Specification

Computer-Based Interlocking Equipment

Version 1.0

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Standard governance

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Document history

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Preface

The Asset Standards Authority (ASA) is a key strategic branch of Transport for NSW (TfNSW). As the network design and standards authority for NSW Transport Assets, as specified in the ASA Charter, the ASA identifies, selects, develops, publishes, maintains and controls a suite of requirements documents on behalf of TfNSW, the asset owner.

The ASA deploys TfNSW requirements for asset and safety assurance by creating and managing TfNSW’s governance models, documents and processes. To achieve this, the ASA focuses on four primary tasks:

- publishing and managing TfNSW’s process and requirements documents including TfNSW plans, standards, manuals and guides
- deploying TfNSW’s Authorised Engineering Organisation (AEO) framework
- continuously improving TfNSW’s Asset Management Framework
- collaborating with the Transport cluster and industry through open engagement

The AEO framework authorises engineering organisations to supply and provide asset related products and services to TfNSW. It works to assure the safety, quality and fitness for purpose of those products and services over the asset's whole-of-life. AEOs are expected to demonstrate how they have applied the requirements of ASA documents, including TfNSW plans, standards and guides, when delivering assets and related services for TfNSW.

Compliance with ASA requirements by itself is not sufficient to ensure satisfactory outcomes for NSW Transport Assets. The ASA expects that professional judgement be used by competent personnel when using ASA requirements to produce those outcomes.

About this document

This specification supersedes RailCorp specification SPG 0719 Computer-Based Interlocking Requirements, version 1.3.

This specification reflects current frameworks and requirements.

This specification is a first issue.
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1. **Introduction**

Computer-based interlocking (CBI) equipment is safety equipment used to provide functional safety as part of railway signalling interlockings. Other terms used for CBIs are electronic interlockings and processor based interlockings. CBI equipment is stationary trackside equipment located along the railway line or in buildings.

Transport for NSW (TfNSW) has adopted the European Train Control System (ETCS) for the metropolitan heavy rail network. Therefore the CBI equipment needs to integrate into a rail system using ETCS.

2. **Purpose**

This specification defines requirements for CBI equipment based on Australian and international standards where suitable standards are available. Additional specific requirements are defined as a performance or interface requirement.

This specification provides the basis for selection and approval of equipment as well as some of the generic requirements for the design and application of CBI equipment as part of the signalling system. Specific compatibility issues are identified for integration into the existing signalling system. Processes are defined for alternative approaches that provide an integrated solution.

2.1. **Scope**

This specification contains criteria for determining the suitability of CBI equipment for use as part of the metropolitan heavy rail passenger network.

Installation and configuration requirements are covered to meet performance and configuration requirements for the CBI equipment.

All CBI equipment and its operational support tools are covered by this specification. The requirements for current technology equipment for signalling interlocking used in the heavy rail transport mode are included.

The processes that apply for the preparation and assurance of computer-based interlocking data and designs are not specifically covered by this specification. The use of support tools by an Authorised Engineering Organisation (AEO) to configure and maintain the CBI equipment is covered.
2.2. **Application**

This specification applies to the metropolitan heavy rail passenger network. This specification can be applicable to other areas of the heavy rail network and rail modes with tailoring of the supported interfaces and specific performance related targets.

This specification is intended for use by people involved in the plan and acquire asset life cycle phases.

This specification applies to new applications of CBI equipment. Alterations to existing CBI equipment may apply the version of specifications and standards applicable to that installation if it is not reasonably practicable to apply this specification.

3. **Reference documents**

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

**International standards**

IEC 60050 161 International electrotechnical vocabulary – Part 161: Electromagnetic compatibility

IEC 60050 192 International electrotechnical vocabulary – Part 192: Dependability

IEC 62278 Railway applications – specification and demonstration of reliability, availability, maintainability and safety (RAMS)

IEC 62279 Railway applications – Communication, signalling and processing systems – Software for railway control and protection systems

IEC 62280 Railway Applications – Communications, signalling and processing systems – Safety-related communication in transmission systems

IEC 62425 Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signalling

IEC 62497-1 Railway applications – Insulation coordination – Part 1: Basic requirements – clearances and creepage distances

IEC 62498-3 Railway applications – Environmental conditions for equipment – Part 3: Equipment for signalling and telecommunications

*Note: The equivalent European standard (EN) is accepted as well as the International Electrotechnical Commission (IEC) standard.*

**Australian standards**

AS 4292 (all parts) Railway safety management

AS IEC 61131 (all parts) Programmable controllers
Transport for NSW standards

ESG 003 Signalling Equipment Configuration Standard
ESG 005 Signalling Operator Interface
ESG 007 Glossary of Signalling Terms
ESG 100 Signalling Design Principles
SPG 0711 (all parts) Inspection and Testing of Signalling
SPG 0723 Level Crossing Equipment Manufacture and Assembly
SPG 1056 Relays Plug-In Vital
SPG 1057 Audio Frequency Jointless Track Circuits for main line applications
SPG 1432 Non Vital Relays for Signalling Applications
SPG 1571 Specification Light Signals
SPG 1588 Point Mechanisms
SPG 1602 High Voltage Impulse Track Circuits
T HR SC 01000 SP Common Signals and Control Systems Equipment Requirements
T HR SC 01250 SP Interface Between Signalling and Control Systems
T HR SC 01251 SP Signalling Control Systems Interface Requirements
T HR SC 01256 ST Telecommunication Transmission Systems for Signalling and Control Systems
T HR SC 01610 SP ETCS Trackside Equipment
T HR SC 02000 ST Mandatory Requirements for Signalling Safeworking Procedures
T MU AM 01001 ST Life Cycle Costing
T MU MD 00005 GU Type Approval of Products

Legislation

Rail Safety National Law (NSW)
4. Terms and definitions

The terms and definitions listed in ESG 007 Glossary of Signalling Terms apply.

