60 days prior to training
192	Training Program Plan, Training Program Schedule, Training Program Location, Instructor's Names and Qualifications, Instructor Materials, Student Materials, and Training Reports	21.1.17, a through 21.1.17, g	60 days prior to delivery
193	Training plan development	21.2.1 through 21.2.5	60 days prior to training
194	Training Program Course Development	21.3.1 through 21.3.7	60 days prior to training
195	Training program material development	21.4.1 through 21.4.8	60 days prior to training
196	Training program presentation	21.5.1 through 21.5.9	60 days prior to training
197	Detailed plan of factory testing	22.1.1, 22.2.13	With 90% submittal
198	Test Plan	22.1.4 22.2.11, d 22.2.15	Not less than 60 days prior to testing
199	Factory and field test plans	22.1.6	Not less than 60 days prior to testing
200	Detailed Test and Inspection Procedures	22.1.7 22.1.9	Not less than 60 days prior to testing
201	Notification of Factory Testing	22.1.10	21 Days Prior to Testing
202	Test data sheets	22.1.24	10 days after tests

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
203	Completed Test reports	22.1.25 22.1.27	10 days after tests
204	Certified Subcontractor Test Results	22.1.26 22.1.31 22.1.32	10 days after tests
205	EMI/RFI Construction Procedure and an EMI/RFI Test Plan and Procedure	22.1.37 22.1.38 22.1.39	30 days prior to factory test
206	Notification of need for retesting in the field	22.2.28	As Required
207	Timing and performance calculations	22.2.11, a,1	With 60% design
208	CTC simulation tests	22.2.19 22.2.20	Factory Test
209	Inspection plan and sample inspection reports	22.2.22 22.2.23	Factory Test
210	Network communication testing and test exemption	22.2.24 22.2.25	Factory Test
211	Network communications factory inspection and test procedures	22.2.26	Factory Test
212	Completed signal system integration test	22.2.28	Factory Test
213	Single point of failure test	22.2.29	Factory Test
214	Certified letter of completion of factory inspection and testing	22.2.33	10 days after tests
215	As-built set of plans	22.2.34	20 days after completion of factory testing
216	Contractor field support test team	22.3.7	Field Testing
217	Certification of full operation of signal system and corrective measures taken	22.3.11	14 days after completion of testing

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
218	CADD files submission	22.3.12	14 days after completion of testing
219	on-call site supervision for 30-day final acceptance test	22.4.1	After completion of field testing
220	On-site maintenance support	22.4.3	As Required
221	Preventive maintenance and repair logs	22.6.1 22.6.2 22.6.3	As Required
222	Test equipment calibration certification	22.7.2 22.7.4 22.7.8	30 Days prior to Factory Test
223	Test documentation	22.9.1 22.9.2	10 days after tests
224	Variance report	22.9.3	As required
225	Variance correction and retesting	22.9.4	As required
226	Network Equipment Test Sets	22.11.1 22.11.4	30 Days prior to Factory Test
227	100Base-FX SFP modules	22.11.3	Per Appendix "E" Schedule
228	Ruggedized Laptops	22.12.1, a through 22.12.1, j 22.12.3 22.12.5 22.12.6	Per Appendix "E" Schedule
229	Tools and test equipment to reprogram, maintain and operate the vital microprocessor-based Ethernet network signal system equipment and associated site-specific program	22.12.2	30 Days prior to Factory Test

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
230	Special tools and equipment required for operation and maintenance of the vital microprocessor-based interlocking system	22.12.7	30 Days prior to Factory Test
231	Complete list of test equipment	22.12.8	30 Days prior to Factory Test
232	Vital and Non-vital Microprocessor Source files and development tools on CD-ROMs	23.1.7	30 days prior to delivery
233	Documentation Set with latest version of all documents	23.1.8	Prior to delivery
234	Definition document	23.1.9	30 days prior to delivery
235	Computer-aided assembly packages, compiler programs, source code and all commercial and Contractor-designed software	23.1.10	30 days prior to delivery
236	Documentation for commercial software packages	23.1.11	With 60% design
237	As-Built equipment plans	23.1.11	Within 30 days of shipment
238	Sample of Proposed CAD Drawing file for approval by the Engineer.	23.1.14	15 days after Notice of Award
239	Corrected Factory Plans and As-Built Plans and Diagrams	23.1.15 23.1.16 23.1.17	30 days prior to delivery
240	Documentation set	23.2.1 23.2.2 23.2.3	30 days prior to delivery
241	Manuals	22.2.3 22.2.4	30 days prior to delivery

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
242	Specifications, internal wiring plans and part lists of all products of the Contractor's own manufacture as well as purchased components	23.2.5	30 days prior to delivery
243	Cross referencing method	23.2.6	With each design submittal
244	Standard reference number tabulation table	23.2.7	With each design submittal
245	Documentation quantities	23.2.8, a through 23.2.8, c	30 days prior to delivery
246	Vital Relay Test and Maintenance Procedures	23.2.9	30 days prior to delivery
247	25 copies of all manuals, specifications of apparatus that make up the entire system furnished	23.2.10	30 days prior to delivery
248	Application Requirements documents	23.2.11	60 days of Contract Award
249	System Overview with a high level functional description	23.3.1, a, 1 through 23.3.1, a, 6	With Proposal/ revised with 60% design
250	Detailed submittal of the Design Documentation	23.3.1, b, 1 through 23.3.1, b, 6	With each design submittal
251	Application Code Software	23.3.2	Before 90% Design Submittal
252	Verification and Validation Testing plans, procedures, and reports	23.3.3	60 days prior to fabrication or programming
253	Configuration control procedure	23.3.4	60 days prior to fabrication or programming

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
254	Test equipment and documentation	23.3.5	60 days prior to fabrication or programming
255	Software version control	23.4.1	With each design submittal
256	Third party software	23.4.2	60 days prior to fabrication or programming
257	Listing of all vital and non-vital functions with a sample of ea. variable	23.3.4	With Proposal
258	Detailed final circuit plans, detailed engineering and design and software listing	23.5.1, a through 23.5.1, c	Prior to wiring
259	As-built drawings and documentation	23.5.2, a 23.5.2, b, 1 through 23.5.2, b, 8	7 days after equipment is shipped
260	Final conformed documents	23.5.3	14 days after receiving final Engineer's comments
261	Quality Policy/QC System requirements	24.1.1	With Proposal
262	Project Quality Assurance Program	24.1.2	30 days of Contract Award
263	Design-Build Quality Management System Manuel	24.2.1 24.2.2	30 days of Contract Award
264	Reliability and Maintainability Program	25.1.1	With each design submittal
265	RMA activities support	25.2.1	With each design submittal

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
266	Reliability	25.3.1	With each design submittal
267	Preliminary Reliability predication analysis	25.3.2, a through 25.3.2, f	With each design submittal
268	Failure modes effects and criticality analysis	25.3.3	With each design submittal
269	Preventative maintenance	25.4.2, a through 25.4.2, c	With each design submittal
270	Corrective maintenance	25.4.3	With each design submittal
271	Maintainability Analysis Reporting	25.4.4	With each design submittal
272	Accessibility Analysis	25.4.5	With each design submittal
273	Handling Analysis	25.4.6	With each design submittal
274	Modularity Analysis	25.4.7	With each design submittal
275	Diagnostic analysis	25.4.8	With each design submittal
276	Safety Assurance Program and Safety Assurance and System Performance (SASP) Program	26.1.1	With each design submittal
277	Software Quality Assurance Program (SQAP)	26.1.13	With each design submittal
278	Preliminary Hazard Analysis	26.2.5 26.2.6	With Proposal, update at 60%
279	Analysis and verification of the translation of specified functional	26.2.8	Prior to fabrication
280	Fault Tree Analysis	26.2.9	Prior to fabrication

Item No.	Submittal	Specification Reference No.	Schedule for Submittal
281	Safety analysis of the signal system	26.2.10	With each design submittal
282	SASP program tasks and procedures	26.3.1	With each design submittal
283	Definitive and comprehensive demonstration of the safety assurance	26.3.2	Before 90% Design Submittal
284	Safety verification of vital and non-vital software	26.3.9	With each design submittal
285	SASP Program objectives	26.4.1 26.4.2 26.4.3	With each design submittal
286	Description of the Safety Assurance Concept(s)	26.5.2	With 60% submittal
287	Description of Methods of Analysis	26.5.3	With 60% submittal
288	Application Logic Analysis	26.5.4	With 60% submittal
289	Vital Hardware Analysis	26.5.5	With 60% submittal
290	Non-Vital Hardware Analysis	26.5.6	With 60% submittal
291	Vital Software Analysis	26.5.7	With 60% submittal
292	Non-Vital Software Analysis	26.5.8	With 60% submittal
293	Relay Circuit Analysis	26.5.9	With 60% submittal
294	Monthly SASP Reports	26.5.10 26.5.11	Monthly

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APPENDICES

APPENDIX "A" QUALITY ASSURANCE PROGRAM

APPENDIX "B" SAMPLE DESIGN-BUILD QUALITY MANAGEMENT SYSTEM MANUAL

APPENDIX "C" LIST OF CONTRACT DRAWINGS

APPENDIX "D" TYPICAL PROCESSOR BASED INTERLOCKING AND INTERMEDIATE TERRITORY SIGNAL SYSTEM LOGIC

APPENDIX "E" MAJOR DELIVERY MILESTONES

APPENDIX "C"
LIST OF CONTRACT DRAWINGS

SHEET #	DRAWING #	TITLE
GENERAL DRAWING INDEX		
0001	G-001	DRAWING INDEX
0002	G-002	DRAWING INDEX
0003	G-003	DRAWING INDEX
0004	G-004	NOT USED
0005	G-005	NOT USED
0006	G-006	DRAWING INDEX
0007	G-007	CAD STANDARD SYMBOLS RELAYS, CONTACTS & PARTS
0008	G-008	CAD ROUTING STANDARD SYMBOLS
BLOCK PLAN DRAWINGS		
0009	BP-101	EXISTING / PROPOSED BLOCK PLAN MP 27.27 TO MP 29.55
0010	BP-102	EXISTING / PROPOSED BLOCK PLAN MP 29.55 TO MP 31.82
0011	BP-103	EXISTING / PROPOSED BLOCK PLAN MP 31.82 TO MP 34.09
0012	BP-104	EXISTING / PROPOSED BLOCK PLAN MP 34.09 TO MP 36.36
0013	BP-105	EXISTING / PROPOSED BLOCK PLAN MP 36.36 TO MP 38.64
0014	BP-106	EXISTING / PROPOSED BLOCK PLAN MP 38.64 TO MP 40.91
0015	BP-107	EXISTING / PROPOSED BLOCK PLAN MP 40.91 TO MP 43.18
SHEETS 0016 TO 0035 ARE NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES - FINAL		
0036	L100I1	MP 12.0 TO MP 42.4 ROUTING INDEX
0037	L100I2	MP 12.0 TO MP 42.4 ROUTING INDEX
SHEETS 0038 TO 0039 ARE NOT USED IN THIS SUBMISSION		
0040	L1007E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 3 & 1 EAST
0041	L1008E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 2 & 4 EAST
0042	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0043	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0044	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0045	L1012E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 EAST
0046	L1013E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 EAST
0047	L1014E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 3 & 1 EAST
0048	L1015E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 2 & 4 EAST
0049	L1007W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 3 & 1 WEST
0050	L1008W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 2 & 4 WEST
0051	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 WEST
0052	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0053	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0054	L1012W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 3 & 1 WEST
0055	L1013W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 2 & 4 WEST
0056	L1014W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 WEST
0057	L1015W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 WEST
0058	L1030X	CP 229 DIVERGING ROUTES - TRACK 3 EAST
0059	L1031X	CP 229 DIVERGING ROUTES - TRACK 1 EAST
0060	L1032X	CP 229 DIVERGING ROUTES - TRACK 2 EAST
0061	L1033X	CP 229 DIVERGING ROUTES - TRACK 4 EAST
0062	L1034X	CP 229 DIVERGING ROUTES - TRACK 3 WEST
0063	L1035X	CP 229 DIVERGING ROUTES - TRACK 1 WEST
0064	L1036X	CP 229 DIVERGING ROUTES - TRACK 2 WEST
0065	L1037X	CP 229 DIVERGING ROUTES - TRACK 4 WEST

SHEET #	DRAWING #	TITLE
0066	L1038X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 EAST
0067	L1039X	CP 232 DIVERGING ROUTES - TRACKS 2 & 4 EAST
0068	L1040X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0069	L1041X	CP 232 DIVERGING ROUTES - TRACK 2 WEST
0070	L1042X	CP 233 DIVERGING ROUTES - TRACKS 5 & 2 EAST
0071	L1043X	CP 233 DIVERGING ROUTES - TRACKS 7 & 4 WEST
0072	L1044X	CP 234 DIVERGING ROUTES - TRACK 5 EAST
0073	L1045X	CP 234 DIVERGING ROUTES - TRACK 3 EAST
0074	L1046X	CP 234 DIVERGING ROUTES - TRACK 1 EAST
0075	L1047X	CP 234 DIVERGING ROUTES - TRACK 2 EAST
0076	L1048X	CP 234 DIVERGING ROUTES - TRACK 4 EAST
0077	L1049X	CP 234 DIVERGING ROUTES - TRACK 5 WEST
0078	L1050X	CP 234 DIVERGING ROUTES - TRACK 3 WEST
0079	L1051X	CP 234 DIVERGING ROUTES - TRACK 1 WEST
0080	L1052X	CP 234 DIVERGING ROUTES - TRACK 2 WEST
0081	L1053X	CP 234 DIVERGING ROUTES - TRACK 4 WEST
0082	L1054X	CP 234 DIVERGING ROUTES - TRACKS 6 & 7 WEST
0083	L1055X	CP 234 DIVERGING ROUTES - STAMFORD YARD ROUTINGS
0084	L1056X	CP 235 DIVERGING ROUTES - TRACKS 5 & 3 EAST
0085	L1057X	CP 235 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0086	L1058X	CP 240 DIVERGING ROUTES - TRACK 1 EAST
0087	L1059X	CP 240 DIVERGING ROUTES - TRACK 2 EAST
0088	L1060X	CP 240 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0089	L1061X	CP 240 DIVERGING ROUTES - TRACKS 2 & 4 WEST
0090	L1062X	CP 241 DIVERGING ROUTES - TRACK 3 EAST
0091	L1063X	CP 241 DIVERGING ROUTES - TRACK 1 EAST
0092	L1064X	CP 241 DIVERGING ROUTES - TRACK 2 EAST
0093	L1065X	CP 241 DIVERGING ROUTES - TRACK 4 EAST
0094	L1066X	CP 241 DIVERGING ROUTES - TRACKS 5 & 6 EAST
0095	L1067X	CP 241 DIVERGING ROUTES - TRACK 3 WEST
0096	L1068X	CP 241 DIVERGING ROUTES - TRACK 1 WEST
0097	L1069X	CP 241 DIVERGING ROUTES - TRACK 2 WEST
0098	L1070X	CP 241 DIVERGING ROUTES - TRACK 4 WEST
0099	L1071X	CP 241 DIVERGING ROUTES - TRACK 5 WEST
SHEET 0100 IS NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES – 270 CODE CUTBACK		
0101	L1007E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 3 & 1 EAST
0102	L1008E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 2 & 4 EAST
0103	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0104	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0105	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0106	L1012E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 EAST
0107	L1013E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 EAST
0108	L1014E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 3 & 1 EAST
0109	L1015E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 2 & 4 EAST
0110	L1007W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 3 & 1 WEST
0111	L1008W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 2 & 4 WEST
0112	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 WEST
0113	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0114	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0115	L1012W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 3 & 1 WEST
0116	L1013W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 2 & 4 WEST
0117	L1014W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 WEST

