O-Train SCADA Alarm Strategy

Plan

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O-Train SCADA Alarm Strategy

APPROVALS		DATE
Joel Lemieux	Manager, Transit Operations Control Centre	
Duane Duquette	Director, Rail Operations	

REVISION HISTORY			
Revision	**Description of Change**	**Author**	**Effective Date**
0.1	Draft	Jon Hulse	2019-08-13
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V 1.0	Incorporating comments	Jon Hulse	2019-08-23
V 1.1	RACI table and Approval table revised	DL Ahee	2019-09-07

RACI Table	
Responsible	Manager, Transit Operations Control Centre; Director, Rail Operations; Chief Safety Officer
Accountable	Manager, Transit Operations Control Centre; Director, Rail Operations
To **C**onsult	Chief Safety Officer; Rideau Transit Maintenance
To **I**nform	Rail Operations Managers; Contract Supervisors; Rideau Transit Maintenance; Training & Development; Document Control Administrator (Coordinator Regulatory Assurance)

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O-Train SCADA Alarm Strategy

1 Purpose

The purpose of this document is to define the Alarm Strategy for the Supervisory Control and Data Acquisition (SCADA) System provided by Willowglen for the supervision, monitoring and control of the O-Train.

The strategy follows the principles outlined in the EEMUA Publication 191, which provides a guide to the design management and procurement of alarm systems.

Since the SCADA system is now in place for the first stage of Line 1, and is based on the Willowglen SCADACOM product, this strategy is thereby constrained by the built in product features and functions, but does provide a strategy to manage the alarms through the SCADA system lifecycle, including the existing alarms configured for the Stage 1 of Line 1 and for the design and implementation of the alarms for the extension of Line 1 and to the upgrade and extension of Line 2.

The existing Line 1 alarm handling will be reviewed against this strategy, and this may then require changes to the SCADA system alarm handling and the Graphical User Interface (GUI) through the configuration tools provided with the SCADA system.

2 Acronyms & Terms

Acronym or Term	Definition
ACK	Acknowledge
AOR	Area of Responsibility
ATS	Automatic Train Supervision
BCC	Back-up Control Centre
BMS	Building Management System
CBTC	Communication Based Train Control
CCTV	Closed Circuit Television
Confederation Line	An electric rail passenger service owned by the City of Ottawa and operated through OC Transpo
EEMUA	Engineering Equipment and Materials Users' Association
ERC	Electric Rail Controller
ERO	Electric Rail Operator
GIDS	Guideway Intrusion Detection System
GUI	Graphical User Interface
HMI	Human Machine Interface
IAC	Intrusion and Access Control
I/O	Input/Output
KPI	Key Performance Indicator

Acronym or Term	Definition
MLC	Mainline Controller
MSF	Maintenance and Storage Facility
OC Transpo	Corporate identifier applicable to the public transit services component of the City of Ottawa, Transportation Services department
RTG	The Rideau Transit Group (RTG), was awarded the contract to design, build, finance and maintain the initial stage of Line 1
RTM	Rideau Transit Maintenance, is the Maintenance Organization, owned by RTG, that will maintain Lines 1 including planned extensions over the 30 year Concession period
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
TOCC	Transit Operations Control Centre
TVS	Tunnel Ventilation System
YCC	Yard Control Centre

3 References

REFERENCE DOCUMENTS		
Document Name	**Document Number**	**Location**
EEMUA Publication 191 – Alarm systems: a guide to design, management and procurement	Publication 191	
SCADA Final Design Document	RES-53-0-0000-REP-0222	E-Builder
SCADACOM 6 User Guide		

4 SCADA System Overview

The SCADA system illustrated in [REF _Ref16614629 \h * MERGEFORMAT] allows remote control and monitoring of systems that support operations of the O-Train Line 1, including:

- Tunnel Ventilation system (TVS);
- Emergency Telephones;
- Fire and Life Safety systems and equipment.
- Traction Power substations;
- Guideway Intrusion Detection system (GIDS);
- Intrusion and Access Control (IAC) system;
- Closed Circuit Television (CCTV) system;
- Passenger Information system;
- Building Management Systems (BMS);
- Station equipment and functions;
- Track switch heaters.

The O-Train Line 2 will include the same system elements as Line 1, with one key exception, that there are no Traction Power substations.

The SCADA Master Station (head-end system) is a high-availability redundant system that is installed on industry standard operating systems. The Master SCADA servers, hosting the Willowglen SCADACOM® application software, are located in the Communications room in the MSF building.