The following terms and definitions specifically apply in this specification:

- **AEO** Authorised Engineering Organisation
- **BRB** British Railways Board
- **CBI** computer-based interlocking
- **COTS** commercial off-the-shelf
- **ELD** earth leakage detector
- **EMC** electromagnetic compatibility (IEC 60050-161, 161-01-07)
- **first line maintenance** initial responder for corrective maintenance and preventative maintenance
- **IP** internet protocol
- **ISA** independent safety assessor
- **LED** light emitting diode
- **LEU** lineside electronic unit
- **LRU** line replaceable unit
- **MACMT** mean active corrective maintenance time (IEC 60050-192, 192-07-22)
- **major railway** a railway with a passenger task of at least 0.25 billion passenger kilometres per year or a freight only railway with a rail freight task of at least 1 billion tonne-kilometres per year
- **MTBF** mean time between failures also known as mean operating time between failures (IEC 60050-192, 192-05-13)

  *Note: MTBF is used as the general term. mean time to failure (MTTF) (IEC 60050-192, 192-05-11) is the applicable term if the equipment is not repairable.*
- **OV** over voltage (IEC 62497-1)
- **PD** pollution degree (IEC 62497-1)
- **PLC** programmable logic controller (AS IEC 61131.1)
- **railML** Railway Markup Language
- **RAMS** reliability, availability, maintainability and safety (IEC 62278)
- **RBC** radio block centre
- **second line maintenance** the support called upon by first line maintenance when they need assistance
SIL safety integrity level

site-specific data the application data that is specific to a particular location where the CBI system is to be installed. It applies the particular control tables and interlocking functionality.

Note: Equivalent terms for site-specific data are 'application data' or 'geographic data'.

TMS traffic management system

THD total harmonic distortion

THR tolerable hazard rate

vital a historical term associated with the signalling system and equipment providing a level of safety integrity. Typically by being designed to ensure all failure modes result in a defined safer state.

vital blocking a vital inhibit to the setting of routes or to the moving of points

5. Certification

The certification of the CBI equipment shall include the following:

i. declaration of conformity for regulatory compliance by the manufacturer

ii. quality management system approval certificate covering design, manufacturing and maintenance of the equipment

iii. evidence of conformity to the nominated standards (from this specification and supporting documents) produced by the manufacturer

iv. confirmation of the equipment being suitable for the purpose is supported by an independent safety assessor (ISA)

v. a TfNSW type approval for the application - type approval is based on T MU MD 00005 GU Type Approval of Products

6. Common requirements amendments

The requirements specified in T HR SC 01000 SP Common Signals and Control Systems Equipment Requirements apply to CBI equipment and their support tools unless specifically excluded or amended in this specification for the particular equipment type.

CBI equipment is primarily railway specific equipment. The use of general commercial off-the-shelf (COTS) equipment as components, line replaceable units (LRUs) and modules to form CBI equipment or its support tools is accepted. Use of COTS equipment shall not prevent the CBI equipment or installations from meeting the overall requirements defined in T HR SC 01000 SP or this specification when it is applied as part of an integrated railway signalling interlocking.
Section 6.1 to Section 6.8 are in addition to the common requirements. Amendments to common requirements specifically identify the requirement as an amendment or deletion.

6.1. **RAMS framework**

CBI equipment has additional reliability, availability, maintainability and safety (RAMS) requirements to those defined in T HR SC 01000 SP. Section 6.1.1 through to Section 6.1.4 define the additional RAMS framework requirements for CBI equipment.

6.1.1. **Reliability**

Reliability performance data from in-service usage of the CBI equipment shall be provided to provide confidence that the theoretical reliability performance has been achieved. The reliability performance data shall be from normal operational use at two or more sites on a major railway. Alternatively the type approval reliability demonstration shall be extended to gain an equivalent confidence level for the reliability of the equipment.

The mean time between failures (MTBF) requirements defined in T HR SC 01000 SP apply to CBI equipment LRUs and COTS equipment used as part of a CBI configuration that can have an operational impact.

6.1.2. **Availability**

The CBI equipment shall facilitate application design options to meet a range of availability and maintainability performance requirements suitable for simple signalling interlockings at less critical locations to complex signalling interlockings at critical locations.

The CBI equipment shall provide configuration options so that 90% of equipment failures of a railway signalling interlocking only have an operational impact on a single railway track.

Replacement, restart and configuration of a failed or faulty LRU that is used in a redundant configuration shall not result in any operational impact.