SHEET #	DRAWING #	TITLE
0118	L1015W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 WEST
0119	L1030X	CP 229 DIVERGING ROUTES - TRACK 3 EAST
0120	L1031X	CP 229 DIVERGING ROUTES - TRACK 1 EAST
0121	L1032X	CP 229 DIVERGING ROUTES - TRACK 2 EAST
0122	L1033X	CP 229 DIVERGING ROUTES - TRACK 4 EAST
0123	L1034X	CP 229 DIVERGING ROUTES - TRACK 3 WEST
0124	L1035X	CP 229 DIVERGING ROUTES - TRACK 1 WEST
0125	L1036X	CP 229 DIVERGING ROUTES - TRACK 2 WEST
0126	L1037X	CP 229 DIVERGING ROUTES - TRACK 4 WEST
0127	L1038X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 EAST
0128	L1039X	CP 232 DIVERGING ROUTES - TRACKS 2 & 4 EAST
0129	L1040X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0130	L1041X	CP 232 DIVERGING ROUTES - TRACK 2 WEST
0131	L1042X	CP 233 DIVERGING ROUTES - TRACKS 5 & 2 EAST
0132	L1043X	CP 233 DIVERGING ROUTES - TRACKS 7 & 4 WEST
0133	L1044X	CP 234 DIVERGING ROUTES - TRACK 5 EAST
0134	L1045X	CP 234 DIVERGING ROUTES - TRACK 3 EAST
0135	L1046X	CP 234 DIVERGING ROUTES - TRACK 1 EAST
0136	L1047X	CP 234 DIVERGING ROUTES - TRACK 2 EAST
0137	L1048X	CP 234 DIVERGING ROUTES - TRACK 4 EAST
0138	L1049X	CP 234 DIVERGING ROUTES - TRACK 5 WEST
0139	L1050X	CP 234 DIVERGING ROUTES - TRACK 3 WEST
0140	L1051X	CP 234 DIVERGING ROUTES - TRACK 1 WEST
0141	L1052X	CP 234 DIVERGING ROUTES - TRACK 2 WEST
0142	L1053X	CP 234 DIVERGING ROUTES - TRACK 4 WEST
0143	L1054X	CP 234 DIVERGING ROUTES – TRACKS 6 & 7 WEST
0144	L1055X	CP 234 STAMFORD YARD ROUTINGS
0145	L1056X	CP 235 DIVERGING ROUTES – TRACKS 5 & 3 EAST
0146	L1057X	CP 235 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0147	L1058X	CP 240 DIVERGING ROUTES - TRACK 1 EAST
0148	L1059X	CP 240 DIVERGING ROUTES - TRACK 2 EAST
0149	L1060X	CP 240 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0150	L1061X	CP 240 DIVERGING ROUTES - TRACKS 2 & 4 WEST
0151	L1062X	CP 241 DIVERGING ROUTES - TRACK 3 EAST
0152	L1063X	CP 241 DIVERGING ROUTES - TRACK 1 EAST
0153	L1064X	CP 241 DIVERGING ROUTES - TRACK 2 EAST
0154	L1065X	CP 241 DIVERGING ROUTES - TRACK 4 EAST
0155	L1066X	CP 241 DIVERGING ROUTES - TRACKS 5 & 6 EAST
0156	L1067X	CP 241 DIVERGING ROUTES - TRACK 3 WEST
0157	L1068X	CP 241 DIVERGING ROUTES - TRACK 1 WEST
0158	L1069X	CP 241 DIVERGING ROUTES - TRACK 2 WEST
0159	L1070X	CP 241 DIVERGING ROUTES - TRACK 4 WEST
0160	L1071X	CP 241 DIVERGING ROUTES - TRACK 5 WEST
SHEETS 0161 TO 0250 ARE NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES - EXISTING		
0251	L1007E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 3 & 1 EAST
0252	L1008E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 2 & 4 EAST
0253	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0254	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0255	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0256	L2001E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 EAST
0257	L2002E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 EAST
0258	L2003E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 3 & 1 EAST

SHEET #	DRAWING #	TITLE
0259	L2004E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 2 & 4 EAST
0260	L1007W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 3 & 1 WEST
0261	L1008W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 2 & 4 WEST
0262	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 WEST
0263	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0264	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0265	L2001W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 3 & 1 WEST
0266	L2002W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 2 & 4 WEST
0267	L2003W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 WEST
0268	L2004W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 WEST
0269	L1030X	CP 229 DIVERGING ROUTES - TRACK 3 EAST
0270	L1031X	CP 229 DIVERGING ROUTES - TRACK 1 EAST
0271	L1032X	CP 229 DIVERGING ROUTES - TRACK 2 EAST
0272	L1033X	CP 229 DIVERGING ROUTES - TRACK 4 EAST
0273	L1034X	CP 229 DIVERGING ROUTES - TRACK 3 WEST
0274	L1035X	CP 229 DIVERGING ROUTES - TRACK 1 WEST
0275	L1036X	CP 229 DIVERGING ROUTES - TRACK 2 WEST
0276	L1037X	CP 229 DIVERGING ROUTES - TRACK 4 WEST
0277	L1038X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 EAST
0278	L1039X	CP 232 DIVERGING ROUTES - TRACKS 2 & 4 EAST
0279	L1040X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0280	L1041X	CP 232 DIVERGING ROUTES - TRACK 2 WEST
0281	L1042X	CP 233 DIVERGING ROUTES
0282	L1043X	CP 234 DIVERGING ROUTES - TRACK 5 EAST
0283	L1044X	CP 234 DIVERGING ROUTES - TRACK 3 EAST
0284	L1045X	CP 234 DIVERGING ROUTES - TRACK 1 EAST
0285	L1046X	CP 234 DIVERGING ROUTES - TRACK 2 EAST
0286	L1047X	CP 234 DIVERGING ROUTES - TRACK 4 EAST
0287	L1048X	CP 234 DIVERGING ROUTES - TRACK 5 WEST
0288	L1049X	CP 234 DIVERGING ROUTES - TRACK 3 WEST
0289	L1050X	CP 234 DIVERGING ROUTES - TRACK 1 WEST
0290	L1051X	CP 234 DIVERGING ROUTES - TRACK 2 WEST
0291	L1052X	CP 234 DIVERGING ROUTES - TRACK 4 WEST
0292	L1053X	CP 234 DIVERGING ROUTES - TRACKS 6 & 7 WEST
0293	L1054X	CP 234 STAMFORD YARD ROUTINGS
0294	L1055X	CP 235 DIVERGING ROUTES - TRACKS 5 & 3 EAST
0295	L1056X	CP 235 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0296	L2001X	CP 240 DIVERGING ROUTES
0297	L2002X	CP 241 DIVERGING ROUTES - TRACK 3 EAST
0298	L2003X	CP 241 DIVERGING ROUTES - TRACK 1 EAST
0299	L2004X	CP 241 DIVERGING ROUTES - TRACK 2 EAST
0300	L2005X	CP 241 DIVERGING ROUTES - TRACK 4 EAST
0301	L2006X	CP 241 DIVERGING ROUTES - TRACKS 5 & 6 EAST
0302	L2007X	CP 241 DIVERGING ROUTES - TRACK 3 WEST
0303	L2008X	CP 241 DIVERGING ROUTES - TRACK 1 WEST
0304	L2009X	CP 241 DIVERGING ROUTES - TRACK 2 WEST
0305	L2010X	CP 241 DIVERGING ROUTES - TRACK 4 WEST
0306	L2011X	CP 241 DIVERGING ROUTES - TRACK 5 WEST
SHEETS 0307 TO 0340 ARE NOT USED IN THIS SUBMISSION		

SHEET #	DRAWING #	TITLE
ROUTINGS & DIVERGING ROUTES – STAGE 1		
0341	L2001E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 EAST
0342	L2002E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 EAST
0343	L2003E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 3 & 1 EAST
0344	L2004E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 2 & 4 EAST
0345	L2001W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 3 & 1 WEST
0346	L2002W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 2 & 4 WEST
0347	L2003W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 WEST
0348	L2004W	MP 42.4 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 WEST
0349	L2001X	CP 240 DIVERGING ROUTES
0350	L2002X	CP 241 DIVERGING ROUTES - TRACK 3 EAST
0351	L2003X	CP 241 DIVERGING ROUTES - TRACK 1 EAST
0352	L2004X	CP 241 DIVERGING ROUTES - TRACK 2 EAST
0353	L2005X	CP 241 DIVERGING ROUTES - TRACK 4 EAST
0354	L2006X	CP 241 DIVERGING ROUTES - TRACKS 5 & 6 EAST
0355	L2007X	CP 241 DIVERGING ROUTES - TRACK 3 WEST
0356	L2008X	CP 241 DIVERGING ROUTES - TRACK 1 WEST
0357	L2009X	CP 241 DIVERGING ROUTES - TRACK 2 WEST
0358	L2010X	CP 241 DIVERGING ROUTES - TRACK 4 WEST
0359	L2011X	CP 241 DIVERGING ROUTES - TRACK 5 WEST
ROUTINGS & DIVERGING ROUTES – STAGE 2		
0360	L1007E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 3 & 1 EAST
0361	L1008E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 2 & 4 EAST
0362	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0363	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0364	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0365	L1007W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 3 & 1 WEST
0366	L1008W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 2 & 4 WEST
0367	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 EAST
0368	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0369	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0370	L1030X	CP 229 DIVERGING ROUTES - TRACK 3 EAST
0371	L1031X	CP 229 DIVERGING ROUTES - TRACK 1 EAST
0372	L1032X	CP 229 DIVERGING ROUTES - TRACK 2 EAST
0373	L1033X	CP 229 DIVERGING ROUTES - TRACK 4 EAST
0374	L1034X	CP 229 DIVERGING ROUTES - TRACK 3 WEST
0375	L1035X	CP 229 DIVERGING ROUTES - TRACK 1 WEST
0376	L1036X	CP 229 DIVERGING ROUTES - TRACK 2 WEST
0377	L1037X	CP 229 DIVERGING ROUTES - TRACK 4 WEST
SHEETS 0378 & 0379 ARE NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES – STAGE 3		
0380	L1007E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 3 & 1 EAST
0381	L1008E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 2 & 4 EAST
0382	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0383	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0384	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0385	L1007W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 3 & 1 WEST
0386	L1008W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 2 & 4 WEST
0387	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 EAST
0388	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0389	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST

SHEET #	DRAWING #	TITLE
0390	L1030X	CP 229 DIVERGING ROUTES - TRACK 3 EAST
0391	L1031X	CP 229 DIVERGING ROUTES - TRACK 1 EAST
0392	L1032X	CP 229 DIVERGING ROUTES - TRACK 2 EAST
0393	L1033X	CP 229 DIVERGING ROUTES - TRACK 4 EAST
0394	L1034X	CP 229 DIVERGING ROUTES - TRACK 3 WEST
0395	L1035X	CP 229 DIVERGING ROUTES - TRACK 1 WEST
0396	L1036X	CP 229 DIVERGING ROUTES - TRACK 2 WEST
0397	L1037X	CP 229 DIVERGING ROUTES - TRACK 4 WEST
SHEETS 0398 TO 0399 ARE NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES – STAGE 4		
0400	L1007E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 3 & 1 EAST
0401	L1008E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 2 & 4 EAST
0402	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0403	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0404	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0405	L1007W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 3 & 1 WEST
0406	L1008W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 2 & 4 WEST
0407	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 EAST
0408	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0409	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0410	L1038X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 EAST
0411	L1039X	CP 232 DIVERGING ROUTES - TRACKS 2 & 4 EAST
0412	L1040X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 EAST
0413	L1041X	CP 232 DIVERGING ROUTES - TRACK 2 WEST
0414	L1042X	CP 233 DIVERGING ROUTES
SHEETS 0415 TO 0449 ARE NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES – STAGE 5		
0450	L1007E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 3 & 1 EAST
0451	L1008E	MP 25.0 TO MP 30.9 ROUTINGS - TRACKS 2 & 4 EAST
0452	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0453	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0454	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0455	L2001E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 EAST
0456	L2002E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 EAST
0457	L1007W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 3 & 1 WEST
0458	L1008W	MP 31.2 TO MP 25.3 ROUTINGS - TRACKS 2 & 4 WEST
0459	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 EAST
0460	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0461	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0462	L2001W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 3 & 1 WEST
0463	L2002W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 2 & 4 WEST
0464	L1038X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 EAST
0465	L1039X	CP 232 DIVERGING ROUTES - TRACKS 2 & 4 EAST
0466	L1040X	CP 232 DIVERGING ROUTES - TRACKS 3 & 1 EAST
0467	L1041X	CP 232 DIVERGING ROUTES - TRACK 2 WEST
0468	L1042X	CP 233 DIVERGING ROUTES
0469	L1044X	CP 234 DIVERGING ROUTES - TRACK 5 EAST
0470	L1045X	CP 234 DIVERGING ROUTES - TRACK 3 EAST
0471	L1046X	CP 234 DIVERGING ROUTES - TRACK 1 EAST
0472	L1047X	CP 234 DIVERGING ROUTES - TRACK 2 EAST
0473	L1048X	CP 234 DIVERGING ROUTES - TRACK 4 EAST
0474	L1049X	CP 234 DIVERGING ROUTES - TRACK 5 WEST