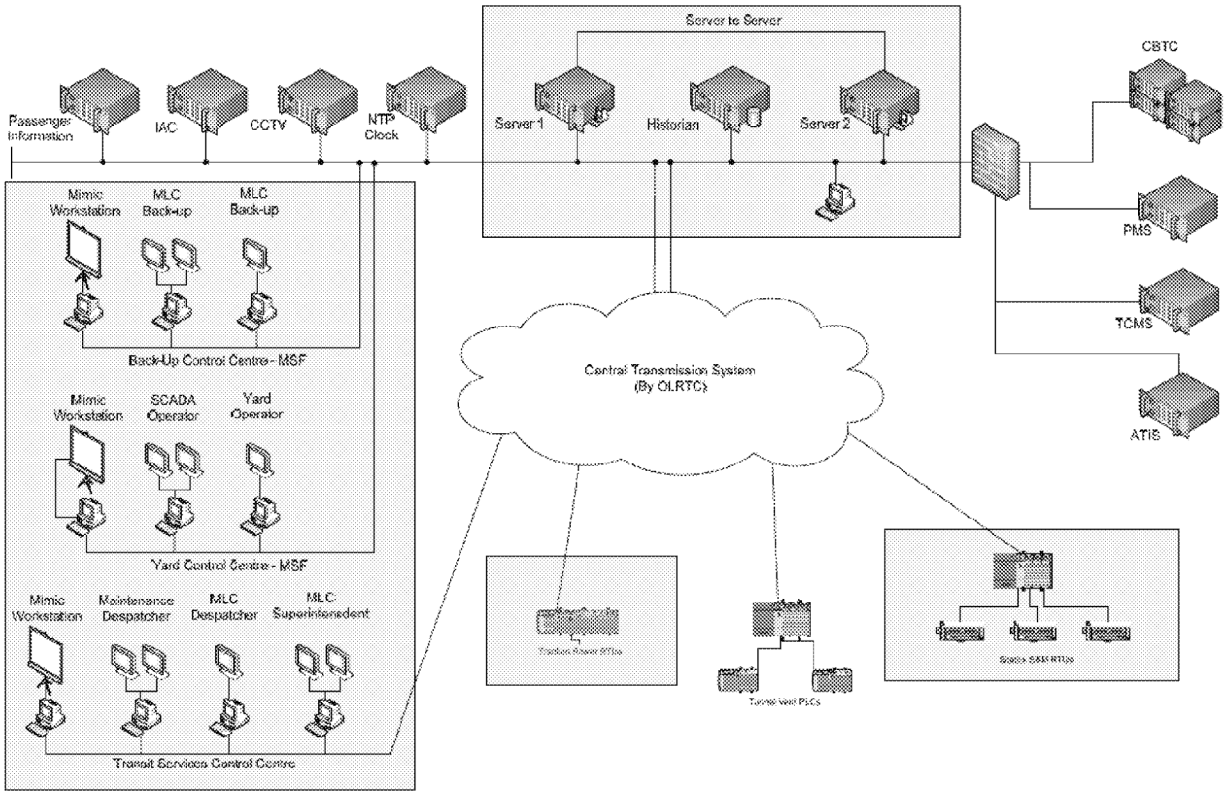

Figure [SEQ Figure * ARABIC]: SCADA System Architecture

The SCADA system interfaces to the various subsystems or equipment either directly through a network interface or through a Remote Terminal Unit (RTU) located in the MSF, the passenger stations and electrical sub-stations.

The SCADA Final Design Document for Line 1, Stage 1 (see section [REF _Ref16615726 \r \h]) includes a list of I/O for each system or equipment monitored or controlled by SCADA, and identifies each I/O point as either an alarm or event. An input in the normal position is generally an event, and in the abnormal position is an alarm. Outputs are generally classified as events.

4.1 Graphical User Interface (GUI)

The GUI interface provides several options to view the status of equipment being monitored and controlled by the SCADA system.

The user interface provides the ability for operators to quickly change between views and allows operators fast access to control equipment. Critical equipment may require additional operator input to confirm actions prior to initiating the change.

The SCADA GUI will be displayed to operator workstations and on video walls located in the Transit Operations Control Centre (TOCC), the Back-up Control Centre (BCC) and the Yard Control Center (YCC).

The video wall displays may be controlled by an operator's workstation and may also be configured to change screen views based on external inputs or automated scripts triggered by alarm conditions.