The two levels of rail traffic density are classified in ESG 003 *Signalling Equipment Configuration Standard*, critical areas (which include high traffic areas) and by default other areas.

Table 1 sets the expected availability performance for the CBI equipment portion of a railway signalling interlocking configured for the reference installation arrangement in the traffic area. The reference installation is 20 double light signals, 4 double ended sets of points, 40 train detection points and 800 signalling application logic functions.

The availability performance requirements for a reference installation are defined in Table 1.
Table 1 – Expected reliability performance for the reference installation

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Critical areas MTBF</th>
<th>Other areas MTBF</th>
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<tbody>
<tr>
<td>Four or more trains that could be in the signalling interlocking area at the one time are delayed at the same time due to one failure</td>
<td>80 years</td>
<td>20 years</td>
</tr>
<tr>
<td>One train could be delayed at the one time due to one failure</td>
<td>20 years</td>
<td>5 years</td>
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The availability performance evaluation shall include consideration of failures due to systemic faults, common mode failures and automatically recoverable failure as well as random equipment failures.

6.1.3. Maintenance

The potential impact of CBI equipment failures requires better maintenance performance than that defined in T HR SC 01000 SP. The required corrective maintenance performance is as follows:

i. The mean active corrective maintenance time (MACMT) shall be < 40 minutes for centralised equipment in main location or buildings. This includes all configuration, verification and validation activities as well as the return to operational service time.

ii. The MACMT shall be < 30 minutes for equipment located in trackside equipment locations. This includes all configuration, verification and validation activities as well as the return to operational service time.

The CBI RAMS framework shall also identify all safety related constraints that installation and maintenance personnel shall comply with to achieve the nominated safety performance.

All test equipment that is specific for the CBI equipment whose operation and use could introduce a hazard shall have documented constraints on its usage. These constraints shall be included in the construction and maintenance procedures. Specific test equipment shall be labelled as having application constraints on its usage if constraints exist.

6.1.4. Safety

The CBI equipment shall be designed and assured to meet a quantitative tolerable hazard rate (THR) due to random failures of less than $1 \times 10^{-9}$ hazardous failures per hour. A hazardous failure of the CBI equipment is the provision of a train movement authority that is less restrictive than that required by the intended application logic and external information.

The CBI equipment, on-line support tools and off-line support tools shall be developed and assured to meet the required THR during operation and maintenance in the nominated environment for the expected life due to random failures, systematic failures and environmental factors.
All equipment that has been allocated a safety integrity level (SIL) of SIL 1 to SIL 4 shall be clearly labelled as such identifying that it is not to be altered or repaired by unauthorised personnel.

The compiler for application data and the supporting processes for configuring the CBI equipment with site specific data shall be included in the safety documentation.

All safety critical time constraints shall be identified and documented in the RAMS framework.

The CBI equipment shall have defined minimum performance for the transmission system required for the CBI equipment to meet its RAMS requirements.

6.2. EMC framework

The effect of integrity tests applied to equipment interfaces shall be included in the RAMS framework, electromagnetic compatibility (EMC) framework and the compatibility requirements for equipment that interfaces to the CBI equipment.

If the CBI equipment interfaces to relays then it shall continue to operate without any detrimental effect due to relays operated by the CBI equipment and due to relays operated by other relays.

Note: A typical compatibility test for detrimental effects from relays operated by other relays via a BRB 930 QN1 50 V dc relay is repeatedly ‘picked’ and ‘dropped’ within 50 mm of the equipment by means of two wires being scratched together. The position of the relay and wiring is moved to test the full range of EMC coupling mechanisms. If the CBI equipment uses inputs driven by a power supply that also powers BRB 930 series relays, then the EMI caused from coupling by means of that arrangement is also tested.

Existing relays include multi-coil relays and twin relays that have inductive coupling between coils. Outputs that control relays shall include compatibility testing for these relay types unless an application constraint excludes control of these relay types.

The specific compatibility requirements for control of signal lights and signal light current detection are defined in Section 9.
6.3. **Human factors framework**

The CBI equipment shall also have functionality to ensure that no hazard to health and safety or environment is created when a single human error during maintenance activities causes the occurrence of the following:

i. wrong data to be installed

*Note: Wrong data includes valid data for the equipment type that is intended for another specific equipment item or is an obsolete version of data for the correct specific equipment item.*

ii. an incorrect telecommunication line connection

iii. swapped telecommunication line connections

iv. an incorrect plug connection to a socket

v. swapped plug and socket connections

vi. incorrect configuration of a replacement LRU

6.4. **Environmental conditions**

Trackside CBI equipment shall meet the requirements for operation in cubicles, shelters and buildings as defined in IEC 62498-3 *Railway applications – Environmental conditions for equipment – Part 3: Equipment for signalling and telecommunications.*

CBI equipment designed for use in a centralised location only shall meet the requirements for operation in shelters and buildings as defined in IEC 62498-3.

6.5. **Maintenance**

Diagnostic facilities shall enable equipment failures to be identified to the LRU level.