SHEET #	DRAWING #	TITLE
0475	L1050X	CP 234 DIVERGING ROUTES - TRACK 3 WEST
0476	L1051X	CP 234 DIVERGING ROUTES - TRACK 1 WEST
0477	L1052X	CP 234 DIVERGING ROUTES - TRACK 2 WEST
0478	L1053X	CP 234 DIVERGING ROUTES - TRACK 4 WEST
0479	L1054X	CP 234 DIVERGING ROUTES - TRACK 6 & 7 WEST
0480	L1055X	CP 235 STAMFORD YARD ROUTINGS
SHEETS 0481 TO 0499 ARE NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES – STAGE 6		
0500	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0501	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0502	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0503	L2001E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 EAST
0504	L2002E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 EAST
0505	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 EAST
0506	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0507	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0508	L2001W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 3 & 1 WEST
0509	L2002W	MP 40.7 TO MP 35.6 ROUTINGS - TRACKS 2 & 4 WEST
0510	L1044X	CP 234 DIVERGING ROUTES - TRACK 5 EAST
0511	L1045X	CP 234 DIVERGING ROUTES - TRACK 3 EAST
0512	L1046X	CP 234 DIVERGING ROUTES - TRACK 1 EAST
0513	L1047X	CP 234 DIVERGING ROUTES - TRACK 2 EAST
0514	L1048X	CP 234 DIVERGING ROUTES - TRACK 4 EAST
0515	L1049X	CP 234 DIVERGING ROUTES - TRACK 5 WEST
0516	L1050X	CP 234 DIVERGING ROUTES - TRACK 3 WEST
0517	L1051X	CP 234 DIVERGING ROUTES - TRACK 1 WEST
0518	L1052X	CP 234 DIVERGING ROUTES - TRACK 2 WEST
0519	L1053X	CP 234 DIVERGING ROUTES - TRACK 4 WEST
0520	L1054X	CP 234 DIVERGING ROUTES - TRACK 6 & 7 WEST
0521	L1055X	CP 235 STANFORD YARD ROUTINGS
0522	L1056X	CP 235 DIVERGING ROUTES - TRACKS 5 & 6 WEST
0523	L1057X	CP 235 DIVERGING ROUTES - TRACKS 3 & 1 WEST
SHEETS 0524 TO 0549 ARE NOT USED IN THIS SUBMISSION		
ROUTINGS & DIVERGING ROUTES – STAGE 7		
0550	L1009E	MP 30.9 TO MP 35.0 ROUTINGS - TRACK 3 CHANGES TO TRACK 5 EAST
0551	L1010E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 3 & 1 EAST
0552	L1011E	MP 30.9 TO MP 35.0 ROUTINGS - TRACKS 2 & 4 EAST
0553	L2001E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 EAST
0554	L2002E	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 EAST
0555	L2003E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 3 & 1 EAST
0556	L2004E	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 2 & 4 EAST
0557	L1009W	MP 35.6 TO MP 31.2 ROUTINGS - TRACK 5 CHANGES TO TRACK 3 EAST
0558	L1010W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 3 & 1 WEST
0559	L1011W	MP 35.6 TO MP 31.2 ROUTINGS - TRACKS 2 & 4 WEST
0560	L2001W	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 3 & 1 WEST
0561	L2002W	MP 35.6 TO MP 40.7 ROUTINGS - TRACKS 2 & 4 WEST
0562	L2003W	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 3 & 1 WEST
0563	L2004W	MP 40.7 TO MP 42.4 ROUTINGS - TRACKS 2 & 4 WEST
0564	L1044X	CP 234 DIVERGING ROUTES - TRACK 5 EAST
0565	L1045X	CP 234 DIVERGING ROUTES - TRACK 3 EAST
0566	L1046X	CP 234 DIVERGING ROUTES - TRACK 1 EAST
0567	L1047X	CP 234 DIVERGING ROUTES - TRACK 2 EAST

SHEET #	DRAWING #	TITLE
0568	L1048X	CP 234 DIVERGING ROUTES - TRACK 4 EAST
0569	L1049X	CP 234 DIVERGING ROUTES - TRACK 5 WEST
0570	L1050X	CP 234 DIVERGING ROUTES - TRACK 3 WEST
0571	L1051X	CP 234 DIVERGING ROUTES - TRACK 1 WEST
0572	L1052X	CP 234 DIVERGING ROUTES - TRACK 2 WEST
0573	L1053X	CP 234 DIVERGING ROUTES - TRACK 4 WEST
0574	L1054X	CP 234 DIVERGING ROUTES - TRACK 6 & 7 WEST
0575	L1055X	CP 235 STANFORD YARD ROUTINGS
0576	L1056X	CP 235 DIVERGING ROUTES - TRACKS 5 & 3 EAST
0577	L1057X	CP 235 DIVERGING ROUTES - TRACKS 3 & 1 WEST
0578	L2001X	CP 240 DIVERGING ROUTES
0579	L2002X	CP 241 DIVERGING ROUTES - TRACK 3 EAST
0580	L2003X	CP 241 DIVERGING ROUTES - TRACK 1 EAST
0581	L2004X	CP 241 DIVERGING ROUTES - TRACK 2 EAST
0582	L2005X	CP 241 DIVERGING ROUTES - TRACK 4 EAST
0583	L2006X	CP 241 DIVERGING ROUTES - TRACKS 5 & 6 EAST
0584	L2007X	CP 241 DIVERGING ROUTES - TRACK 3 WEST
0585	L2008X	CP 241 DIVERGING ROUTES - TRACK 1 WEST
0586	L2009X	CP 241 DIVERGING ROUTES - TRACK 2 WEST
0587	L2010X	CP 241 DIVERGING ROUTES - TRACK 4 WEST
0588	L2011X	CP 241 DIVERGING ROUTES - TRACK 5 WEST
SHEETS 0589 TO 0599 ARE NOT USED IN THIS SUBMISSION		
SIGNAL NETWORK BLOCK DIAGRAMS		
0600	BT-019	SIGNAL NETWORK OVERVIEW BLOCK DIAGRAM 1 OF 2
0601	BT-020	SIGNAL NETWORK OVERVIEW BLOCK DIAGRAM 2 OF 2
SIGNAL DESIGN DRAWINGS		
1000	NHL2821000	ML-282 TRACK CIRCUIT 2823T
1001	NHL2901000	CP 229 TRACK LAYOUT
1002	NHL2901001	CP 229 CABLE PLAN
1003	NHL2901002	CP 229 MICROPROCESSOR ZONING PLAN
1004	NHL2901003	CP 229 MICROPROCESSOR BLOCK DIAGRAM
1005	NHL2901004	CP 229 NON-VITAL MICROPROCESSOR BLOCK DIAGRAM
1006	NHL2901005	CP 229 INTERLOCKING TRACK CIRCUIT TRACK 1AT
1007	NHL2901006	CP 229 INTERLOCKING TRACK CIRCUIT TRACK 1BT
1008	NHL2901007	CP 229 SWITCH CONTROL AND INDICATION 21
1009	NHL2901008	CP 229 SWITCH CONTROL AND INDICATION 31
1010	NHL2901009	CP 229 SIGNAL LIGHTING 3E, 3W, 1E, 1W
1011	NHL2901010	CP 229 MISCELLANEOUS CIRCUITS
1012	NHL2901011	CP 229 ETHERNET POWER CIRCUITS
1013	NHL2901012	CP 229 CIL 100HZ TRANSFER SWITCH
1014	NHL2901013	CP 229 CIL 100HZ POWER DISTRIBUTION
1015	NHL2901014	CP 229 CIL SWITCH POWER
1016	NHL2901015	CP 229 CIL 60HZ TRANSFER SWITCH
1017	NHL2901016	CP 229 CIL 60HZ POWER DISTRIBUTION
1018	NHL2901017	CP 229 CIL BATTERY AND CHARGER B12, B12-NV
1019	NHL2901018	CP 229 CIL BATTERY AND CHARGER LB12, B12-E
1020	NHL2901019	CP 229 CIL GROUND DETECTOR NETWORK
1021	NHL2901020	CP 229 LOC. A MISCELLANEOUS CIRCUITS
1022	NHL2901021	CP 229 LOC. A POWER CIRCUITS
1023	NHL2901022	CP 229 DC POWER CIRCUITS VITAL MICROPROCESSOR TRACK 3
1024	NHL2901023	CP 229 LOCAL CONTROL POWER CIRCUITS
1025	NHL2901024	CP 229 LOCAL CONTROL OUTPUT CIRCUITS

SHEET #	DRAWING #	TITLE
1026	NHL2901025	CP 229 LOCAL CONTROL INPUT CIRCUITS SHEET 1 OF 5
1027	NHL2901026	CP 229 LOCAL CONTROL INPUT CIRCUITS SHEET 2 OF 5
1028	NHL2901027	CP 229 LOCAL CONTROL INPUT CIRCUITS SHEET 3 OF 5
1029	NHL2901028	CP 229 LOCAL CONTROL INPUT CIRCUITS SHEET 4 OF 5
1030	NHL2901029	CP 229 LOCAL CONTROL INPUT CIRCUITS SHEET 5 OF 5
1031	NHL2901030	CP 229 LOCAL CONTROL PANEL
1032	NHL2901031	CP 229 SERIAL I/O CHART CIL
1033	NHL2901032	CP 229 TEST PANEL CIRCUITS
1034	NHL2901033	CP 229 RACK LAYOUT ZONE 1 VITAL MICROPROCESSOR
1035	NHL2901034	CP 229 RACK LAYOUT ZONE 2 VITAL MICROPROCESSOR
1036	NHL2901035	CP 229 RACK LAYOUT ZONE 3 VITAL MICROPROCESSOR
1037	NHL2901036	CP 229 RACK LAYOUT NON-VITAL MICROPROCESSOR
1038	NHL2901037	CP 229 RACK LAYOUT TRACK 1
1039	NHL2901038	CP 229 RACK LAYOUT TRACK 2
1040	NHL2901039	CP 229 RACK LAYOUT TRACK 3
1041	NHL2901040	CP 229 RACK LAYOUT TRACK 4
1042	NHL2901041	CP 229 WALL LAYOUT SHEET 1 OF 3
1043	NHL2901042	CP 229 WALL LAYOUT SHEET 2 OF 3
1044	NHL2901043	CP 229 WALL LAYOUT SHEET 3 OF 3
1045	NHL2931000	ELECTRIC LOCK 293 TRACK AND CABLE PLAN
1046	NHL2991000	CP 230 TRACK AND CABLE PLAN
1047	NHL2991001	CP 230 MICROPROCESSOR ZONING PLAN
1048	NHL2991002	CP 230 LOC. B MICROPROCESSOR BLOCK DIAGRAM
1049	NHL2991003	CP 230 CIL MICROPROCESSOR BLOCK DIAGRAM
1050	NHL2991004	CP 230 SWITCH CONTROL AND INDICATION 10A
1051	NHL2991005	CP 230 SWITCH CONTROL AND INDICATION 10B
1052	NHL2991006	CP 230 LOC. B SNOWMELTER CIRCUITS
1053	NHL2991007	CP 230 DRAWBRIDGE CIRCUITS SPAN CONTROL
1054	NHL2991008	CP 230 DRAWBRIDGE SPAN LOCK CIRCUITS
1055	NHL2991009	CP 230 DRAWBRIDGE TRACK 1 EAST RAIL SEAT
1056	NHL2991010	CP 230 DRAWBRIDGE TRACK 1 WEST RAIL SEAT
1057	NHL2991011	CP 230 DRAWBRIDGE CIRCUITS AND POWER DISTRIBUTION
1058	NHL3071000	TCML 308 TRACK AND CABLE PLAN
1059	NHL3071001	TCML 308 TRACK CIRCUITS 3021T/3071T
1060	NHL3121000	ML 312 / TCML 315 TRACK AND CABLE PLAN
1061	NHL3121001	ML 312 MISCELLANEOUS CIRCUITS
1062	NHL3121002	ML 312 100HZ TRANSFER SWITCH
1063	NHL3121003	ML 312 100HZ POWER DISTRIBUTION 1 OF 2
1064	NHL3121004	ML 312 100HZ POWER DISTRIBUTION 2 OF 2
1065	NHL3121005	ML 312 BATTERY CHARGER B12, B12-NV
1066	NHL3121006	ML 312 GROUND DETECTOR NETWORK
1067	NHL3121007	ML 312 DC POWER CIRCUIT MICROPROCESSOR TRACK 3
1068	NHL3121008	TCML 315 POWER CIRCUITS
1069	NHL3181000	ML 318 TRACK AND CABLE PLAN
1070	NHL3181001	ML 318 MICROPROCESSOR ZONING PLAN
1071	NHL3181002	ML 318 VITAL MICROPROCESSOR BLOCK DIAGRAM
1072	NHL3181003	ML 318 TRACK CIRCUITS 3151T/3181T
1073	NHL3181004	ML 318 LOCAL INDICATION PANEL
1074	NHL3251000	CP 232 TRACK AND CABLE PLAN
1075	NHL3251001	CP 232 CIL - 10' X 40' HOUSE LAYOUT
1076	NHL3291000	CP 233 TRACK AND CABLE PLAN
1077	NHL3291001	CP 233 CIL - 10' X 40' HOUSE LAYOUT
1078	NHL3341000	CP 234 TRACK LAYOUT SHEET 1 OF 2