Configuration tools allowing changes to the SCADA system, alarm notification, priorities and actions are fully integrated with the overall SCADA system.

Graphical tools allow changes to the user GUI, the addition of new devices to be monitored, actions, mapping displays or other changes to operator workstations.

4.2 Transit Operations Control Centre (TOCC) and MSF SCADA Configuration

The control console for Line 1 operations in the TOCC is configured with three operator workstations, located side by side, and facing the display wall. Each workstation is equipped with ATS, SCADA and communication workstations and equipment. While each workstation is identical and can perform any and all functions, specific responsibilities are assigned to each position. Each position is attended by an Electric Rail Controller (ERC).

- The central position is used for mainline control. The ERC at this console is designated the Mainline Controller (MLC);
- The position to the right is the SCADA console. The ERC at this console is designated the SCADA Controller.
- The position to the right is the Communications console. The ERC at this console monitors CCTV, operates PA/PIDS and communicates with other TOCC employees.

A Backup Control Centre (BCC) and Yard Control Centre (YCC) are collocated in the MSF. In the event that rail operations is not possible from the TOCC, then operations will be transferred to the BCC.

The BCC includes two full operator positions and a display wall. If the BCC is active, one of the two consoles would be assigned the MLC position and one the SCADA position.

The YCC includes a single, fully identically equipped operator position and is staffed by RTM to manage yard operations and to also act as a help desk in the management of maintenance activities.

5 Alarm Management

5.1 Alarm Management Principles

The following primary principles are identified in the guidelines:

1. The purpose of an alarm system is to direct the operator's attention towards system or equipment conditions requiring timely assessment or action.
2. Each alarm should alert, inform and guide.
3. Every alarm presented to the operator should be useful and relevant to the operator.
4. Every alarm should have a defined response.
5. Adequate time should be allowed for the operator to carry out a defined response.
6. The alarm system should be explicitly designed to take account of human limitations.

The alarm system also has a secondary function of providing an alarm log which can be used for optimizing System operation, identifying trends, tracking key performance indicators (KPI) or as part of an audit or accounting function.

The alarm handling for the O-Train Lines 1 and 2 must be managed as part of a continuous lifecycle process, monitoring the alarm handling, and then managing and implementing any identified changes. This is illustrated in [REF _Ref17123711 \h * MERGEFORMAT], taken from the EEMUA guidelines.

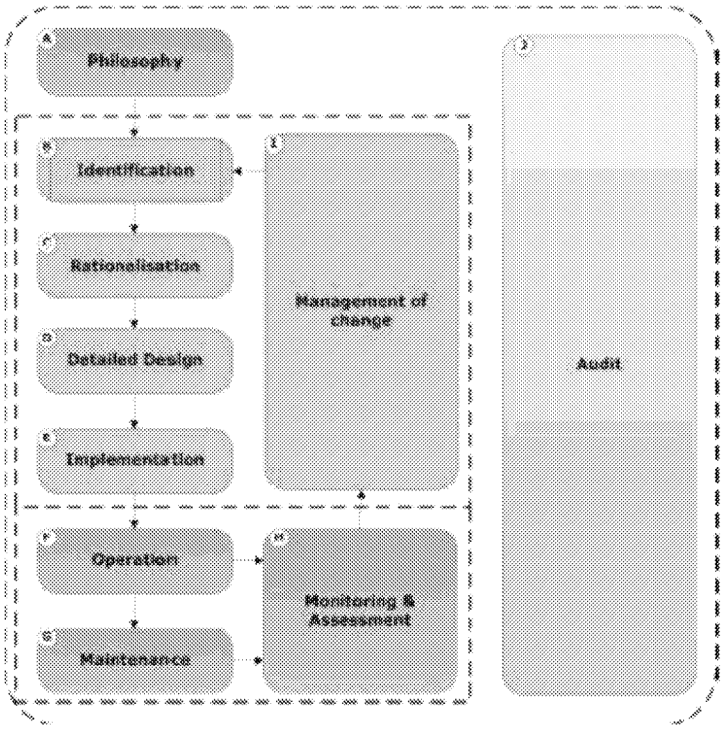

Figure [SEQ Figure * ARABIC]: Alarm Management Lifecycle

Alarm management also requires:

1. Configuration and change management of alarms;
2. Management of unused or disabled alarms;
3. Measurement of system performance against KPIs;
4. Periodic system test to confirm continued performance;
5. Assignment within the organization of responsibilities.

