

Guidance document

G2501 Manual of Good (Formerly M7058) Practice - Signalling control systems (computer systems)

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1 Purpose

- 1.1 This Guidance Document defines guidelines to assist in the additions to, and the maintenance of, existing control systems used on the Bakerloo, Central, Metropolitan and Piccadilly lines. It also defines the design principles used in the development of the control systems.
- 1.2 Signalling Control systems are implemented either as a distributed computer system or as a set of Programme Machines and relays/electronic modules. This document is the Code of Practice relating to the application of Computer Systems for Signalling Control. For the application of Programme Machines to Signalling Control see M7057, Manual of Good Practice – Programme Machines.

2 Scope

- 2.1 The Control of the London Underground railway is exercised through a Control system of which the signalling Control system is a part. The philosophy of Signalling Control Systems is specified in E7002, Signalling control systems.
- 2.2 For new control systems or the addition to an existing system of an interface with a new system, reference should be made to standard E7002.

3 Requirements

3.1 Safety considerations

3.1.1 General

- 3.1.1.1 During consideration of potential Control systems hazards, account should be taken of human limitations.
- 3.1.1.2 The control system should incorporate such fault tolerant features as are necessary to ensure that, in the event of a hazard affecting system operation, the system degrades gracefully.
- 3.1.1.3 The design should incorporate such Safety Features as necessary to reduce the magnitude of the loss or risk once a hazardous mode has been entered. Care should be taken to ensure that the safety device does not introduce an additional hazard or system malfunction.
- 3.1.1.4 Warning devices and systems should be incorporated where necessary to alert the operator to an incident with potential safety implications.

3.1.2 System safety

- 3.1.2.1 As part of the safety engineering activity, analyses of identified potential hazards should be prepared to ensure the resolution of hazards. The following analyses should be prepared as required in the Systems Requirements Specification:

Subsystem hazard analysis (SSHA),

Interface hazard analysis (IHA),

Operating and Support hazard analysis (O&SHA),

3.1.3 Safety of personnel

- 3.1.3.1 The supplier of signalling Control Systems should recommend special equipment and/or operating procedures to reduce the probability of a hazardous event,

provide a training programme as specified, and recommend the level of training required based on the complexity of the task and anticipated trainee qualifications.

- 3.1.3.2 The provision of Signalling Control Systems should conform to the requirements stated in Reference (Section 6).

3.2 Functional requirements

3.2.1 General operational requirements

- 3.2.1.1 Computer based signalling Control Systems are used for the following purposes:

To identify and follow trains as they move through an area under control;

To automatically call for Routes according to train position, Timetable and other information, in order to ensure the minimum delay to the train service;

To provide service exception alarms and reports;

To provide service prediction information;

To provide automatic service and headway regulation;

To allow manual intervention by SCC staff both to modify automatic routing and to exercise direct control of Signalling equipment;

To monitor the state and health of the Signalling system equipment and Control System equipment, producing alarms and reports as required, and provide summary reports;

To provide train loading measurements.

To provide passenger information.

To provide remote controlling of Interlockings and remote indication of Signalling equipment status to and from the SCC.

To provide remote supervision of train service performance from the SCC, with presentation of system status and service Performance information on Control Consoles, overview displays and data terminals.

To collect service operation statistics including crew information, train miles operated and Performance of the train service relative to the Timetable.

To log Control System events.

- 3.2.1.2 The railway Timetable should be used as the primary source of information for the automatic Control of trains during Traffic Hours.

- 3.2.1.3 It should be possible to identify uniquely, every train capable of being monitored or controlled by the Signalling Control System. Trains are normally identified by the Timetable Identity (TTID) of the current Trip of the train. Because there is a possibility of two trains having the same TTID, the Control System should allocate a Train Number to each train to prevent confusion.

- 3.2.1.4 In the absence of an available Timetable, the system should attempt to route trains from any destination information that is provided by the Signalling system.

- 3.2.1.5 If the identity of a train entering into the Area of Control of a system is not known, the system should generate a warning and should attempt to allocate the train identity from a variety of sources dependent upon the Signalling system and facilities available. These may include PTI, ATC data and independent train

description. If none are available, then the train should be allocated as the next expected from the Timetable.