SHEET #	DRAWING #	TITLE
1079	NHL3341001	CP 234 TRACK LAYOUT SHEET 2 OF 2
1080	NHL3341002	CP 234 CABLE PLAN SHEET 1 OF 2
1081	NHL3341003	CP 234 CABLE PLAN SHEET 2 OF 2
1082	NHL3341004	CP 234 MICROPROCESSOR ZONING PLAN
1083	NHL3341005	CP 234 LOC. B MICROPROCESSOR BLOCK DIAGRAM
1084	NHL3341006	CP 234 CIL MICROPROCESSOR BLOCK DIAGRAM
1085	NHL3341007	CP 234 LOC. G & LOC. J MICROPROCESSOR BLOCK DIAGRAM
1086	NHL3341008	CP 234 SIGNAL LIGHTING 66E, 66W
1087	NHL3371000	ELECTRIC LOCK 337 TRACK AND CABLE PLAN
1088	NHL3401000	ELECTRIC LOCK 340 TRACK AND CABLE PLAN
1089	NHL3401001	ELECTRIC LOCK 340 CIRCUITS
1090	NHL3451000	CP 235 TRACK AND CABLE PLAN
1091	NHL3451001	CP 235 CIL - 10' X 40' HOUSE LAYOUT
1092	NHL3541000	ML 354 TRACK AND CABLE PLAN
1093	NHL3601000	ML 360 / TCML 364 TRACK AND CABLE PLAN
1094	NHL3691000	ML/EL 369 TRACK AND CABLE PLAN
1095	NHL3791000	TCML 375 / ML 379 TRACK AND CABLE PLAN
1096	NHL3841000	ML 384 TRACK AND CABLE PLAN
1097	NHL3931000	ML 393 TRACK AND CABLE PLAN
1098	NHL4011000	TCML 401 TRACK AND CABLE PLAN
1099	NHL4081000	CP 240 TRACK AND CABLE PLAN
1100	NHL4081001	CP 240 TRACK AND CABLE PLAN
1101	NHL4081002	CP 240 CIL - 10' X 46' HOUSE LAYOUT
1102	NHL4081004	CP 240 BLOCK DIAGRAM
1103	NHL4131000	CP 241 TRACK AND CABLE PLAN SHEET 1 OF 2
1104	NHL4131001	CP 241 TRACK AND CABLE PLAN SHEET 2 OF 2
1105	NHL4131002	CP 241 MICROPROCESSOR ZONING PLAN
1106	NHL4131003	CP 241 INTERLOCKING TRACK CIRCUIT TRACK 1AT

APPENDIX "D"

TYPICAL PROCESSOR BASED INTERLOCKING AND INTERMEDIATE TERRITORY SIGNAL SYSTEM LOGIC

The following provides a conceptual software design for a typical Metro-North interlocking using Boolean logic. The I/O, Code System Interface, Variables, Timer and other status/mnemonic declaration where presented are typical in nature and format but would vary with the specific processor used. All Boolean logic shall conform to Metro-North's latest C&S Engineering Operating Manual Typical Signal Circuits, Section 205; "Vital Node Logic Philosophy" and Section 206; "Vital Signal Circuits".

One Non-Vital Processor (NVP) provides the NX processing as well as a control and indication interface to Central (Primary Node). The NVP also outputs Local Control Panel (LCP) indications that are exclusively used for NX operation. Unit lever functions are performed in the Vital Processor. Since some LCP indication resulting from NX function are also used for unit lever function, certain raw information including PBS indication are passed to the vital processor where the LCP indication are driven.

Three vital processors are used. Vital Processor 1 (VP1) controls all equipment related to Track 3. VP2 controls all equipment related to Tracks 1 and 2. Vital Processor 3 (VP3) controls all equipment related to Track 4. Control of switches is split between both vital processors in such a way that a failed vital processor will not affect traffic on a track controlled by the other vital processor. The following programming examples of Boolean equations are based on a two-zoned controlled system. Contractor shall base their design on a three-zone interlocking system as shown on the Contract Drawings.

Serial/Ethernet connections are made between all vital processor and from all vital processor to the NVP. All vital processor are connected to adjacent location by a dedicated vital serial link over diverse path fiber optic cables for vital communication of traffic and/or line circuits. A serial/Ethernet connection is also made between the NVP and Central Office.

Nomenclature Convention: To facilitate the reading of the Boolean statements, the origin/destination of each serial interface bit is indicated as a prefix to each variable name. An underscore "_" is used to separate the prefix from the variable name.

C - Code Line
VP1, VP2 or VP2 - Vital Processor
NVP - Non-Vital Processor
P – Panel

Non Vital Processor

NX controls and indication as well as I/O to and from Central are processed in this non-vital processor. Local Control Panel (LCP) indications that are used only for Non-Vital Processor (NVP) function are driven out of this processor. LCP indication that are used for Local Control Panel function (LCP) that use the vital processor only are driven from the non-vital I/O section of each vital processor as required.

% Input-Output and Variable Definition: The Contractor shall provide site-specific listings as required by vendor specific equipment. \

% LOCAL INPUT-OUTPUT SECTION \

% SERIAL INPUT-OUTPUT SECTION \

% SERIAL I/O TO CENTRAL (Indicated by C_ prefix)\

% SERIAL I/O TO VITAL PROCESSOR ONE (Indicated by VP1_ prefix) \

% SERIAL I/O TO VITAL PROCESSOR TWO (Indicated by VP2_ prefix) \

% SERIAL I/O TO VITAL PROCESSOR THREE (Indicated by VP3_ prefix) \

% LOCAL VARIABLES \

% TIMER SETTINGS \

BEGIN LOGIC

% ENTRANCE LOCKOUT \

```
ASSIGN
(~1EPBS + 12ANW + 12RW) * (~1WPBS + 21BNE + 21RE)
 * (~2EPBS + 21ANW + 21RW) * (~2WPBS + 12BNE + 12RE)          TO ELO;
```