Alarms indicating a failure that cause or are likely to cause an operational delay shall be as follows:

i. configurable to be sent to the signalling operator interface to advise of the failure

ii. sent to the permanently installed maintenance on-line support tools

The equipment shall provide active indications of correct operation without use of additional equipment.
6.6. Time

T HR SC 01000 SP requires equipment with time functionality to support time synchronisation. CBI equipment shall have the time synchronised for the items of equipment in an installation. The common source for the time and date shall be provided by the maintenance on-line support tool or by equipment whose specific purpose is to provide a reference time source.

6.7. On-line support tools

The CBI equipment shall have permanently installed on-line support tools for diagnostics, maintenance, event recording and replay. The on-line support tools shall comply with T HR SC 01000 SP.

The permanently installed on-line support tools shall be provided with an electrical power supply protected against 10 minutes loss of electrical grid supply. The time to restore the protection against loss of electrical grid supply shall be less than eight hours whilst powering the equipment. Continuous event recording during power supply disruption events is required for incident investigation.

Portable on-line support tools for diagnostics and maintenance shall be in accordance with T HR SC 01000 SP.

Telecommunications links from decentralised CBI equipment to centralised on-line support tools shall use a similar transmission system and equipment to that used by the CBI equipment. The security framework for the on-line support tools shall comply with T HR SC 01000 SP.

The diagnostics and maintenance facility shall be provided as part of the CBI equipment.

The CBI equipment shall provide the capability for first line maintainer to have authorised access for using the event recording facility and replay facility from a location that they access as part of the maintenance role.

Note: The maintenance, event recording facility and replay facility may be provided as part of the CBI equipment installation or the traffic management system (TMS) installation.

Note: Maintenance and replay displays should be based on or reuse either the displays used to test the CBI installation or the TMS.

6.7.1. Diagnostics

The diagnostic facility shall provide access to all CBI equipment diagnostics available for use by first line and second line maintenance personnel.

The diagnostic functionality shall be as required for the maintainer to consistently achieve the nominated corrective and preventative maintenance performance.
6.7.2. Maintenance

A maintenance function is provided to support the maintainer performing corrective maintenance, preventative maintenance and investigation of incidents.

The following maintenance functionality shall be provided:

i. maintenance display that shows the current status of the CBI equipment, related trackside equipment, associated telecommunications links and the signalling installation

ii. management of the display, acknowledgement and archiving of alarms and warnings for the CBI equipment, related equipment and associated telecommunications links in a signalling interlocking installation

iii. display, application and removal of maintainer's vital blocks

iv. operation of all control, monitoring and interrogation functions provided as part of the CBI equipment for use by the maintainer

v. facilities required by first line maintenance personnel to configure the CBI equipment and LRUs for the specific site and usage as part of corrective maintenance

The on-line support tools provided shall be sufficient for first line maintenance personnel to comply with the maintenance related processes and safety related constraints for the CBI equipment.

6.7.3. Event recording

An event recorder shall be provided for each CBI signalling installation for analysing failures and incidents.

The event recorder shall meet the following requirements:

i. Record all changes for each input and output of the CBI system to a time resolution of ≤ 1 s. Each record shall be time and date stamped.

ii. Record complete status of all recorded information at start-up and regular intervals.

iii. Separate record files for manageable geographic regions of the CBI installation. Every record file shall include a reference to the site-specific data name.

iv. Maintain greater than 90 days of recorded information.

v. Records shall be stored on non-volatile media with an expected usable life that complies with the equipment life defined in T HR SC 01000 SP.

vi. The first line maintainer shall have facilities to select, view and export recorded events to either a removable media or another system. Use of these facilities shall not interrupt or delay the recording and timestamping of events.
vii. Record the event in the record file when the event recorder starts recording, time or date is 
adjusted and when event recorder stops recording with a date and time stamp.

viii. All CBI equipment alarms or warning messages shall be recorded with a date and time 
stamp.

ix. If the event recorders power is lost then all events shall remain recorded with the exception 
of events occurring in the preceding 1 minute which may be lost.

x. The event recorder shall automatically restart and begin recording after the mains power is 
applied to the event recorder.

xi. The start-up delay for the event recorder shall be less than or equal the start-up delay for 
the equipment that it is recording information for.

6.7.4. Replay

The replay function shall use the information recorded by the event recorder. Replay shall 
permit the commencement of replay at any 10 min time interval, for example 1:00 pm, 1:10 pm, 
and 1:20 pm and so on.

Replay controls shall be modelled on the controls for playing a video. For example play, fast 
forward, slow forward, fast reverse, slow reverse, pause and stop. Fast speeds shall range from 
2 times to 30 times the normal speed. Slow speeds shall range from 0.5 times to 0.1 times the 
normal speed. At least two intermediate speed options shall be provided in each range.

Setup time for the replay of any events currently held by the event recorder shall be < 5 min for 
a selected time period that contains less than 9000 events.

Screens shall be provided so that at least 50% of the interlocking area is visible to the user at 
any time. The user shall be able to adjust the view so that visible area is suitable for the incident 
being investigated.

Use of the replay facility shall not disrupt the event recording facility. A user error in the use of 
the replay facility shall be unlikely to delete event records or stop event recording.

The replay display will be used by people that normally view signalling equipment status on a 
TMS display. The replay display states and layout shall be designed so that it is unlikely that 
these people misinterpret the information when it is viewed on an intermittent basis (less than 
onece every six months).