- 3.2.1.6 The system should generate train prediction information for a number of Control Points on the railway. This should be a prediction of which trains will pass each point during the next twenty minutes, and should include a prediction of the time at which the train will pass the point, the TTID, the Train Number and associated information.
- 3.2.1.7 Train prediction information should be re-evaluated at least every fifteen seconds. It should take into account train position, Timetable information, convergence modes (see section 5), trains due to reverse at termini and sidings, layover, trains due to enter service, regulation strategy, outstanding Renummer Commands, station dwell times, and alternative routing and transit times for sections of the railway, including time left on the current section.
- 3.2.1.8 The train prediction information should be used by the Control System as the basis for automatic routing decisions and passenger and staff information displays. The prediction should have a resolution of one minute.
- 3.2.1.9 The Control System should be capable of generating Prediction Lists for the maximum number of Control Points defined in the System Requirements Specification.
- 3.2.1.10 If a prediction identifies that two trains will arrive at a Convergence Point other than in Timetable order, then a warning should be generated to Service Control Centre (SCC) staff. The warning should identify the trains, their present position and the Convergence Point. The warning should be generated at a specified time before the predicted arrival time of the first train at the Convergence Point, the specified time should be defined in the System Requirements Specification.
- 3.2.1.11 Where practicable, an on-line help facility should be included as one of the facilities of the signalling Control system. The facility should include help information directly related to the context of the operation currently being carried out.

3.2.2 Personnel requirements

- 3.2.2.1 The Control System should provide facilities for a number of users whose functions are described in the following clauses. The titles given below may change, but the functions will continue.
- 3.2.2.2 Service Controllers will be accommodated in the SCC Control room and will have responsibility for complete train service operation on a particular line.
- 3.2.2.3 Signal Control Assistants will be accommodated in the SCC Control room and will have the responsibility to Control and regulate the train service on an allocated section of railway. They will implement the strategy developed by the Service Controller.
- 3.2.2.4 Systems Control Assistants will be accommodated in the SCC Control room and will have the responsibility to monitor and control auxiliary systems, as defined in the System Requirements Specification e.g. the traction power, tunnel ventilation and miscellaneous station systems.
- 3.2.2.5 Information Assistants will be accommodated in the SCC Control room and will have the responsibility to pass information about the train service to station staff and to customers and to record certain events.
- 3.2.2.6 The Control Centre Manager will have overall responsibility for the operation of the SCC. He will normally be accommodated in an office external to the SCC Control

room and does not require any dedicated Control System facilities. On occasion, he may assist in the Control room and, in that event, he will use a spare Console.

3.2.2.7 During Engineering Hours the Engineering Works Controller will be responsible for the condition of the railway, train movements and for the granting and lifting of possessions. He will be accommodated in the SCC Control room and will utilise one of the Consoles during Engineering Hours used by the Service Control Assistants or Systems Control Assistants during Traffic Hours, or a dedicated Console should be provided as defined by the Systems Requirements Specification.

3.2.2.8 The Service Control Centre should accommodate a Technical Officer, who shall be responsible for the Maintenance of the Control System facilities at the SCC and for such diagnostic and system Control activities that can be operated from the SCC.

3.2.2.9 A Software Technician will be accommodated in the SCC computer centre and will be responsible for the configuration of all Control System Software and data files.

3.2.3 Routing functions

3.2.3.1 There should be at least three modes for automatic arbitration of conflicting train routing requirements through Convergence Points. The Convergence Point mode setting should determine the sequence in which Route setting calls will be issued to the signalling equipment in those cases where out-of-turn train approaches are predicted to occur within a predefined time window. The three modes should correspond to Normal, First Come First Served, and No Out Of Turn working (see section 5).

3.2.3.2 Three sets of routing application functions should be supplied, providing successively lower levels of functionality. The functions to be provided are specified in the following three clauses and detailed requirements for each function should be specified in the User Requirements Specification. The use of the highest level possible, to produce the required functionality, is to be preferred.