% ENTRANCE SELECTION \

```
ASSIGN
NVP.MODE * ~LCP.MODE
 * (P_1EPB * ~12ANW * ~12RW * VP1_1ATSSK * ELO
 + (1ATK + VP1_1EFLK) * ~P_1EPBCAN * 1EPBS
 * ~VP1_1GZTEK * ~1ETOCAN)                                    TO 1EPBS;
```

```
ASSIGN
NVP.MODE * ~LCP.MODE
 * (P_1WPB * ~21BNE * ~21RE * VP1_1BTNWK * ELO
 + (1BTK + VP1_1WFLK) * ~P_1WPBCAN * 1WPBS
 * ~VP1_1GZTEK * ~1WTOCAN)                          TO 1WPBS;

ASSIGN
NVP.MODE * ~LCP.MODE
 * (P_2EPB * ~21BNW * VP2_2ATSSK * ELO
 + (2ATK + VP2_2EFLK)
 * ~P_2EPBCAN * 2EPBS * ~VP2_2GZTEK * ~2ETOCAN)     TO 2EPBS;

ASSIGN
NVP.MODE * ~LCP.MODE *
(P_2WPB * ~21ANE * VP2_2BTNWK * ELO
 + (2BTK + VP2_2WFLK)
 * ~P_2WPBCAN * 2WPBS * ~VP2_2GZTEK * ~2WTOCAN)     TO 2WPBS;


% EXIT SELECTION  \

ASSIGN
((P_1EPB * ~12ANE * ~12RE) + 1EXS) * (12ANW + 12RW)  TO 1EXS;

ASSIGN
((P_1WPB * ~21BNW * ~21RW) + 1WXS) * (21BNE + 21RE)  TO 1WXS;

ASSIGN
((P_2EPB * ~12BNE) + 2EXS) * 12BNW                   TO 2EXS;

ASSIGN
((P_2WPB * ~21ANW) + 2WXS) * 21ANE                   TO 2WXS;

% ROUTE SELECTION LOGIC  \

ASSIGN
(12BNE + 12RE) * ~21RW * ~21RPBS * ~21RWK
 * (VP2_2ETBK * ~VP2_2WGZ * VP2_2EFK_N + 21ANW)     TO 21ANE;

ASSIGN
(2WPBS + 2WXS) * ~21RW * ~21RPBS * ~21RWK            TO 21ANW;

ASSIGN
12ANE * ~21RE * ~21RPBS * ~21RWK
 * (VP1_1ETBK * ~VP1_1WGZ * VP1_1EFK_N + 21BNW)     TO 21BNE;

ASSIGN
(1WPBS + 1WXS) * ~21RE * ~21RPBS * ~21RWK            TO 21BNW;
```

```
ASSIGN
(12BNE + 12RE) * ~21ANW * ~21BNE * ~21NPBS * ~21NWK
 * (VP1_1ETBK * ~VP1_1WGZ * VP1_1EFK_N + 21RW)                TO 21RE;

ASSIGN
(1WPBS + 1WXS) * ~21BNE * ~21ANW * ~21NPBS * ~21NWK          TO 21RW;

ASSIGN
(2EPBS + 2EXS) * ~12RW * ~12RPBS * ~12RWK                     TO 12BNE;

ASSIGN
(21ANW + 21RW) * ~12RE * ~12RPBS * ~12RWK
 * (VP2_2WTBK * ~VP2_2EGZ * VP2_2WFK_S + 12BNE)               TO 12BNW;

ASSIGN
(1EPBS + 1EXS) * ~12RW * ~12PBS * ~12RWK                      TO 12ANE;

ASSIGN
21BNW * ~12RW * ~12PBS * ~12RWK
 * (VP1_1WTBK * ~VP1_1EGZ * VP1_1WFK_S + 12ANE)               TO 12ANW;

ASSIGN
(21PBS + 1EXS) * ~12BNE * ~12ANW * ~12NPBS * ~12NWK           TO 12RE;

ASSIGN
(21ANW + 21RW) * ~12BNE * ~12ANW * ~12NPBS * ~12NWK
 * (VP1_1WTBK * ~VP1_1EGZ * VP1_1WFK_S + 12RE)                TO 21RW;


% ROUTE SELECTION TIMEOUT CANCEL (30 SECOND SET ) \

ASSIGN
1EPBS * ~VP1_1ERCK * ~P_1EPB                          TO 1ETOCAN;

ASSIGN
1WPBS * ~VP1_1WRCK * ~P_1WPB                          TO 1WTOCAN;

ASSIGN
2EPBS * ~VP2_2ERCK * ~P_2EPB                          TO 2ETOCAN;

ASSIGN
2WPBS * ~VP2_2WRCK * ~P_2WPB                          TO 2WTOCAN;


%     SWITCH PB LOCK STICK WITH STUCK BUTTON PROTECTION  \

ASSIGN
(12PBLS + ~P_12NPB * ~P_12RPB) * 12LK                 TO 12PBLS;
```

```
ASSIGN
(21PBLS + ~P_21NPB * ~P_21RPB) * 21LK                    TO 21PBLS;


% SWITCH PUSH BUTTON STICK  \

ASSIGN
(P_12NPB * ~P_12RPB * 12PBLS + 12NPBS * ~12RPBS)
 * NVP.MODE * ~LCP.MODE * ~P_12AUTOPB * 12WBK            TO 12NPBS,
                                                              VP1_12NPBS,
                                                              VP2_12NPBS;

ASSIGN
(P_12RPB * ~ P_12NPB * 12PBLS + 12RPBS * ~12NPBS)
 * NVP.MODE * ~LCP.MODE * ~P_12AUTOPB * 12WBK            TO 12RPBS,
                                                              VP1_12RPBS,
                                                              VP2_12RPBS;

ASSIGN
(P_21NPB * ~P_21RPB * 21PBLS + 21NPBS * ~21RPBS)
 * NVP.MODE * ~LCP.MODE * ~P_21AUTOPB * 21WBK            TO 21NPBS,
                                                              VP1_21NPBS,
                                                              VP2_21NPBS;

ASSIGN
(P_21RPB * ~ P_21NPB * 21PBLS + 21RPBS * ~21NPBS)
 * NVP.MODE * ~LCP.MODE * ~P_21AUTOPB * 21WBK            TO 21RPBS,
                                                              VP1_21RPBS,
                                                              VP2_21RPBS;

% SWITCH REQUEST \

ASSIGN
(12NPBS + C_12NWZ + (12ANE * 12ANW + 12BNE * 12BNW ))
 * ~ 12RWZ                                                TO 12NWZ,
                                                              VP1_12NWZ,
                                                              VP2_12NWZ;

ASSIGN
(12RPBS + C_12RWZ + (12RE * 12RW)) * ~ 12NWZ              TO 12RWZ,
                                                              VP1_12RWZ;

ASSIGN
(21NPBS + C_21NWZ +( 21ANE * 21ANW + 21BNE * 21BNW ))
 * ~ 21RWZ                                                TO 21NWZ,
                                                              VP1_21NWZ,
                                                              VP2_21NWZ;
```

```
ASSIGN
(21RPBS + C_21RWZ + (21RE * 21RW)) * ~ 21NWZ                TO 21RWZ,
                                                                VP1_21RWZ;


% TRACK INDICATION ************Overlays removed!********* \

ASSIGN
(~VP1_CPS + VP1_1ATPK) * (~VP2_CPS + VP2_1ATPK)
 * (VP1.CPS + VP2.CPS)                                        TO 1ATK;

ASSIGN
(~VP1.CPS + VP1_1BTPK) * (~VP2.CPS + VP1_1BTPK)
 * (VP1.CPS + VP2.CPS)                                        TO 1BTK;

ASSIGN
(~VP1.CPS + VP1_2ATPK) * (~VP2.CPS + VP2_2ATPK)
 * (VP1.CPS + VP2.CPS)                                        TO 2ATK;

ASSIGN
(~VP1.CPS + VP1_2BTPK) * (~VP2.CPS + VP2_2BTPK)
 * (VP1.CPS + VP2.CPS)                                        TO 2BTK;


% SWITCH INDICATION  \

ASSIGN
(VP1_12NWZ + ~VP1_12LK) * VP1_12NWK * VP1.CPS
 + (VP2_12NWZ + ~VP2_12LK) * VP2_12NWK * VP2.CPS             TO 12NWK;

ASSIGN
(VP1_12RWZ + ~VP1_12LK) * VP1_12RWK * VP1.CPS                TO 12RWK;

ASSIGN
(VP1_21NWZ + ~VP1_21LK) * VP1_21NWK * VP1.CPS
 + (VP2_21NWZ + ~VP2_21LK) * VP2_21NWK * VP2.CPS             TO 21NWK;

ASSIGN
(VP1_21RWZ + ~VP1_21LK) * VP1_21RWK * VP1.CPS                TO 21RWK;


% SWITCH LOCK INDICATION  \

ASSIGN
VP1_12LK * VP1.CPS + VP2_12LK * VP2.CPS                      TO 12LK;

ASSIGN
VP1_21LK * VP1.CPS + VP2_21LK * VP2.CPS                      TO 21LK;
```

```
% SWITCH BLOCK  INDICATION  \

ASSIGN
VP1_12WBK * VP1.CPS + VP2_12WBK * VP2.CPS                TO 12WBK;

ASSIGN
VP1_21WBK * VP1.CPS + VP2_21WBK * VP2.CPS                TO 21WBK;


%     GZ EXIT LOGIC  (EASTBOUND)   \

ASSIGN
VP1_1EFK_N * 1WXS                                        TO 1E.GZEXIT;

ASSIGN
VP2_2EFK_N * 2WXS                                        TO 2E.GZEXIT;


%     GZ EXIT LOGIC  (WESTBOUND)  \

ASSIGN
VP1_1WFK_S * 1EXS                                        TO 1W.GZEXIT;


ASSIGN
VP2_2WFK_S * 2EXS                                        TO 2W.GZEXIT;


% FACING POINT SWITCH ( NODE ) GZ LOGIC  ( EASTBOUND )  \

ASSIGN
12NWK * 21NWK * 1E.GZEXIT + 12RWK * 21A.GZ               TO 12A.GZ;

ASSIGN
21NWK * 2EGZEXIT + 21RWK * 1E.GZEXIT                     TO 21A.GZ;


% FACING POINT SWITCH ( NODE ) GZ LOGIC ( WESTBOUND )  \

ASSIGN
12NWK * 2W.GZEXIT + 12RWK * 1W.GZEXIT                    TO 12B.GZ;

ASSIGN
21NWK * 12NWK * 1W.GZEXIT + 21RWK * 12B.GZ               TO 21B.GZ;
```

```
% SIGNAL REQUESTS Use of the GZ simplifies RCSR requirements.  \

ASSIGN
12A.GZ * 1EPBS + C_1EGZ
 + VP1_1EGZ * ~VP1_1EGZC
 * (1ATK + VP1_1EFLK) * ~1ETOCAN                    TO VP1_1EGZ;

ASSIGN
12NWK * 21A.GZ * 2EPBS + C_2EGZ
 + VP2_2EGZ * ~VP2_2EGZC
 * (2ATK + VP2_2EFLK) * ~2ETOCAN                    TO VP2_2EGZ;

ASSIGN
21B.GZ * 1WPBS + C_1WGZ
 + VP1_1WGZ * ~VP1_1WGZC
 * (1BTK + VP1_1WFLK) * ~1WTOCAN                    TO VP1_1WGZ;

ASSIGN
21NWK * 12B.GZ * 2WPBS + C_2WGZ
 + VP2_2WGZ * ~VP2_2WGZC
 * (2BTK + VP2_2WFLK) * ~2WTOCAN                    TO VP2_2WGZ;


% ROUTE CANCEL \

ASSIGN
P_1EPBCAN * NVP.MODE + C_1EGZC
 + VP1_1EGZC * VP1_1ERCK * PBENABLE                TO VP1_1EGZC;

ASSIGN
P_1WPBCAN * NVP.MODE + C_1WGZC
 + VP1_1WGZC * VP1_1WRCK  * PBENABLE               TO VP1_1WGZC;

ASSIGN
P_2WPBCAN * NVP.MODE + C_2WGZC
 + VP2_2WGZC * VP2_2WRCK * PBENABLE                TO VP2_2WGZC;

ASSIGN
P_2EPBCAN * NVP.MODE + C_2EGZC
 + VP2_2EGZC * VP2_2ERCK * PBENABLE                TO VP2_2EGZC;
% INTRUSION DETECTION  \

ASSIGN
DBK * (ALRM.RWTS + DBK1W)                          TO DBK1W;

ASSIGN
(ALRM.RWT + ALRM.RWTS) * ~DBK1W                    TO ALRM.RWTS;
```

```
ASSIGN
~DBK1W * ~ALRM.RWTS                                    TO INT.ALARMR;


% LOCAL CONTROL PANEL LIGHTING  \

% LAMP TEST BUSHBUTTON STUCK BUTTON PROTECTION (30 SEC. SET) \

ASSIGN
P_LTPB                                                 TO LTTE;

ASSIGN
P_LTPB * ~LTTE                                         TO LAMPTEST;


% LOCAL CONTROL PANEL LIGHTING TRACK SEGMENT GREEN LIGHT \

ASSIGN
((12ANW + 12RW) * FLASH
 + (~VP1_1ATSSK + ~VP1_1ATNWK))
 * 1ATK1 * NVP.MODE + LAMPTEST                          TO P_1ATKAGE;

ASSIGN
(~VP1_1ATSSK + ~VP1_1ATNWK)
 * 1ATK1 * NVP.MODE + LAMPTEST                          TO P_1ATKBGE;

ASSIGN
(~VP1_1ATSSK + ~VP1_1ATNWK) * 12NWK
 *1ATK1 * NVP.MODE + LAMPTEST                          TO P_1ATKCGE;

ASSIGN
((21ANE * FLASH + (~VP1_1BTSSK + ~VP1_1BTNWK))
 * 1BTK1 * NVP.MODE + LAMPTEST                          TO P_1BTKBGE;

ASSIGN
(~VP1_1BTSSK + ~VP1_1BTNWK) * 21NWK
 *12NWK * 1BTK1 * NVP.MODE + LAMPTEST                  TO P_1BTKAGE;

ASSIGN
((21BNW + 21RW) * FLASH
 + (12NWK * (~VP2_2ATSSK + ~VP2_2ATNWK)))
 * 2ATK1 * NVP.MODE + LAMPTEST                          TO P_2ATKAGE;

ASSIGN
(~VP2_2ATSSK + ~VP2_2ATNWK) * 12NWK
 *2ATK1 * NVP.MODE + LAMPTEST                          TO P_2ATKBGE;
```

```
ASSIGN
(~VP2_2ATSSK + ~VP2_2ATNWK)
 * 2ATK1 * NVP.MODE + LAMPTEST                    TO P_2ATKCGE;

ASSIGN
((12BNE + 12RE) * FLASH
 + (21NWK * (~VP2_2BTSSK + ~VP2_2BTNWK)))
 * 2BTK1 * NVP.MODE + LAMPTEST                    TO P_2BTKCGE;

ASSIGN
(~VP2_2BTSSK + ~VP2_2BTNWK) * 21NWK
 * 2BTK1 * NVP.MODE + LAMPTEST                    TO P_2BTKBGE;

ASSIGN
(~VP2_2BTSSK + ~VP2_2BTNWK)
 *2BTK1 * NVP.MODE + LAMPTEST                    TO P_2BTKAGE;


%  LOCAL CONTROL PANEL LIGHTING
TRACK SEGMENT RED LAMPS ARE DONE IN THE VITAL SIDE.\

%   LOCAL CONTROL PANEL LIGHTING
RED SWITCH TRACK SEGMENT LAMPS ARE PROCESSED IN THE VITAL SIDE.
THE SWITCH PBS BITS ARE SENT THERE FROM HERE.\

ASSIGN
(12NPBS * ~12NWK * FLASH
 + 12NWK * (12NPBS + ~VP1_1BTSSK + ~VP1_1BTNWK)
 * 1BTK1) * NVP.MODE + LAMPTEST                   TO P_12ANKGE;

ASSIGN
(12NPBS * ~12NWK * FLASH
 + 12NWK * (12NPBS + ~VP2_2BTSSK + ~VP2_2BTNWK)
 * 2BTK1) * NVP.MODE + LAMPTEST                   TO P_12BNKGE;

ASSIGN
(12RPBS * ~12RWK * FLASH
 + 12RWK * (~VP1_1BTSSK + ~VP1_1BTNWK
 + ~VP2_2BTSSK + ~VP2_2BTNWK + 12RPBS)
 * 1BTK1 * 2BTK1) * NVP.MODE + LAMPTEST            TO P_12RKGE;
ASSIGN
(21NPBS * ~21NWK * FLASH
 + 21NWK * (21NPBS + ~VP2_2ATSSK + ~VP2_2ATNWK)
 * 2ATK1) * NVP.MODE + LAMPTEST                   TO P_21ANKGE;

ASSIGN
(21NPBS * ~21NWK * FLASH
 + 21NWK * (21NPBS + ~VP1_1BTSSK + ~VP1_1BTNWK)
 * 1BTK1) * NVP.MODE + LAMPTEST                   TO P_21BNKGE;
```

```
ASSIGN
(21RPBS * ~21RWK * FLASH
 + 21RWK * (~VP1_1BTSSK + ~VP1_1BTNWK
 + ~VP2_2BTSSK + ~VP2_2BTNWK + 21RPBS)
 * 1BTK1 * 2BTK1) * NVP.MODE + LAMPTEST                    TO P_21RKGE;


% TRACK SEGMENT RED LIGHTS - PROCESSED IN VITAL SIDE\

% SIGNAL INDICATION GREEN LIGHTS -PROCESSED IN VITAL SIDE\

% AUTOMATIC SWITCH PUSHBUTTON WHITE LIGHT  \

ASSIGN
~12NPBS * ~12RPBS * NVP.MODE + LAMPTEST                  TO P_12AUTOKWE;

ASSIGN
~21NPBS * ~21RPBS * NVP.MODE + LAMPTEST                  TO P_21AUTOKWE;


% ALARM INDICATION LAMPS  \
% These are only available when the interlocking is in Primary (NVP active) mode. \

ASSIGN
~60HZPOK + LAMPTEST                                      TO P_ACPOKRE;

ASSIGN
~B120POK + ~B12POK + ~B12AFO.NVPOK
 + ~LB12POK + LAMPTEST                                   TO P_DCPOKRE;

ASSIGN
~GNDK + LAMPTEST                                         TO P_GNDKRE;

ASSIGN
SDK + LAMPTEST                                           TO P_SDKRE;
ASSIGN
~CLAFK + LAMPTEST                                        TO P_CLAFKRE;

ASSIGN
~CLBFK + LAMPTEST                                        TO P_CLBFKRE;

ASSIGN
C_MCON * ~C_MCOFF + LAMPTEST                             TO P_MCKRE;

ASSIGN
ENTK + LAMPTEST                                          TO P_BEKRE;

ASSIGN
~SPK + LAMPTEST                                          TO P_SPKRE;
```

```
% SERIAL INDICATIONW TO CENTRAL  \

ASSIGN
VP1_12NWCPR                                          TO C_12NWK;

ASSIGN
VP1_12RWCPR                                          TO C_12RWK;

ASSIGN
~VP1_12WBS                                           TO C_12WBK;

ASSIGN
~VP1_12LR                                            TO C_12LK;

ASSIGN
VP1_21NWCPR                                          TO C_21NWK;

ASSIGN
VP1_21RWCPR                                          TO C_21RWK;

ASSIGN
~VP1_21WBS                                           TO C_21WBK;

ASSIGN
~VP1_21LR                                            TO C_21LK;


%_ NON-VITAL TRACK BLOCK INDICATIONS _\

ASSIGN
VP1_1ETBS                                            TO C_1ETBK;
ASSIGN
VP1_1WTBS                                            TO C_1WTBK;

ASSIGN
VP2_2ETBS                                            TO C_2ETBK;

ASSIGN
VP2_2WTBS                                            TO C_2WTBK;


%_ NON-VITAL SIGNAL INDICATIONS _\

ASSIGN
VP1_1WGR                                             TO C_1WGK;

ASSIGN
VP1_1EGR                                             TO C_1EGK;
```

```
ASSIGN
VP1_1GZTE                                   TO C_1GZTEK;

ASSIGN
VP1_1ERCR                                   TO C_1ERCK;

ASSIGN
VP1_1WRCR                                   TO C_1WRCK;

ASSIGN
VP1_1ATWS                                   TO C_1ATWSK;

ASSIGN
VP1_1BTWS                                   TO C_1BTWSK;

ASSIGN
VP1_1ATNW                                   TO C_1ATNWK;

ASSIGN
VP1_1BTNW                                   TO C_1BTNWK;

ASSIGN
VP1_1WFLZR                                  TO C_1WFLK;

ASSIGN
VP1_1EFLZR                                  TO C_1EFLK;

ASSIGN
VP1_1WABHR                                  TO C_1WABGK;

ASSIGN
VP1_1EABHR                                  TO C_1EABGK;

ASSIGN
VP2_2WGR                                    TO C_2WGK;

ASSIGN
VP2_2EGR                                    TO C_2EGK;

ASSIGN
VP2_2GZTE                                   TO C_2GZTEK;

ASSIGN
VP2_2ERCR                                   TO C_2ERCK;

ASSIGN
VP2_2WRCR                                   TO C_2WRCK;
```

```
ASSIGN
VP2_2ATES                                   TO C_2ATESK;

ASSIGN
VP2_2BTES                                   TO C_2BTESK;

ASSIGN
VP2_2ATNW                                   TO C_2ATNWK;

ASSIGN
VP2_2BTNW                                   TO C_2BTNWK;

ASSIGN
VP2_2WFLZR                                  TO C_2WFLK;

ASSIGN
VP2_2EFLZR                                  TO C_2EFLK;

ASSIGN
VP2_2WABHR                                  TO C_2WABGK;

ASSIGN
VP2_2EABHR                                  TO C_2EABGK;

ASSIGN
BOK                                         TO C_BOK;

%_ NON-VITAL MISC INDICATIONS FROM NON-VITAL PROCESSOR TO CENTRAL \

AS NEEDED

END LOGIC

END PROGRAM
```

Vital Processor 1

This is the typical source code for Vital Processor 1.

It should be noted that the Non-Vital NX function are performed in the Non-Vital processor (Primary Mode). In the event that the NVP is non-functional, local Control Panel function that allow unit lever control are processed as non-vital operation in the vital processor. Certain indication on the LCP must be available regardless of the NVP status. When the NVP is functional, these indications are passed to the Vital Processor from where the Vital Processor would normally drive those indications.