6.7.5. LRU test facility

An LRU test facility is intended for use by first line maintenance personnel to confirm an LRU is 
operational prior to placing in-service or confirming an LRU removed from service is faulty.

The LRU test facility shall provide diagnostic testing and continuous testing for each type of CBI 
equipment.
Provision of LRU test facilities is based on project specific requirements.

6.8. Off-line support tools

Off-line support tools shall be available for the CBI application design and validation. The off-line support tools shall be configurable for compliance with ESG 100 Signalling Design Principles and requirements defined in this specification and supporting documents.

Import and export of CBI data to a railML format is not required.

The off-line support tools for testing a CBI shall be designed to support the goal of minimising the quantity and duration of possessions of the railway line when altering or commissioning signalling interlocking's using the CBI equipment. The testing off-line support tools shall provide a method for the AEO to conduct and assure at an offsite location all tests other than correspondence testing to onsite wiring and end to end testing. These tests shall include all functionality and system integration.

The off-line support tools shall comply with T HR SC 01000 SP.

7. Functional requirements

The CBI equipment is configured by application design to form an essential part of the signalling system in the context of AS 4292 (all parts) Railway safety management.

A railway signalling CBI is effectively a functional safety programmable controller with a safety integrity level capability of SIL 4. CBIs have historically been developed to meet custom requirements.

AS IEC 61131 (all parts) Programmable controller is the product standard for programmable controllers with Part 6 of AS IEC 61131 specifically addressing functional safety programmable logic controllers (PLCs). Applications up to for SIL 3 are covered by the standard. AS IEC 61131 is used as one of the references for the CBI equipment requirements defined in this specification.

The CBI equipment shall provide the following functions:

i. application logic as defined in Section 8

ii. programming, debugging and testing tools for the application logic both in creation of an installation and during maintenance of the installation

iii. evaluation of the application logic

iv. interfaces to the range of equipment defined in Section 9

v. detection of hazards and defined safe response

vi. defined on-line support tool functionality
Usage of the metropolitan heavy rail passenger network is increasing which is decreasing access to rail system for maintenance and alteration works. The CBI equipment, configuration of the equipment, support tools shall provide facilities so that a new CBI for a complex installation does not prevent a new signalling interlocking being brought into service in less than 48 hours interruption to rail operations. A complex alteration to CBI application logic shall be able to be implemented in less than two hours interruption to rail operations.

Disaster recovery is an element of the management plans for the metropolitan heavy rail passenger network. CBI equipment that uses centralised architectures shall provide a configuration that supports implementation of a separate disaster recovery site to the primary installation.

Signalling installations for particular locations have a range of business needs. The CBI equipment shall have a range of design and configuration options to meet availability, maintainability and performance requirements. The range includes single line locations with two trains per hour to those with six lines and up to twenty trains per hour on a line.

Historically the defined ‘safer’ state for railway signalling is the ‘OFF’ state. The CBI equipment shall use the ‘OFF’ state as the ‘safer’ more restrictive state.

Interfaces to external equipment shall be designed so that all steady state failure modes and transient failure modes are compatible with external equipment’s safety constraints.

8. Application logic

CBI equipment shall include the evaluation of application logic defined for a specific installation. The application logic implements the logic for the particular location to meet the functionality required and comply with the signal design principles.

Application logic functions shall include the Boolean logic functions of ‘AND’, ‘OR’ and ‘NOT’. The logic functions shall have a method to control the evaluation order for expressions.

Application logic variables shall be able to be named by the application designer. Variable names shall allow letters, numbers and underscore '_'. If not all characters in a variable name are significant or variable names are not case sensitive then an automated tool shall be included to identify variable names that appear to be different but are interpreted as identical by the logic evaluation.

The application logic shall have consistent syntax requirements to the naming of and interface to digital inputs, digital outputs, data communication inputs, data communication outputs, event logging, equipment status and equipment control.

Application logic functions shall include 'ON-delay', 'OFF-delay' timers with a resolution of ≤ 1 s.
The application logic syntax shall only permit a single assignment statement for a variable or output. Computer software programming language based logic is not consistent with this requirement when it allows multiple assignment statements to a variable.

The evaluation of the application logic shall follow a defined, predictable order of evaluation.

The application logic syntax shall provide for the inclusion of comments with the logic.

CBI equipment designed for distributed installation in trackside cubicles shall support at least 1000 logic statements with five variables in each statement and 100 timers.

CBI equipment designed for centralised installation in buildings shall support at least 10,000 logic statements with five variables in each statement and 1000 timers.

The application logic shall have defined rules for management of and response to logic instability and recursion.

Application logic evaluation shall manage input, output and logic changes due to external disruptions without loss of functionality. External disruptions include telecommunication links intermittently failing and power supply for external inputs and outputs turning off and on.