3.2.3.3 The highest level of functionality should include the following commands:

- Activate Timetable,
- Selection of Regulation Strategy,
- Stop Trains
 - Code Amber,
 - Code Red,
- Extend Trains,
- Divert Trains,
- Reverse Trains.

3.2.3.4 The intermediate level of functionality should include the following commands:

- Renumber,
- Cancel Renumber,
- Edit Trip,
- Cancel Trip,



Extra Trip,
Restore Trip,
Extend Train,
Divert Train,
Reverse Train.

- 3.2.3.5 The lowest level of functionality should include the commands listed below. The manual commands specified in this section should temporarily Over-ride the Route setting command for the Route concerned and should be the only ones available during Engineering Hours. They should be available to a Console operator who has Control of the site or part of the site.

Convergence Point Mode,
Layover Time,
Release Trains,
Hold trains,
Move Trains,
Platform Hold,
Platform Move,
Override of Station Dwell Time (ATC only),
Selection of Speed Distance Profile (ATC only),
Time Adjust,
Train Order,
Set Route,
Reset Route,
Hold Route,
Move Route,
Remote Securing of Points,
Local Manual Control.

- 3.2.3.6 The Control System should recognise a stalled train and deliver a warning to an operator.
- 3.2.3.7 The Control System should normally set Routes in accordance with the Timetable entry for the train being considered, as modified by automatic routing requirements and manual intervention. Trains should not be Routed early from depots or sidings nor from platforms, except when required by the automatic regulation strategy.
- 3.2.3.8 Facilities to handle trains entering and leaving depots and sidings should be provided.
- 3.2.3.9 The Control System should support the implementation and use of Control zones. A Control zone should consist of convergence points and automatic blocks. The

limits of each Control zone should be dependent upon the operational Control requirements in each portion of the line. The limits of the Control zones should be modifiable at the Software Technician's Console. A Service Control Assistant may have Control of any number of Control zones.

- 3.2.3.10 The Control System should support functional partitioning based upon the different types of Control System users. Only one functional partition should be assigned to a Console at a time. Once a user functional partition has been assigned to a Console, only those Control System capabilities for that user should be accessible from that Console.
- 3.2.3.11 The functional partition and Control zone(s) assigned to a Console should determine the application Programs, Control functions, indications and communications requirements for that particular Console.
- 3.2.3.12 Functional partitions should be assigned automatically according to the identity of individual users. User identity should be entered as part of a secure Log-in procedure.
- 3.2.3.13 The minimum number of Operators that need to be logged on to the Control system at any one time will be defined in the System Requirements Specification. It should be possible for a user to interrogate the Control system to ascertain who is logged on and what facilities they have access to.
- 3.2.3.14 Automatic train regulation facilities should be provided. The facilities should include regulation to optimise energy consumption, regulation to minimise journey time, and regulation to optimise headway.

3.2.4 Additional requirements for ATC signalling systems

- 3.2.4.1 The Control System should hold three station dwell times per platform with the capability for the operator to command the system to switch between them according to the type of Timetable, day of the week, and the time of day.
- 3.2.4.2 Different speed-distance profiles should be available for each station to station section, including a full Performance profile.
- 3.2.4.3 There should be a specific command to change the direction of traffic on one or more of the sections where bi-directional working is available. Once the command and the section(s) have been selected, the Control System should check for trains which are in the selected section(s) or are approaching, and would be stopped when the command is implemented. A list of these trains should be displayed in the SCC giving the TTID, train description, current train location and last train loading measurement. The user may then confirm the command and it will be implemented by the signalling system.
- 3.2.4.4 There should be a specific command to implement non-stopping at selected stations.
- 3.2.4.5 There should be a command to apply and remove temporary speed restrictions for any track section. The command to remove a speed restriction or to apply a less restrictive one should require input by both the Service Control Assistant and Service Controller.
- 3.2.4.6 If required by the System Requirements Specification a command should be provided to select a reduced brake rate or the standard brake rate for surface sections. It should be possible to apply either rate to each individual station to station section in either direction.