ZONE 1 (Track 1)

% Input-Output and Variable Definition: The Contractor shall provide site-specific listings as required by vendor specific equipment. \

HARDWARE INTERFACE

VITAL LAMP DRIVER:

% Lamp driver output shall be arranged to shut down if the current draw exceeds that of one lamp filament. \

%Lamp Outputs (Typical)\
1WGE, 1WARE, 1WBRE, 1EGE,
1EARE, 1EBRE, SPARE, SPARE;

%Lamp out status \
1WGLO, 1WARLO, 1WBRLO,
1EGLO, 1EARLO, 1EBRLO;

VITAL OUTPUT:

VITAL INPUT:

NON-VITAL OUTPUT:

NON-VITAL INPUT:

% Vital Serial Link
This is information that is shared by both zones. \

MASTER
ADDRESS: 1 % Zone 2 \

OUTPUT:

INPUT:

% Non-Vital Processor
Central is accessed through the Non-Vital processor. The NX function is also processed there. \

SLAVE
ADDRESS: 1

OUTPUT:

```
INPUT:

% Internal variables \

VARIABLE

TIMER BITS

TIMER
% Coil Pick-up time Release time \
INITE: SET=3:SEC CLEAR=0:SEC;
1ATPTE: SET=5:SEC CLEAR=0:SEC;
1BTPTE: SET=5:SEC CLEAR=0:SEC;
2ATPTE: SET=5:SEC CLEAR=0:SEC;
2BTPTE: SET=5:SEC CLEAR=0:SEC;
DLVYTE: SET=3:SEC CLEAR=0:SEC;
PMCANP: SET=0:SEC CLEAR=1:SEC;
1GZTE: SET=30:SEC CLEAR=0:SEC;
1WTOP: SET=0:SEC CLEAR=1:SEC;
12AWZTE: SET=0:SEC CLEAR=1:SEC;
12BWZTE: SET=0:SEC CLEAR=1:SEC;
21AWZTE: SET=0:SEC CLEAR=1:SEC;
21BWZTE: SET=0:SEC CLEAR=1:SEC;
12ORTE: SET=6:SEC CLEAR=0:SEC;
21ORTE: SET=6:SEC CLEAR=0:SEC;
1WASTE: SET=180:SEC CLEAR=0:SEC;
1EASTE: SET=180:SEC CLEAR=0:SEC;
1ANTE: SET=3:SEC CLEAR=0:SEC;
1BNTE: SET-2:SEC CLEAR=0:SEC;
1WG: SET=0:SEC CLEAR=1:SEC;
1EG: SET=0:SEC CLEAR=1:SEC;
1ATSVSR: SET=0:SEC CLEAR=500:MSEC;
1ATNVSR, VP2_1ATNVSR: SET=0:SEC CLEAR=500:MSEC;
1BTSVSR, VP2_1BTSVSR: SET=0:SEC CLEAR=500:MSEC;
1BTNVSR: SET=0:SEC CLEAR=500:MSEC;
NDOORTE: SET=30:SEC CLEAR=0:SEC;
XDOORTE: SET=30:SEC CLEAR=0:SEC;
ECPEO: SET=1:SEC CLEAR=1:SEC;.% Page 8 \
FLTSTOP: SET=1600:MSEC CLEAR=500:MSEC;.
FLTCLEAR: SET=500:MSEC CLEAR=1600:MSEC;

LOGIC BEGIN

%_ ENABLE CIRCUITS _\

ASSIGN
~LCP.MODE * NVP.1.STATUS * PB.ENABLEP                    TO NVP.MODE;
```

```
ASSIGN
P_MOKP * ~NVP.1.STATUS * PB.ENABLEP                    TO LCP.MODE;

ASSIGN
1EARLO + 1EGLO + 1EBRLO + 1WARLO
 + 1WGLO + 1WBRLO + 2EARLO + 2EGLO + 2EBRLO            TO BOK;

ASSIGN
~EOR * (1WGR + 1EGR)                                   TO EOR;

ASSIGN
VPOKAY * ~2XFER                                   TO SW12_ENABLE,
                                                     SW21_ENABLE;


%_ INTERLOCKING TRACK _\

% Track repeater - loss of shunt timing) \

ASSIGN
1AT * ~1ATP                                            TO 1ATPTE;

ASSIGN
1AT * (1ATP + 1ATPTE)                                  TO 1ATP;

ASSIGN
1BT * ~1BTP                                            TO 1BTPTE;


ASSIGN
1BT * (1BTP + 1BTPTE)                                  TO 1BTP;

ASSIGN
1ATP1 * 1BTP1                                          TO 1TPR;

ASSIGN
2AT * ~2ATP                                            TO 2ATPTE;

ASSIGN
2AT * (2ATP + 2ATPTE)                                  TO 2ATP;

ASSIGN
2BT * ~2BTP                                            TO 2BTPTE;

ASSIGN
2BT * (2BTP + 2BTPTE)                                  TO 2BTP;

ASSIGN
2ATP1 * 2BTP1                                          TO 2TPR;
```

```
%_ TRACK BLOCKS _\

ASSIGN
(NVP_1ETBZ * ~NVP_1ETBCAN * NVP.MODE)
 + (P_1ETBPB * ~P_MCANPB * LCP.MODE)
 + (1ETBZR * ~1ETBCAN)                                  TO 1ETBZR;

ASSIGN
(NVP_1WTBZ * ~NVP_1WTBCAN * NVP.MODE)
 + (P_1WTBPB * ~P_MCANPB * LCP.MODE)
 + (1WTBZR * ~1WTBCAN)                                  TO 1WTBZR;

ASSIGN
(NVP.MODE  * NVP_1ETBCAN)
 + (LCP.MODE * P_1ETBPB * P_MCANPB)                     TO 1ETBCAN;

ASSIGN
(NVP.MODE  * NVP_1WTBCAN)
 + (LCP.MODE * P_1WTBPB * P_MCANPB)                     TO 1WTBCAN;

ASSIGN
(NVP_1ETBCAN * ~NVP_1ETBZ * NVP.MODE)
 + (P_1ETBPB * P_MCANPB * LCP.MODE)
 + (1ETBS * ~1ETBZR)                                    TO 1ETBS;

ASSIGN
(NVP_1WTBCAN * ~NVP_1WTBZ * NVP.MODE)
 + (P_1WTBPB * P_MCANPB * LCP.MODE)
 + (1WTBS * ~1WTBZR)                                    TO 1WTBS;


%_ SWITCH CONTROL _\

ASSIGN
12ANWP * 12BNWP                                         TO 12NWP;

ASSIGN
12ARWP * 12BRWP                                         TO 12RWP;

ASSIGN
((((NVP_12NWZ * ~NVP_12RWZ * NVP.MODE)
 + (P_12NWPB * ~P_12RWPB * LCP.MODE))
 * 12LR * 12WBS * VPOKAY) + (12NWZR * ~12RWZR)
 + (~VPOKAY * 12NWP * ~12RWP * ~12RWZR))
 * SW12_ENABLE                                          TO 12NWZR;
```

```
ASSIGN
((((NVP_12RWZ * ~NVP_12NWZ * NVP.MODE)
 + (P_12RWPB * ~P_12NWPB * LCP.MODE))
 * 12LR * 12WBS * VPOKAY) + (12RWZR * ~12NWZR)
 + (~VPOKAY * 12RWCP * ~12NWCP * ~12NWZR))
 * SW12_ENABLE                                          TO 12RWZR;

ASSIGN
(((NVP_12WBZ * ~NVP_12WBCAN * NVP.MODE )
 + (P_12WBPB * ~P_MCANPB * LCP.MODE))
 * SW12_ENABLE                                          TO 12WBZR;

ASSIGN
((NVP_12WBCAN * ~NVP_12WBZ * NVP.MODE)
 + (P_12WBPB *  P_MCANPB * LCP.MODE)
 + (12WBS * (~12WBZR + (~12NWCPR * ~12RWCPR))))
 * SW12_ENABLE                                          TO 12WBS;

ASSIGN
12NWZR * ~12RWZR * ~12NWCPR * ~12ORTE * 12LR
 * SW12_ENABLE                                          TO 12NWR;

ASSIGN
12RWZR * ~12NWZR * ~12RWCPR * ~12ORTE * 12LR
 * SW12_ENABLE                                          TO 12RWR;

ASSIGN
1TPR * 1TSS * 1TNW * 2TSS * 2TNW * TP_12LP
 * SW12_ENABLE                                          TO 12LR,
                                                           VP2_12LR,
                                                           TP_12LKE;

ASSIGN
(1TPR * ~12NWCPR * ~12RWCPR * ~12ORTE * (12LR + 12LS))
 * SW12_ENABLE                                          TO 12LS;

ASSIGN
(12LS + (12ORTE * ((12NWZR * ~12RWZR)
 + (12RWZR * ~12NWZR))))
 * SW12_ENABLE                                          TO 12ORTE;

ASSIGN
21ANWP * 21BNWP                                         TO 21NWP;

ASSIGN
21ARWP * 21BRWP                                         TO 21RWP;
```

```
ASSIGN
((((NVP_21NWZ * ~NVP_21RWZ * NVP.MODE)
 + (P_21NWPB * ~P_21RWPB * LCP.MODE))
 * 21LR * 21WBS * VPOKAY) + (21NWZR * ~21RWZR)
 + (~VPOKAY * 21NWP * ~21RWP * ~21RWZR))
 * SW21_ENABLE                                          TO 21NWZR;

ASSIGN
((((NVP_21RWZ * ~NVP_21NWZ * NVP.MODE)
 + (P_21RWPB * ~P_21NWPB * LCP.MODE))
 * 21LR * 21WBS * VPOKAY) + (21RWZR * ~21NWZR)
 + (~VPOKAY * 21RWCP * ~21NWCP * ~21NWZR))
 * SW21_ENABLE                                          TO 21RWZR,
                                                          VP2_21RWZR;
ASSIGN
(((NVP_21WBZ * ~NVP_21WBCAN * NVP.MODE )
 + (P_21WBPB * ~P_MCANPB * LCP.MODE))
 * SW21_ENABLE                                          TO 21WBZR;

ASSIGN
((NVP_12WBCAN * ~NVP_12WBZ * NVP.MODE)
 + (P_12WBPB *  P_MCANPB * LCP.MODE)
 + (12WBS * (~12WBZR + (~12NWCPR * ~12RWCPR))))
 * SW12_ENABLE                                          TO 12WBS;

ASSIGN
21NWZR * ~21RWZR * ~21NWCPR * ~21ORTE * 21LR
 * SW21_ENABLE                                          TO 21NWR;

ASSIGN
21RWZR * ~21NWZR * ~21RWCPR * ~21ORTE * 21LR
 * SW21_ENABLE                                          TO 21RWR;

ASSIGN
1TPR * 1TSS * 1TNW * 2TSS * 2TNW * TP_21LP
 * SW21_ENABLE                                          TO 21LR,
                                                          VP2_21LR,
                                                          TP_21LKE;

ASSIGN
(1TPR * ~21NWCPR * ~21RWCPR * ~21ORTE * (21LR + 21LS))
 * SW21_ENABLE                                          TO 21LS;

ASSIGN
(21LS + (21ORTE * ((21NWZR * ~21RWZR)
 + (21RWZR * ~21NWZR))))
 * SW21_ENABLE                                          TO 21ORTE;
```

```
%_ SWITCH CORRESPONDENCE _\

ASSIGN
12NWCP * ~12RWCP * ~12RWCPR
 * 12NWZR * ~12RWZR * ~12RWR                          TO 12NWCPR;

ASSIGN
12RWCP * ~12NWCP * ~12NWCPR
 * 12RWZR * ~12NWZR * ~12NWR                          TO 12RWCPR;

ASSIGN
21NWCP * ~21RWCP * ~21RWCPR
 * 21NWZR * ~21RWZR * ~21RWR                          TO 21NWCPR;
ASSIGN
21RWCP * ~21NWCP * ~21NWCPR
 * 21RWZR * ~21NWZR * ~21NWR                          TO 21RWCPR;


%_ SIGNAL REQUEST _\

ASSIGN
((NVP_1WGZ * ~1GZTE * ~NVP_1EGZ * NVP.MODE)
 + (P_1WGPB * ~P_1EGPB * LCP.MODE)
 + (1WGZR * ~1GZTE))
 * 1TNW * (1TPR + 1WFLZR) * ~1EGZR * ~1WTOP            TO 1WGZR;

ASSIGN
((NVP_1WFLZ * ~NVP_1WFLCAN * NVP.MODE)
 + (P_1WFLPB * ~P_1WFLCAN * LCP.MODE)
 + (1WFLZR * ~1WFLCAN)) * 1WGZR                        TO 1WFLZR;

ASSIGN
NVP_1WFLCAN * NVP.MODE + P_1WFLCAN * LCP.MODE          TO 1WFLCAN;

ASSIGN
((NVP_1WABZ * ~NVP_1WABCAN * NVP.MODE)
+ (P_1WABGPB * ~P_MCANPB * LCP.MODE)
 + (1WABZR * 1WABHR * ~1WABCAN)) * 1WGZR               TO 1WABZR;

ASSIGN
NVP_1WABCAN *
NVP.MODE + P_1WABGPB * P_MCANPB * LCP.MODE             TO 1WABCAN;

ASSIGN
((NVP_1EGZ * ~1GZTE * ~NVP_1EGZ * NVP.MODE)
 + (P_1EGPB * ~P_1EGPB * LCP.MODE)
 + (1EGZR * ~1GZTE))
 * 1TNW * (1TPR + 1EFLZR) * ~1EGZR * ~1ETOP             TO 1EGZR;
```

```
ASSIGN
((NVP_1EFLZ * ~NVP_1EFLCAN * NVP.MODE)
 + (P_1EFLPB * ~P_1EFLCAN * LCP.MODE)
 + (1EFLZR * ~1EFLCAN)) * 1EGZR                    TO 1EFLZR;

ASSIGN
NVP_1EFLCAN * NVP.MODE + P_1EFLCAN * LCP.MODE      TO 1EFLCAN;

ASSIGN
((NVP_1EABZ * ~NVP_1EABCAN * NVP.MODE)
+ (P_1EABGPB * ~P_MCANPB * LCP.MODE)
 + (1EABZR * 1EABHR * ~1EABCAN)) * 1EGZR           TO 1EABZR;

ASSIGN
NVP_1EABCAN *
NVP.MODE + P_1EABGPB * P_MCANPB * LCP.MODE         TO 1EABCAN;

ASSIGN
(1WGZR * ~1WRCR + 1EGZR * ~1ERCR)
 * ~1WFLZR * ~1EFLZR                               TO 1GZTE;

ASSIGN
((NVP_1WGCAN + NVP_1EGCAN) * NVP.MODE)
 + ((P_1WGCAN + P_1EGCAN) * LCP.MODE)              TO 1WTOP;


%_ ROUTE CHECK _ \

ASSIGN
(1WHDR + 1WFS) * 1WTBS                             TO 1WRCXR,
                                                      VP2_1WRCXR;

ASSIGN
(1EHDR * 1EFS) * 1ETBS                             TO 1ERCXR,
                                                      VP2_1ERCXR;

ASSIGN
21NWCR * 12NWCR * 1WRCXR
 + 21RWCR * VP2_12B.RC                             TO 21B.RC;

ASSIGN
12NWCR * 21NWCR * 1ERCXR
 + 12RWCR * VP2_21A.RC                             TO 12A.RC;

ASSIGN
1WGZR * 1BTNW * 21B.RC                             TO 1WRCR;

ASSIGN
1EGZR * 1ATSS * 12A.RC                             TO 1ERCR;
```

```
%_ APPROACH STICKS _\

ASSIGN
~1WRCR * 1WRGPR * ~1WASR * 1BTPR
 * (1WASTE + (21NWCR * 1ATPR) + (21RWCR * 2BTPR))          TO 1BWTE;

ASSIGN
~1WRCR * 1WRGPR * ~1WASR * 1BTPR                            TO 1WASTE;

ASSIGN
~1WRCR * 1WRGPR *
((RESTART * POSR * 1BWTE * (21NWCR * ~1ATPR
 + 21RWCR * ~2BTPR) + (1WASTE * 1BTPR) + 1WASR)              TO 1WASR;

ASSIGN
~1ERCR * 1ERGPR * ~1EASR * 1ATPR
 * (1EANTE + (12NWCR * 1BTPR) + (12RWCR * 2ATPR))          TO 1AETE;

ASSIGN
~1ERCR * 1ERGPR * ~1EASR * 1ATPR                            TO 1EASTE;

ASSIGN
~1ERCR * 1ERGPR *
((RESTART * POSR * 1AETE * (12NWCR * ~1BTPR
 + 12RWCR * ~2ATPR) + (1EASTE * 1ATPR) + 1EASR))             TO 1EASR;

ASSIGN
1WASR * (1BTPR + 1BTWS)                                     TO 1BTWS,
                                                                VP2_1BTWS,
                                                                NVP_1BTWS;

ASSIGN
(1BTSS + 12RWCR) * (VP2_2BTWS + 12NWCR)
 * (1ATPR + 1ATWS)                                          TO 1ATWS,
                                                               VP2_1ATWS,
                                                               NVP_1ATWS;

ASSIGN
1EASR * (1ATPR + 1ATNW)                                     TO 1ATNW,
                                                               VP2_1ATNW,
                                                               NVP_1ATNW;

ASSIGN
(1ATNW + 21RWCR) * (VP2_2ATNW + 21NWCR)
 * (1BTPR + 1BTNW)                                          TO 1BTNW,
                                                               VP2_1BTNW,
                                                               NVP_1BTNW;
```

```
%_ FOLLOW STICKS  (WHERE REQUIRED)  _\

ASSIGN
~1ATPR * ~1ATWS * 1ATNW * 1WHDR
 + (1WFS * ~1WHDR * ~1WTPR)                                  TO 1WFS;

ASSIGN
~1BTPR * ~1BTNW * 1BTWS * 1EHDR
 + (1EFS * ~1EHDR * ~1ETPR)                                  TO 1EFS;

%_ SIGNAL CONTROL _\

ASSIGN
1WRCR * 1BTPR * ~1WASR * ~1WASTE * ~21LR * 21B.G            TO 1WGR;

ASSIGN
1ERCR * 1ATPR * ~1EASR * ~1EASTE * ~12LR * 12A.G            TO 1EGR;

ASSIGN
(21NWCR * 1ERCXR + 21RWCR * VP2_12B.G) * ~21LR              TO 21B.G;

ASSIGN
(12NWCR * 1ERCXR + 12RWCR * VP2_21A.G) * ~12LR              TO 12A.G;

ASSIGN
1WGR * ~1WGLO * 21NWCR * 1ATPR
 * (21NWCR + 21RWCR * 2BTPR * VP2_12B.HYPR)                  TO 1WHYPR;

ASSIGN
1EGR * ~1EGLO * 12NWCR * 1BTPR
 * (12NWCR + 12RWCR * 2ATPR * VP2_21A.HYPR)                  TO 1EHYPR;

ASSIGN
1WABZR * 1WHYPR * ((1WDP * 1WBP * 21NWCR)
 + (VP2_12B.ABHR * 21RWCR))                                  TO 1WABHR;

ASSIGN
1EABZR * 1EHYPR * ((1EDP * 1EBP * 12NWCR)
 + (VP2_21A.ABHR * 12RWCR))                                  TO 1EABHR;


%_ SIGNAL LIGHTING _\

ASSIGN
1WGR * EOR                                                   TO 1WGE;

ASSIGN
1EGR * EOR                                                   TO 1EGE;
```

```
ASSIGN
~1WGR + 1WGR * 1WABHR * ~EOR                    TO 1WARE,
                                                   1WBRE;

ASSIGN
~1EGR + 1EGR * 1EABHR * ~EOR                    TO 1EARE,
                                                   1EBRE;

ASSIGN
~1WGR * TP_1WRGP                                TO 1WRGPR;

ASSIGN
~1EGR * TP_1ERGP                                TO 1ERGPR;


%_ CODE SELECTION STATEMENTS _\

%_ Eastward Routes _\
%_ 1AT Eastward _\

ASSIGN
12NWCR * 1BTPR                                  TO 1A.1E;

ASSIGN
12RWCR * 2ATPR                                  TO 1A.2E;

ASSIGN
~1ATPR * (1A.1E + 1A.2E)
 * (1EGR * ~1EGLO * + 1ATEVSR)                  TO 1ATEVSR,
                                                   VP2_1ATEVSR;

ASSIGN
1BTEHDR * 1BTPR                                 TO 1ATEHDR,
                                                   VP2_1ATEHDR;

%_ 1AT Westward -\

ASSIGN
1WWFP * ~1WEFP * 1WTPR                          TO 1A.1W;

ASSIGN
~1ATP * 1A.1W * (12NWCR + 12RWCR)
 * ((1BTWVSR * 12NWCR + VP2_2ATWVSR * 12RWCR)
 + 1ATWVSR)                                     TO 1ATWVSR;

ASSIGN
1ATNW * ~1ATWS * 1WHDR                          TO 1ATWHDR,
                                                   VP2_1ATWHDR;
```

```
ASSIGN
1WDP                                                    TO 1ATWDR,
                                                           1BTWDR,
                                                           VP2_1ATWDR;

ASSIGN
1ATWVSR * 1ATWHDR * ~1ATWDR
 + 1ATEVSR * 1ATEHDR * ~1ATEDR                          TO 1AT75R;

ASSIGN
1ATWVSR * 1ATWHDR * 1ATWDR
 + 1ATEVSR * 1ATEHDR * 1ATEDR * ~1AT75R                 TO 1AT180R;


%_ 1BT Eastward_\

ASSIGN
1ENFP * ~1ESFP * 1ETPR                                  TO 1B.1E;

ASSIGN
~1BTPR * 1B.1E * (21NWCR + 21RWCR) *
((1ATEVSR * 21NWCR + VP2_2BTEVSR * 21RWCR)
 + 1BTEVSR)                                             TO 1BTEVSR;

ASSIGN
1BTSS * ~1BTNW * 1EHDR                                  TO 1BTEHDR,
                                                           VP2_1BTEHDR;

ASSIGN
1EDP                                                    TO 1BTEDR,
                                                           1ATEDR,
                                                           VP2_1BTEDR;


%_ 1BT Westward _\

ASSIGN
21NWCR * 1ATPR                                          TO 1B.1W;

ASSIGN
21RWCR * 2BTPR                                          TO 1B.2W;

ASSIGN
~1BTPR * (1B.1W + 1B.2W)
 * (1WGR * ~1WGLO + 1BTWVSR)                            TO 1BTWVSR,
                                                           VP2_1BTWVSR;
```

```
ASSIGN
1ATWHDR * 1ATPR                                    TO 1BTWHDR,
                                                      VP2_1BTWHDR;

ASSIGN
1BTEVSR * 1BTEHDR * ~1BTEDR
 + 1BTWVSR * 1BTWHDR * ~1BTWDR                     TO 1BT75R;

ASSIGN
1BTEVSR * 1BTEHDR * 1BTEDR
 + 1BTVWSR * 1BTWHDR * 1BTWDR * ~1BT75R            TO 1BT180R;
```