Application logic functions beyond the Boolean logic functions of 'AND', 'OR' and 'NOT' shall be compliant with AS IEC 61131 or meet the following requirements:

i. be specifically designed for railway signalling interlocking

ii. be supported by safety case with a human factors error analysis for the production of the application data

iii. not prevent production of application logic to meet the signalling principles defined in ESG 100

iv. have a positive life cycle costing to support the change

v. produce documentation for first line maintenance staff to trace faults back via logical relationships to a potentially faulty input as a root cause to meet the required maintainability performance
9. Interface requirements

The interfaces defined in this section are based on the existing equipment that interfaces to CBI equipment. Only the CBI equipment specific interfaces are detailed in this section. The common requirements specified in T HR SC 01000 SP cover the common equipment interfaces.

The CBI equipment shall interface and function correctly with the existing signalling equipment unless an alternative arrangement is approved by means of a type approval.

Alternative arrangement proposals shall be supported by a life cycle costing in accordance with T MU AM 01001 ST Life Cycle Costing that shows a positive benefit for the alternative arrangement.

The functional interfaces are applied in the context of ESG 100.

9.1. Functional interfaces

Functional interfaces identify the equipment and functionality to which CBI equipment shall provide an interface. Specific interfaces are defined in Section 9.1.1 through to Section 9.1.9.

9.1.1. Level crossings

The CBI equipment is required to control the equipment for active railway level (grade) crossings. Active level crossing protection equipment includes flashing lights, road booms, bells, advance warning lights, traffic light interface, pedestrian gates, pedestrian warning lights and pedestrian audible warning devices that form a railway level crossing.

The CBI equipment shall interface to level crossing protection equipment compliant with SPG 0723 Level Crossing Equipment Manufacture and Assembly. The interface shall be either direct to the equipment or by means of a relay interface.

Flashing light loads are up to 60 W on a single light circuit. Light circuits typically have two or three lights.

Level crossing lights flash at a 50% duty cycle with a period of 1.33 s with a tolerance of +10%, -10%.

9.1.2. Points

The CBI equipment shall interface to point mechanisms compliant with SPG 1588 Point Mechanisms for the operation and detection of each type of point mechanism.

A points control isolation output is also used. The points control isolation output shall be independent from all fault events that could cause a momentary 'ON' output for the points normal position and reverse position controls.

Point's operation durations are typically between 2 s to 8 s.
9.1.3. **Signals**

The CBI equipment shall interface to light signals compliant with SPG 1571 *Specification Light Signals* either directly or by way of a relay interface.

Existing signal light direct control outputs are 110 V ac or 120 V ac nominal. Signal light loads are between 5 VA and 120 VA ranging from a single light emitting diode (LED) subsidiary light to two incandescent lamps.

LED signal lights are in common use. Individual, bicolour and tricolour lights are used. Light load currents are non-linear. Light currents can take up to 200 ms to stabilise.

CBI equipment outputs that control bicolour and tricolour lights shall control hazards relating to false outputs that could combine signal light colours to represent a false proceed aspect when operating a bicolour or tricolour signal lights.

Outputs that directly control signal lights shall provide a function to pulsate or flash the controlled signal light. Refer to Section 9.2.2 for specific details.

Lamp proving is a function that uses detection of the current drawn by a signal light to provide confidence that the signal light is illuminated and displaying an indication to train drivers. The equipment shall provide a lamp proving function for LED signal lights. Lamp proving shall have configuration parameters for detection of different signal light loads. Refer to Section 9.2.1 for specific details.

The lamp proving function shall work correctly with pulsating/flashing signal lights.

The lamp proving function shall have safety integrity level of SIL 1 or higher.

LED signals do not guarantee a correlation between current drawn and light output.

9.1.4. **Train detection**

The CBI equipment shall support train detection by the following equipment:

i. track circuit equipment as specified in SPG 1057 *Audio Frequency Jointless Track Circuits for Main Line Applications* and SPG 1602 *High Voltage Impulse Track Circuits*

ii. axle counter equipment for train detection

The integration of train detection functionality into the CBI equipment is accepted.

The interface between CBI equipment and axle counter equipment for train detection shall support occupancy status, axle counter equipment status and a SIL 1 or higher axle counter reset functionality.

An interface to coded track circuits is not required for metropolitan heavy rail passenger network.
The CBI equipment shall provide timer functionality to permit train detection delays to be normalised for each train detection status used in a CBI installation. This is to achieve a transition to unoccupied status delay for train detection of at least 2 seconds.

Note: This is typically provided by individual 'ON-delay timer' for each train detection function adjusted to normalise the pick-up delay for the train detection equipment.

9.1.5. Relay

A range of signalling equipment requires control through a relay interface.

The CBI equipment shall electrically interface with the signalling equipment with the minimal use of vital signalling relays. This interface shall meet the requirements and application constraints for the equipment being controlled.

The CBI equipment shall control relays that comply with SPG 1056 *Relays Plug In Vital* or SPG 1432 *Non Vital Relays for Signalling Applications*.

The CBI equipment shall detect the status of relays that comply with SPG 1056 or SPG 1432.

The control arrangement shall include a specific risk assessment for latching functionality in the relay interface if a latching function is provided as part of the interface.

9.1.6. Vital blocking

The CBI application data shall support application functionality for the provision of vital blocking facilities for both the signaller and the maintainer. Application and removal of the signaller and maintainer vital blocks shall be independent of each other. Neither signaller nor maintainer shall be able to apply or remove the other party's vital blocks.