Alarm management at the design phase, and applicable to the Line 1 extensions and Line 2 upgrade and extension, must consider the operations involved, including:

- Numbers and type of alarms.
- Alarm frequencies.
- Alarm severities and priorities – alarms must be reviewed to identify safety or mission critical alarms, with priorities assigned.

- Operator functions and responsibilities – alarms should be assigned to operators based on the functions and responsibilities defined, and the alarms should align with any control functions defined.

- The human factors involved.

5.2 Line 1 SCADA Alarms and Events

The SCADA system for Line 1 has been configured with a combination of alarms and events consistent with the SCADACOM product functionality, and generally described with some differences in the SCADACOM 6 User Manual (see reference section [REF _Ref16615726 \r \h]).

Alarms can be assigned one of four levels:

- Priority 0 – Safety, security or operationally critical, requiring an immediate response.

- Priority 1 – High priority – these are safety or operationally critical alarms requiring an operator response, within one hour;

- Priority 2 – Medium priority, with response required during operating hours;

- Priority 3 – Lowest priority, with response required during engineering hours.

Events may be assigned one of two levels, level 1 and level 0. For the SCADA system as configured for Line 1, all events have been set at level 0.

An event occurs when an alarm is cleared, and the alarm input has returned to its Normal state. Events may also occur due to state changes in field equipment, and the same equipment may also present an alarm. For example:

a) When a sump pump activates - this would be an event, but this does not need to be viewed by either Operations or Maintenance; however, it should be recorded.

b) If the pump fails – this should cause an alarm that should be directed to the maintenance SCADA workstation for maintenance action.

c) The pump fails to maintain the water level within the acceptable range – this should cause an alarm to be directed to both maintenance and operations; maintenance to respond to the flooding and/or equipment failure, and operations to stop trains from entering the flooded area.

Other events may for example record the normal movement of personnel through access doors, but they should not represent an alarm unless it is an unauthorized access.

The SCADA HMI is configured with two screens shown in [REF _Ref17196659 \h * MERGEFORMAT] and [REF _Ref17196671 \h * MERGEFORMAT]. The first providing an alarm page, displaying the Current Alarms Display and typically one of three schematic displays: station, ventilation or OCS overview. The second screen displays the Alarm Journal, with an alternative schematic display. The second screen also identifies the user and the SCADACOM role.