%_ LCP LIGHTING _\

```
ASSIGN
~LCPEO * LCP.MODE                                  TO LCPEO;

ASSIGN
~LCPEO2 * LCP.MODE                                 TO LCPEO2;
```

%_ Crossing Control Statements (WHERE REQUIRED) _\

```
ASSIGN
((1BTSSR + 1BTPR) * (1ATSSR + 1ATPR))
 + 12RWCR + 21RWCR                                 TO 1WXR;
```

%_ LCP TRAFFIC INDICATIONS Non Vital Outputs _\

```
ASSIGN
((1WHDR + 1WFS) * 1WTBS) + LAMPTEST                TO P_1WFK_SGE;

ASSIGN
((1EHDR + 1EFS) * 1ETBS) + LAMPTEST                TO P_1EFK.NGE;
```

%_ LCP TRACK INDICATIONS Non Vital Outputs _\

```
ASSIGN
~1ATK1 * LAMPTEST                                  TO P_1ATKARE,
                                                      P_1ATKBRE;

ASSIGN
~1ATK1 * ~12RWK + LAMPTEST                         TO P_1ATKCRE;

ASSIGN
~1BTK1 * LAMPTEST                                  TO P_1BTKARE;
```

```
ASSIGN
~1BTK1 * ~21RWK + LAMPTEST                    TO P_1BTKBRE,
                                                 P_1BTKCRE;

ASSIGN
~1ATPR * ~12RWCPR + LAMPTEST                  TO P_12NTKRE;

ASSIGN
~1BTPR * ~21NWCPR + LAMPTEST                  TO P_21RTKRE;

ASSIGN
~1WTPR + LAMPTEST                             TO P_1WTKRE;

ASSIGN
~1ETPR + LAMPTEST                             TO P_1ETKRE;
```