The maintainer's vital blocks shall be suitable for the actions required by T HR SC 02000 ST *Mandatory Requirements for Signalling Safeworking Procedures* to book items of signalling equipment out of use.

On CBI equipment start or restart the vital blocks that were in-place when the CBI equipment ceased operating shall either be restored, all vital blocks applied or start-up halted until maintenance has entered and verified all maintenance blocks.

9.1.7. Lineside electronic unit (LEU)

The CBI shall support a redundant interface to multiple lineside electronic units (LEUs) as defined in T HR SC 01610 SP *ETCS Trackside Equipment* for remote inputs.

9.1.8. Radio block centre (RBC)

The CBI shall support a redundant interface to at least one radio block centre (RBC) as defined in T HR SC 01610 SP.
9.1.9. **TMS**

The CBI system shall interface to an operator interface as specified in ESG 005 *Signalling Operator Interface*.

T HR SC 01250 SP *Interface Between Signalling and Control Systems* is applicable to the interface between the CBI equipment and the TMS. Only existing interfaces used by the metropolitan heavy rail passenger network are defined in T HR SC 01250 SP. T HR SC 01250 SP will be updated when CBI equipment, compliant with this specification, introduces a new protocol to the metropolitan heavy rail passenger network. T HR SC 01250 SP is applicable as guidance information on the functionality required for a new CBI to TMS interface.

The requirements defined in T HR SC 01251 SP *Signalling Control Systems Interface Requirements* are not applicable to the interface between the CBI Equipment and the TMS.

The CBI equipment supplier shall share information with the provider of a TMS being used by TfNSW or being procured by TfNSW to enable an interface protocol supported by the CBI equipment to be used for the TMS interface.

9.2. **Electrical interfaces**

Input and output voltages shall be compatible with the existing voltages used by the signalling system or the recommended input and output (I/O) signals voltages defined in Part 2 of AS IEC 61131.

The mechanical contact switching devices are primarily relays in accordance with SPG 1056 or SPG 1432 for the existing signalling system.

The electrical power supply arrangement, power quality and rating requirements shall be defined for digital inputs and outputs.


Connector, cabling and wiring restrictions for digital input and output circuit arrangements shall be defined to meet the RAMS requirements for the expected life in the defined environmental conditions.

The arrangement for the operation of a digital input directly from a digital output shall be defined.

Digital input and outputs shall provide an interface for equipment installed within the same equipment location and equipment installed at another equipment location.
Note: Typically arrangements that switch one leg of the circuit are used for co-located 
equipment and both legs of the circuit are switched for equipment installed at other 
locations.

Wiring and external power supplies for digital I/O's typically have a safety integrity level 
allocated as part of the I/O functions. Digital I/O's for the CBI equipment shall have one of the 
following features:

i. no safety integrity level allocated to the external wiring and power supplies

ii. support insulation testing of the external wiring and external power supply with minimal 
operational impact

iii. support the use of a permanent insulation monitor for the external wiring and external 
power supply

Note: A permanent insulation monitor is also known as an earth leakage detector 
(ELD).

9.2.1. Digital inputs

The CBI equipment shall provide digital inputs for sensing signals from mechanical contact 
switching devices.

Note: Existing vital relay (BRB 930 series) contact wetting current and potential for 
maintenance of contacts in good electrical order is considered to be 2 mA at 120 V ac, 
5 mA at 50 V dc, 10 mA at 24 V dc, or 20 mA at 12 V dc initially then at least 1 mA 
under steady state conditions while the circuit is energised.

Inputs shall have defined U/I operating regions compatible with the existing equipment or the 
recommended operating ranges for digital inputs in Part 2 of AS IEC 61131. The defined 
operating regions shall include the 'OFF' state, Transition and 'ON' state.

The status of and management of digital inputs in the transition region shall be defined in the 
RAMS documentation.

The state of digital inputs for dc voltages with a reverse polarity applied shall be defined.

The response of digital inputs designed for dc operation shall be defined for ac voltage 
application up to the maximum ac voltage likely to be present in an installation. This is likely to 
be the highest power supply voltage used as part of the installation which is currently 415 V ac.

Immunity of digital inputs to false 'ON' states due to electrical noise shall be defined in terms of 
amplitude and duration.

Digital input time delays for all transitions and safe response times shall be defined.

Digital inputs used to detect signal light current shall have the following functions:
i. Provide signal light ac current detection threshold settings for the signals lights approved for use with the CBI.

*Note: Signal light currents range from 30 mA to 1000 mA rms for existing approved signals. These light currents waveforms can vary from 50 Hz sine wave to two pulse rectified and irregular due to the use of LED signal lights. Up to 20% total harmonic distortion (THD) can occur on the supply voltage.*

ii. Detect flashing light periods and duty cycles compatible with the direct control signal light outputs.

iii. Detect and respond in a predefined manner to input currents that are not in a valid state.

iv. Allow current up to 200 ms to stabilise after the signal light is turned 'ON'.

v. Provide immunity from electromagnetic emissions from the signal light in accordance with the EMC framework.