3.2.5 Display facilities

- 3.2.5.1 An operator should have the facility to request current, historic and predictive information from the Control System for display. The information should be presented in chronologically, numerically, alphabetically or logically ordered sequence, as appropriate.
- 3.2.5.2 When it is necessary to use multiple page lists, the default page of the list should present the initial portion of the ordered data. For chronologically ordered data, the most recent data should be at the top of the default page. The operator should be able to scroll through the displayed list.
- 3.2.5.3 Once called up, each list should remain active until overwritten by another Listing command. Dynamic data contained in the list should be automatically updated by the Control System in response to new data entering or being generated by the Control System.
- 3.2.5.4 It should be possible to display the information detailed below. By Default, the information displayed should be that relating to the current working day, but it should be possible to select and display information relating to the seven previous days.

Train Prediction List

Display a list of trains, and their associated information, predicted to pass a specific point in the next twenty minutes.

List Renumbers

Display a list of all outstanding train renumbering commands.

List Trip

Display an array of Timetable information for a selected Trip and Set Number.

List Cancelled Trips

Display an array of all Trips cancelled during the current traffic day.

List Extra Trips

Display an array of all the extra Trips generated manually during the current traffic day.

List Edited Trips

Display an array of all the Trips that have been edited manually or automatically, together with the alteration, during the current traffic day.

Where is Set?

On selection of a Set Number, display a dynamically updated array containing the Set Number and associated information.

Where was Set?

On selection of a Set Number and a time, display an array containing the Set Number and associated information.

Where is Unit?

On selection of a unit number, display a dynamically updated array containing unit numbers and associated information.

Where is Crew Duty?

On selection of a Crew Duty number, display a dynamically updated array containing Crew Duty number and associated information.

Where is Crew Identity? (where possible)

On selection of a Crew Identity number, display a dynamically updated array containing Crew Identity and associated information.

Where was Crew Duty?

On selection of a Crew Duty number and a time, display an array containing Crew Duty number and associated information.

Where was Crew Identity? (where possible)

On selection of a Crew Identity number and a time, display an array containing Crew Identity and associated information.

- 3.2.5.5 The Control System should include Interfaces to passenger information systems. The information to be supplied should include:

The destination, Set Number, Train Number and time to arrive (or depart for terminal stations) for the next five trains which depart from the associated platform.

Triggers for various fixed messages to be displayed, the actual text being held in the passenger information system,

Real Time Train Departure Message, Text Messages initiated at the SCC.

The format for the information should be defined in the System Requirements Specification.

- 3.2.5.6 To allow messages to be initiated at the SCC, the Control System should hold a Library of standard messages, some or all of which will have up to four blank fields to be filled by a selection from available inserts.

- 3.2.5.7 A free text facility should also be provided to enable special messages to be prepared and transmitted to site. A spell checker should be provided to aid this facility.

3.2.6 Logged information

- 3.2.6.1 A range of information should be recorded on disc. It is required for the generation of basic historic information by the Control System and for transmission to a separate Management Information System. The information to be recorded should be as follows:

- (a) Half Minute Log:-

Every half minute, for every train, the following as a minimum:

TTID (set and Trip),

Train Number,

Unit numbers,



Train description,

Location,

Time train entered the section, used for identifying train location,

Details of any outstanding rennumbers,

Time deviation from Timetable (late or early),

In service or out of service,

Where crew data is available:

Crew Duty number,

Crew identification,

Where ATC is available:

Passenger loading (if available),

Mode of operation,

(b) Control Point Log:-

At certain specified locations (Control Points), the following information, as a minimum, for every train which reaches that location:

TTID (set and Trip),

Train Number,

Unit numbers,

Train description,

Time,

Time deviation from Timetable (late or early),

In service or out of service,

Where ATC is available:

Passenger loading,

Mode of operation of train.

(c) For all commands entered at the SCC, the identity of the person entering the command, the time of entry, all parameters entered as part of the command and all alterations made to the Timetable.

(d) A list of all alarms and warnings generated by the Control System, together with the identity of the person logged on to the Console where the information was displayed, the time of display and the time of acknowledgement.

(e) A list of regulation decisions taken including:

Strategy in force,

TTID,

Train position,
Station dwell time,
Intervals between trains,
Train loading, where available.