%_ LCP SWITCH INDICATION Non Vital Outputs _\

```
ASSIGN
(12NWCR + 12NWZR * LCPEO + LAMPTEST)
 * SW12_ENABLE                                TO P_12NWGKE;

ASSIGN
(12RWCR + 12RWZR * LCPEO + LAMPTEST)
 * SW12_ENABLE                                TO P_12RWYKE;

ASSIGN
(~12WBS + 12WBZR * LCPEO + LAMPTEST)
 * SW12_ENABLE                                TO P_12WBKBE;

ASSIGN
~12LR + LAMPTEST * SW12_ENABLE                TO P_12LKRE;

ASSIGN
(12ANWP + LAMPTEST) * SW12_ENABLE             TO P_12ANWKGE;

ASSIGN
(12BNWP + LAMPTEST) * SW12_ENABLE             TO P_12BNWKGE;

ASSIGN
(12ARWP + LAMPTEST) * SW12_ENABLE             TO P_12ARWKYE;

ASSIGN
(12BRWP + LAMPTEST) * SW12_ENABLE             TO P_12BRWKYE;

ASSIGN
(21NWCR + 21NWZR * LCPEO + LAMPTEST)
 * SW21_ENABLE                                TO P_21NWGKE;
```

```
ASSIGN
(21RWCR + 21RWZR * LCPEO + LAMPTEST)
 * SW21_ENABLE                                    TO P_21RWYKE;

ASSIGN
(~21WBS + 21WBZR * LCPEO + LAMPTEST)
 * SW21_ENABLE                                    TO P_21WBKBE;

ASSIGN
~21LR + LAMPTEST * SW21_ENABLE                     TO P_21LKRE;

ASSIGN
(21ANWP + LAMPTEST) * SW21_ENABLE                  TO P_21ANWKGE;

ASSIGN
(21BNWP + LAMPTEST) * SW21_ENABLE                  TO P_21BNWKGE;

ASSIGN
(21ARWP + LAMPTEST) * SW21_ENABLE                  TO P_21ARWKYE;

ASSIGN
(21BRWP + LAMPTEST) * SW21_ENABLE                  TO P_21BRWKYE;


%_ LCP TRACK BLOCK INDICATIONS _\

ASSIGN
(~1WTBS + (1WTBZR * 1W1TBS * LCPEO)
 + P_LTPB) * LCP.MODE                              TO P_1WTBKE;

ASSIGN
(~1ETBS + (1ETBZR * 1ETBS * LCPEO)
 + P_LTPB) * LCP.MODE                              TO P_1ETBKE;


%_ LCP SIGNAL INDICATIONS _\

ASSIGN
(((NVP_1WPBS * NVP.MODE + 1WGZR)
 * ~1WGK * LCPEO + 1WGK) * ~1WFLZR
 + 1WFLZR * (~1WGK * FLTSTOP + 1WGK * FLTCLEAR))
 + LAMPTEST                                        TO P_1WGKGE;

ASSIGN
(((NVP_1EPBS * NVP.MODE + 1EGZR)
 * ~1EGK * LCPEO + 1EGK) * ~1EFLZR
 + 1EFLZR * (~1EGK * FLTSTOP + 1EGK * FLTCLEAR))
 + LAMPTEST                                        TO P_1EGKGE;
```

```
ASSIGN
1WABHR + 1WABZR * LCPEO + LAMPTEST                    TO P_1WABGKE;

ASSIGN
1EABHR + 1EABZR * LCPEO + LAMPTEST                    TO P_1EABGKE;


%_ NON-VITAL TRACK INDICATIONS _\

ASSIGN
1TPR                                                  TO NVP_1TPK;

ASSIGN
1BPR                                                  TO NVP_1BPK;

ASSIGN
A1TPR                                                 TO NVP_A1TPK;

ASSIGN
B1TPR                                                 TO NVP_B1TPK;


%_ NON-VITAL SWITCH INDICATIONS _\

ASSIGN
12NWCPR                                               TO NVP_12NWK;

ASSIGN
12RWCPR                                               TO NVP_12RWK;

ASSIGN
~12WBS                                                TO NVP_12WBK;

ASSIGN
~12LR                                                 TO NVP_12LK;

ASSIGN
21NWCPR                                               TO NVP_21NWK;

ASSIGN
21RWCPR                                               TO NVP_21RWK;

ASSIGN
~21WBS                                                TO NVP_21WBK;

ASSIGN
~21LR                                                 TO NVP_21LK;
```

```
%_ NON-VITAL TRACK BLOCK INDICATIONS _\

ASSIGN
1ETBS                                                   TO NVP_1ETBK;

ASSIGN
1WTBS                                                   TO NVP_1WTBK;


%_ NON-VITAL SIGNAL INDICATIONS _\

ASSIGN
1WGR                                                    TO NVP_1WGK;

ASSIGN
1EGR                                                    TO NVP_1EGK;

ASSIGN
1GZTE                                                   TO NVP_1GZTEK;

ASSIGN
1ERCR                                                   TO NVP_1ERCK;

ASSIGN
1WRCR                                                   TO NVP_1WRCK;

ASSIGN
1TWS                                                    TO NVP_1TWSK;

ASSIGN
1TNW                                                    TO NVP_1TNWK;

ASSIGN
1WFLZR                                                  TO NVP_1WFLK;

ASSIGN
1EFLZR                                                  TO NVP_1EFLK;

ASSIGN
1WABHR                                                  TO NVP_1WABGK;

ASSIGN
1EABHR                                                  TO NVP_1EABGK;

ASSIGN
BOK                                                     TO NVP_BOK;
```

```
%_ NON-VITAL MISC INDICATIONS _\

ASSIGN
(1W.HDR + 1WFS) * 1WTBS                                  TO NVP_1WF.SNK;

ASSIGN
(1E.HDR + 1EFS) * 1ETBS                                  TO NVP_1EF.NEK;

END of Local LOGIC to Processor 1

END PROGRAM

%_Typical Interlocking  -  ONE TRACK VP1 \

%_Typical Traffic Logic From Typical CP1 TO CP 2 - Three Track \

BEGIN CP1 LISTINGS

%_SERIAL OUTPUTS CP1 TO ML2:
CP1-CP2-3WFLR_OUT, CP1-CP2-3EFCANR,
CP1-CP2-3EFLR, CP1-CP2-3WFCANCR_OUT,
CP1-CP2-3EFPR, CP2-CP1-3WFRR;

%_SERIAL INPUTS ML2 TO CP1:
CP2-CP1-3EFLR_IN, CP2-CP1-3WFCANR,
CP2-CP1-3EFCANCR_IN, CP2-CP1-3EFRR,
CP2-CP1-3WFR_IN;

ASSIGN
3BTESR * 3E1TPR                                     TO CP1-CP2-3WFLR_OUT;

%_LOGIC FOR CP1:

ASSIGN
CP2-CP1-3EFLR_IN * 3E1TPR                           TO CP2-CP1-3EFLR;

ASSIGN
CP2-CP1-3EFCANCR_IN * ~CP2-CP1-3WFR                 TO CP2-CP1-3EFCANCR;

ASSIGN
~CP1-CP2-3EFR * ~CP1-CP2-3EFPR                 TO CP1-CP2-3WFCANCR_OUT;

ASSIGN
(CP1-CP2-3EFCANR * CP2-CP1-3EFLR * ~CP2-CP1-3WFR
 + CP1-CP2-3EFR + ~CP1-CP2-3EFR
 * ~CP2-CP1-3WFR * CP2-CP1-3EFRR)
 * ~CP2-CP1-3WFCANR                                  TO CP1-CP2-3EFR;
```

```
ASSIGN
(3EXS * ~CP1-CP2-3EFR + CP1-CP2-3EFCANR
 * ~CP2-CP1-3EFCANCR) * CP2-CP1-3EFLR                TO CP1-CP2-3EFCANR;

ASSIGN
CP1-CP2-3EFR * (CP2-CP1-3EFCANCR
 + CP2-CP1-3EFRR * ~CP2-CP1-3WFR
 * ~CP1-CP2-3EFPR + CP1-CP2-3EFPR)                  TO CP1-CP2-3EFPR;

ASSIGN
(CP2-CP1-3WFR_IN + CP2-CP1-3WFR)
 * ~CP1-CP2-3EFCANR                                 TO CP2-CP1-3WFR;


BEGIN ML2 LISTINGS

%_SERIAL OUTPUTS ML2 TO CP1:
CP2-CP1-3EFLR_OUT, CP2-CP1-3WFCANR,
CP2-CP1-3EFCANCR_OUT, CP2-CP1-3EFRR,
CP2-CP1-3WFR_OUT;

%_SERIAL INPUTS CP1TO ML2:
CP1-CP2-3WFLR_IN, CP1-CP2-3EFCANR,
CP2-CP1-3EFLPR, CP1-CP2-3WFCACR_IN,
CP1-CP2-3EFR_IN, CP1-CP2-3WFRR:

%_SERIAL OUTPUTS ML2 TO ML4
CP1-CP2-3WFLR_OUT, CP1-CP2-3EFCANR,
CP2-CP1-3EFLPPR,CP1-CP2-3WFCANCR_OUT,
CP1-CP2-3EFR_OUT, CP1-CP2-3WFRR;

%_SERIAL INPUTS ML4 TO ML2:
CP2-CP1-3EFLR_IN, CP2-CP1-3WFCANR,
CP2-CP1-3EFCANCR_IN, CP2-CP1-3EFRR,
CP2-CP1-3WFR_IN;


%_LOGIC FOR ML2:

ASSIGN
CP1-CP2-3WFLR_IN * 3E2TPR * 3E3TPR                 TO CP1-CP2-3WFLR_OUT;

ASSIGN
CP2-CP1-3EFLR_IN * 3E3TPR * 3E2TPR                 TO CP2-CP1-3EFLR_OUT;

ASSIGN
CP2-CP1-3EFCANCR_IN * ~CP2-CP1-3WFR_OUT
 * ~CP2-CP1-3WFR_IN                          TO CP2-CP1-3EFCANCR_OUT;
```

```
ASSIGN
CP1-CP2-3WFCANCR_IN * ~CP1-CP2-3EFR_OUT
 * ~CP1-CP2-3EFR_IN                          TO CP1-CP2-3WFCANCR_OUT;

ASSIGN
(CP2-CP1-3WFR_IN + CP2-CP1-3WFR_OUT)
 * ~CP1-CP2-3EFR_IN * ~CP1-CP2-3EFCANR            TO CP2-CP1-3WFR_OUT;

ASSIGN
(CP1-CP2-3EFR_IN + CP1-CP2-3EFR_OUT
 * ~CP2-CP1-3WFR_IN) * ~CP2-CP1-3WFCANR           TO CP1-CP2-3EFR_OUT;


BEGIN ML4 LISTINGS

%_SERIAL OUTPUTS ML4 TO ML2:
CP2-CP1-3EFLR_OUT, CP2-CP1-3WFCANR_OUT,
CP2-CP1-3EFCANCR_OUT, CP1-CP2-3EFRR,
CP2-CP1-3WFR_OUT;

%_SERIAL INPUTS ML2 TO ML4:
CP1-CP2-3WFLR_IN, CP1-CP2-3EFCANR_IN,
CP2-CP1-3EFLPPR, CP1-CP2-3WFCANCR_IN,
CP1-CP2-3EFR_IN, CP1-CP2-3WFRR;

%_SERIAL OUTPUTS ML4 TO CP2:
CP1-CP2-3WFLR_OUT, CP1-CP2-3EFCANR_OUT,
CP1-CP2-3WCANCR_OUT, CP1-CP2-3EFR_OUT,
CP1-CP2-3WFRR;

%_SERIAL INPUTS CP2 TO ML4:
CP2-CP1-3EFLR_IN, CP2-CP1-3WFCANR_IN,
CP1-CP2-3WFLPR, CP2-CP1-3EFCANCR_IN,
CP2-CP1-3EFRR, CP2-CP1-3WFR_IN;


%_LOGIC FOR ML4

ASSIGN
CP1-CP2-3WFLR_IN * 3W3TPR * 3W2TPR * NWLP        TO CP1-CP2-3WFLR_OUT;

ASSIGN
CP2-CP1-3EFLR_IN * 3W2TPR * 3W3TPR * NWLP        TO CP2-CP1-3EFLR_OUT;

ASSIGN
CP2-CP1-3WFCANR_IN + 3WLCR                       TO CP2-CP1-3WFCANR_OUT;

ASSIGN
CP1-CP2-3EFCANR_IN + 3WLCR                       TO CP1-CP2-3EFCANR_OUT;
```

```
ASSIGN
CP2-CP1-3EFCANCR_IN * ~CP2-CP1-3WFR_OUT
 * ~CP2-CP1-3WFR_IN                          TO CP2-CP1-3EFCANCR_OUT;

ASSIGN
CP1-CP2-3WFCANCR_IN * ~CP1-CP2-3EFR_IN
 * ~CP1-CP2-3EFR_OUT                         TO CP1-CP2-3WFCANCR_OUT;

ASSIGN
 ~CP1-CP2-3EFCANR * (CP2-CP1-3WFR_IN
 + ~CP1-CP2-3EFR_IN * 3WLCR
 + CP2-CP1-3WFR_OUT * ~CP1-CP2-3EFR_IN)          TO CP2-CP1-3WFR_OUT;

ASSIGN
 ~CP2-CP1-3WFCANR * (CP1-CP2-3EFR_IN
 + ~CP2-CP1-3WFR_IN * 3WLCR
 + CP1-CP2-3EFR_OUT * ~CP1-CP2-WFR_IN)           TO CP1-CP2-3EFR_OUT;

ASSIGN
 ~NWLP * (CP2-CP1-3EFLPPR * CP1-CP2-3WFLPR + 3WLCR)          TO 3WLCR;

ASSIGN
CP1-CP2-3EFR_OUT * CP2-CP1-3WFR_OUT * 3WLCR                  TO 3WLR;

%_Note 3WLR = ELECTRIC LOCK CONTROL RELAY


BEGIN CP2 LISTINGS

%_SERIAL OUTPUTS CP2 TO ML4:
CP2-CP1-3EFLR_OUT, CP2-CP1-3WFCANR
 CP1-CP2-3WFLR, CP2-CP1-3EFCANCR_OUT,
CP2-CP1-3EFRR, CP2-CP1-3WFR;

%_SERIAL INPUTS ML4 TO CP2:
CP1-CP2-3WFLR_IN, CP1-CP2-3EFCANR,
CP1-CP2-3WFCANCR_IN,  CP1-CP2-3EFR_IN,
CP1-CP2-3WFRR;


%_LOGIC FOR CP2

ASSIGN
CP1-CP2-3WFLR_IN * 3W1TPR                        TO CP1-CP2-3WFLR;

ASSIGN
3ATWSR * 3W1TPR                                  TO CP2-CP1-3EFLR_OUT;
```

```
ASSIGN
~CP2-CP1-3WFR * ~CP2-CP1-3WFPR                TO CP2-CP1-3EFCANCR_OUT;

ASSIGN
CP1-CP2-3WFCANCR_IN * ~CP1-CP2-3EFR                TO CP1-CP2-3WFCANCR;

ASSIGN
CP1-CP2-3EFCANR * (CP2-CP1-3WFCANR
 * CP1-CP2-3WFLR * ~CP1-CP2-3EFR
 + CP1-CP2-3WFRR * ~CP1-CP2-3EFR
 * ~CP2-CP1-3WFR + CP2-CP1-3WFR)                TO CP2-CP1-3WFR;

ASSIGN
CP1-CP-3WFLR * (3WXS * ~CP2-CP1-3WFR
 + ~CP1-CP2-3WFCANCR * CP2-CP1-3WFCANR)        TO CP2-CP1-3WFCANR;

ASSIGN
CP2-CP1-3WFR * (CP1-CP2-3WFCANCR
 + CP1-CP2-3WFRR * ~CP1-CP2-3EFR
* ~CP2-CP1-3WFPR + CP2-CP1-3WFPR)               TO CP2-CP1-3WFPR;

ASSIGN
~CP2-CP1-3WFCANR
 * (CP1-CP2-3EFR_IN + CP1-CP2-3EFR)             TO CP1-CP2-3EFR;
```

END of Typical Traffic Logic Typical CP 1 to CP 2 Three Track

END PROGRAM

APPENDIX "E"
MAJOR DELIVERY MILESTONES

The Contractor shall provide the major services, systems and material as follows:

Deliverable	**Due** (Days from Contract Award)
STAGE 1 – 60% Design Submittal	
STAGE 2 – 60% Design Submittal	
STAGE 3 – 60% Design Submittal	
STAGE 4 – 60% Design Submittal	
STAGE 5 – 60% Design Submittal	
STAGE 6 – 60% Design Submittal	
STAGE 7 – 60% Design Submittal	
STAGE 1 – 90% Design Submittal	
STAGE 2 – 90% Design Submittal	
STAGE 3 – 90% Design Submittal	
STAGE 4 – 90% Design Submittal	
STAGE 5 – 90% Design Submittal	
STAGE 6 – 90% Design Submittal	
STAGE 7 – 90% Design Submittal	
STAGE 1 – 100% Design Submittal	
STAGE 2 – 100% Design Submittal	
STAGE 3 – 100% Design Submittal	
STAGE 4 – 100% Design Submittal	
STAGE 5 – 100% Design Submittal	
STAGE 6 – 100% Design Submittal	
STAGE 7 – 100% Design Submittal	

Deliverable	**Due** (Days from Contract Award)
STAGE 1 – All Houses, Cases and Other Signal Equipment for CP-241	
STAGE 2 – All Houses, Cases and Other Signal Equipment for CP-229	
STAGE 3 – All Houses, Cases and Other Signal Equipment for CP-230	
STAGE 4 – All Houses, Cases and Other Signal Equipment for the Intermediate Territory from CP-230 to CP-232 (Including Fiber Equipment)	
STAGE 5 – All Houses, Cases and Other Signal Equipment for the Intermediate Territory from CP-233 (Including Fiber Equipment) to CP-234 (Inclusive)	
STAGE 6 – All Houses Cases and Other Signal Equipment for the Intermediate Territory from CP-234 to CP-235 (Including Fiber Equipment)	
STAGE 7 – All Houses Cases and Other Signal Equipment for Intermediate Territory from CP-235 to CP-240 (Including Fiber Equipment)	
One Computer Engineering Application System	
One Portable Vital and non-Vital Diagnostic Test set	
One Remote Office Diagnostic System	
One Wayside Vital, Non-Vital and Communications Systems Training System	
System Training	
System Documentation	
Spare Parts	