### 9.2.2. Digital outputs

Digital outputs shall meet the following requirements:

i. a rating suitable for electromagnetic loads

ii. defined load characteristics for minimum, continuous and maximum voltage and current combinations

iii. defined load resistance, inductance and capacitance characteristics

iv. maximum leakage current defined for the 'OFF' state of each output type

v. the permitted inrush current characteristics specified for equipment that can be controlled

vi. the maximum voltage drop in the CBI equipment specified to allow determination of permissible voltage drop in external wiring

Digital output time delays for all transitions and safe response times shall be defined.

A fault in the load connected to a digital output shall be unlikely to require the CBI equipment to be returned to the manufacturer for repair.

The level of independence of outputs for failure modes shall be defined to permit external interfaces to be designed using outputs that are independent of momentary false 'ON' outputs due to a single cause.

Groups of outputs that can be disabled due to a fault without the whole CBI equipment failing shall be defined to allow application designers to allocate outputs so that the number of rail lines affected by a single fault is minimised.

Digital outputs for the control of signal lights shall:

i. control signal light circuit loads in the range of 5 VA to 120 VA
Note: The maximum individual LED signal light load is less than 40 VA

ii. provide 'OFF', 'FLASHING' and 'ON' output states

iii. the flashing state shall turn the signal light on and off at a defined duty cycle and period that is compatible with the existing signal aspects displayed on the heavy rail network based on a human factors assessment

Note: Two different arrangements in use. The first has a 840 ms nominal period with a 76% duty cycle and the second has a 990 ms nominal period with a 66% duty cycle.

Note: Pulsating arrangements were traditionally used with incandescent signal lights. Pulsating provides dim illumination in the 'OFF' part of the flashing cycle using a separate 'ON' output feeding the light via a voltage dropping resistor. Not all LED signal lights are able to provide a dim illumination.

iv. provide a design option for stop aspects to remain illuminated when the CBI equipment has failed

Digital output diagnostic and control tests shall not affect the operation of the controlled equipment. Considerations for effects on the controlled equipment are duration of test, frequency of test, transient response of the equipment and EMC.

9.2.3. Data communication links

The data communications links and protocols used by the CBI shall meet the following requirements:

i. be internet protocol (IP) based

ii. be included in the CBI safety case produced in accordance with IEC 62278 Railway applications – specification and demonstration of reliability, availability, maintainability and safety (RAMS) , IEC 62279 Railway applications – Communication, signalling and processing systems – Software for railway control and protection systems and IEC 62425 Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signalling that supports their use on both category 1 and category 2 networks according to IEC 62280 Railway applications – Communications, signalling and processing systems – Safety-related communication in transmission systems that is supported by an ISA

iii. support redundant telecommunication links between equipment for availability

iv. be tolerant of a 1 second reconvergence of the IP network as a result of disruption, equipment failure or cable failure on one of the redundant telecommunication links

The transmission system that provides the telecommunication links is specified in T HR SC 01256 ST Telecommunication Transmission Systems for Signalling and Control Systems.
The CBI shall support interfaces to data communication links for the following:

v. CBI to CBI and within the CBI

vi. CBI to RBC

vii. CBI to TMS

viii. CBI to on-line support tools

Note: CBI equipment that can exchange functional safety data with a separate CBI of the same type by means of data communications links meets the CBI to CBI requirement.

The CBI equipment that is part of redundant telecommunications links shall be able to be independently isolated at each LRU and connector without affecting the related link.

10. Performance

The response time performance requirements for a CBI installation, or a sub-system of a distributed CBI installation, are as follows:

i. The time an input has to be 'ON' before it is detected being 'ON' by the CBI shall be less than 0.5 s.

ii. The time an input has to be 'OFF' before it is detected being 'OFF' by the CBI shall be less than 0.5 s.

iii. The time an output, which should not be 'ON', may be incorrectly 'ON' (that is, the maximum duration for incorrect (unsafe) output before the condition is detected and reverts to the defined safe state) shall be less than 0.4 s.

iv. The time for an output to change state as a direct result of an input changing state shall be less than 2 s excluding delays introduced as part of the application design.

v. The end to end latency between the beginning of control messages sent from the TMS to the resultant CBI output to trackside equipment shall be less than 1.2 s excluding delays introduced as part of the application design. The transmission system performance requirements to meet this shall be defined for the CBI equipment.

vi. The end to end latency between input received by the CBI from trackside equipment to the beginning of the resultant message sent to the TMS shall be less than 1.2 s excluding delays introduced as part of the application design. The transmission system performance requirements to meet this shall be defined for the CBI equipment.

vii. The CBI equipment shall detect and report a fault in less than 10 s for more than 90% of detectable faults.

viii. In a distributed CBI arrangement the CBI equipment, installation, configuration and transmission system between subsystems has a direct effect on the overall CBI installation.
response times. The CBI equipment shall support arrangements that add < 0.5 s for each intermediate CBI equipment block that the application data passes through.

11. Testing

Testing and certification of the signalling system including CBI equipment, its application data and associated facilities is conducted in accordance with SPG 0711 (all parts) Inspection and Testing of Signalling, T HR SC 02000 ST, AEO framework, AS 4292 and the Rail Safety National Law (NSW).

The CBI equipment shall support the existing testing arrangements or be supported by a life cycle costing in accordance with T MU AM 01001 ST that shows a positive benefit for the changed testing arrangement.