(f) For each traffic day, the identity of the Timetable selected.

(g) Headway Log:-

The Log will establish the number of missed headways and when they occurred between two times entered by the operator.

(h) Asset Performance Log:-

This log will enable asset performance statistics to be generated by the Management Information System. Base data to enable the following statistics to be generated will be logged.

Number of operation over certain time periods for mechanical signalling equipment such as points and trainstops.

Time to operate data for certain mechanical items of equipment, such as points and trainstops. This data should enable the Control System to generate warnings associated with sluggish equipment.

Asset availability / asset downtime.

- 3.2.6.2 The Control System should support the interrogation and display on the VDUs or the printed output of Signal Control Logs from the Control System real time Database. The Log should be retained on disc until periodic seven day cycle archiving takes place and for 28 days in Auxiliary Memory.
- 3.2.6.3 The print request for the half minute train Log should require the user to enter the TTID for any number of trains including "all" and a maximum thirty minute time interval based on five minute increments. The maximum time interval should be adjustable at the Software Technician's Console.
- 3.2.6.4 The print request for the systems event Log should require the user to select a particular Console or user and a maximum twenty four hour time interval based on thirty minute increments. The maximum time interval and increment should be adjustable at the Software Technician's Console.
- 3.2.6.5 The print request for the alarm summary Log should require the user to select a particular Console or user and a maximum time interval based on thirty minute increments. The maximum time interval and increment should be adjustable at the Software Technician's Console.
- 3.2.6.6 The Control System should provide a table indicating the average wait by a passenger at a specific station travelling to another specific station on the line. It should be possible for the user to interrogate the Log. The table should list for each starting station, the average wait for a train to destinations past the starting station. The average wait information for each destination station should consist of the actual average wait (minutes: seconds), design average wait (minutes: seconds) and headways over a selectable value of time.
- 3.2.6.7 Where Unit Numbers are provided, the Control System should calculate the mileage of each unit in service each traffic day based upon the destinations

achieved by each unit. The mileage of each unit should be updated in the Database at fifteen minute intervals throughout the traffic day. The user should be able to interrogate the Log.

- 3.2.6.8 Where ATC is provided, the Control System should compile a Log of all SCC originating ATC messages displayed in each train cab for each traffic day. The train messages for each train for each traffic day should be retained in the Control System Database. The user should be able to interrogate the Log.

3.2.7 Alarms

- 3.2.7.1 The Control System should enunciate specific occurrences affecting the operation or Performance of that system. These alarms should be enunciated by visual means, and optionally by audible means, on the Console logged-in to the related area. Equipment alarms will be presented on the TO's Console. The audible annunciation should be coded to identify which Console it applies to. Alarms should include but not be limited to the following:

Train service alarms,

Un-commanded change of state of a system Peripheral device,

Application Program alarm,

Communication error,

Control System Hardware or Software error,

Alarms reported by the signalling and communication systems.

Alarms reported by other systems such as traction power supply.

- 3.2.7.2 The Control System should support intelligent alarm filtering for the train service alarms and other Control System alarms, but the system design should ensure that alarms which relate to the safe operation of the railway should always be displayed.

- 3.2.7.3 Alarms should be grouped into classes dependent upon the action required by the user to resolve or acknowledge a specific alarm and the level of criticality for that alarm. As a minimum, the class types should be:

Those alarms requiring acknowledgement and an action to resolve the alarm by the user,

Those alarms only requiring acknowledgement,

Alarms for information only.

The first two classes respectively should have subgroups delineating different criticality levels within each class. The alarm class should determine the manner in which the alarm is enunciated, displayed and logged. The Control System should support a minimum of three alarm classes and the subdivision of these classes into three subgroups. Alarm parameters should be modifiable at the Software Technician's Console.

- 3.2.7.4 Alarm conditions should be clearly displayed in a alarm area (defined in the System Requirements Specification) on the tabular or graphic displays which comprise the operator consoles. The alarm attributes should convey to the user which alarms have not been acknowledged and which alarms have been acknowledged. The present state of the alarm and acknowledgement should be consistently