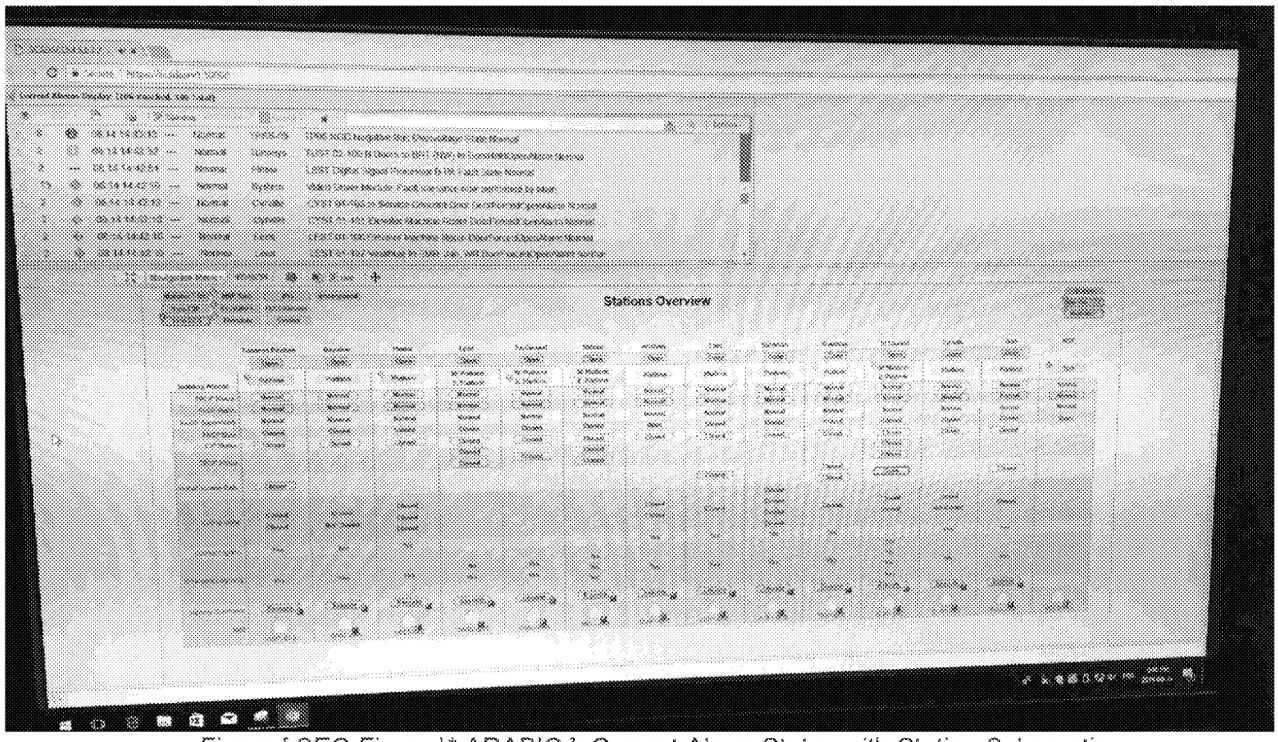

Figure [SEQ Figure * ARABIC]: Current Alarm Status with Station Schematic

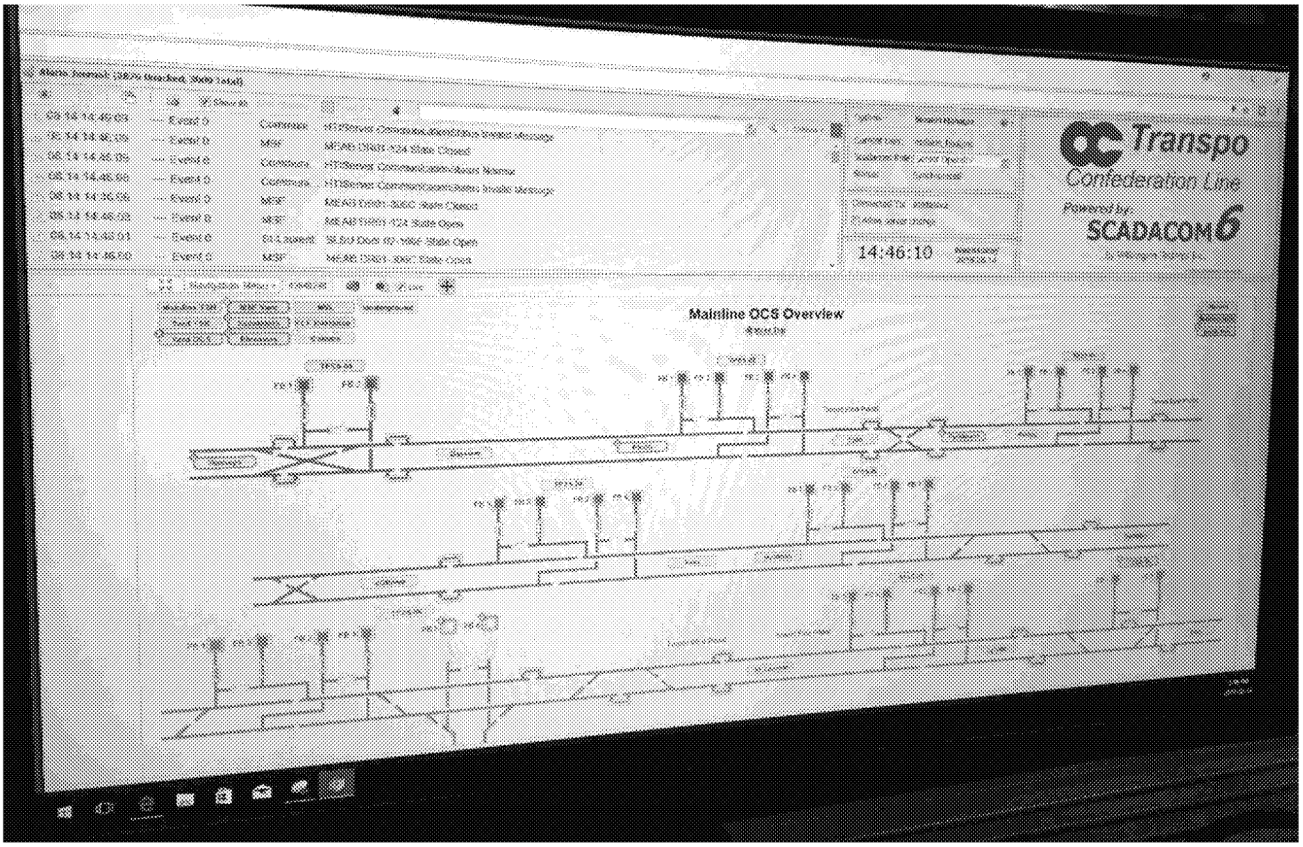

Figure [SEQ Figure * ARABIC]: Journal Alarm Status with OCS Schematic

5.2.1 The Alarm Journal

The Alarm Journal illustrated in [REF _Ref17110524 \h * MERGEFORMAT] below, presents all alarm transitions that have occurred on the SCADA system. Operators may use the Alarm Journal to monitor alarms in real-time and to act upon them. The Alarm Journal provides mechanisms for capturing an operator's attention, such as color or sound indicators. The Alarm Journal has optional features, such as alarm acknowledgement and viewing the most recent alarm transitions.

The list of alarms shown in the Alarm Journal can be filtered by severity or area of responsibility:

- Choosing a severity level in the Severity Filter drop-down menu restricts the visible alarms to that severity level (or greater).
- The list of alarms shown in the Alarm Journal can be filtered by Area of Responsibility (AOR). The AOR Filtering button is used to choose which AORs are shown on the display.

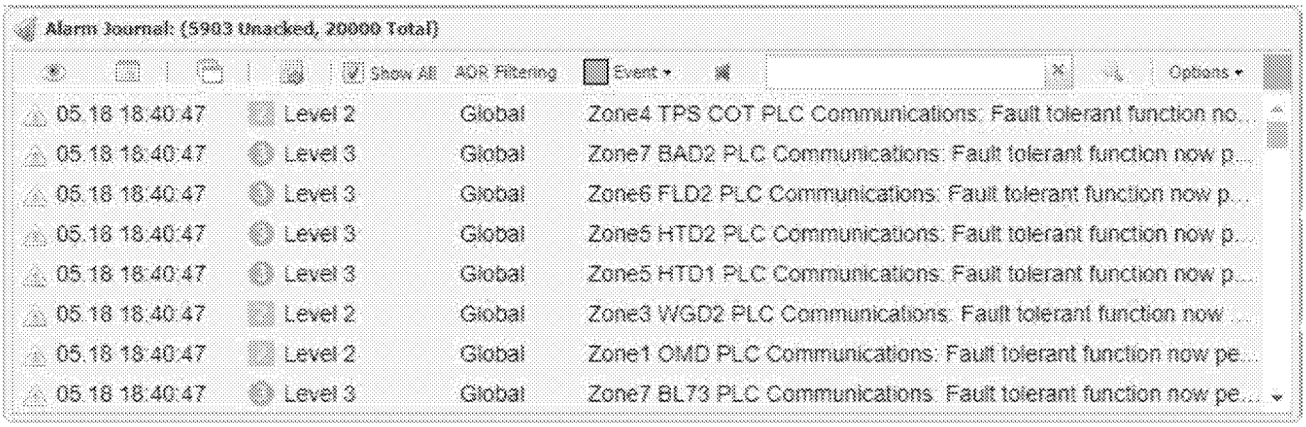

Figure [SEQ Figure * ARABIC]: Alarm Journal

5.2.2 Current Alarm Display

The Current Alarms Display illustrated in [REF _Ref17111939 \h * MERGEFORMAT] allows a user to monitor and interact with active alarms in the system and includes the following features.

- The user has the ability to filter, acknowledge, and shelve alarms.
- The title bar displays the number of unacknowledged and the total number of alarms in the operator's AOR.
- The top of the Current Alarms Display contains the Recent Alarms Grid which displays the 3 most recent alarms and remains visible at all times. As new alarms come in, older alarms are shifted to the Scrollable Alarms Grid immediately below. The Recent Alarms and Scrollable Alarms Grids are shown in [REF _Ref17111939 \h * MERGEFORMAT].
- The Recent Alarm Grid:
    - Displays the most recent alarms from the server.
    - Remains visible at all times.
    - As new alarms come in, older alarms are shifted to the Scrollable Alarms Grid.
- The Scrollable Alarms Grid allows an operator to scroll through previous entries, and:
    - Lists all remaining alarms from the server.

- Exists as a collapsible extension from the bottom of the Recent Alarms Grid.

- The current unacknowledged and standing alarms are displayed by default in the Alarm Display.

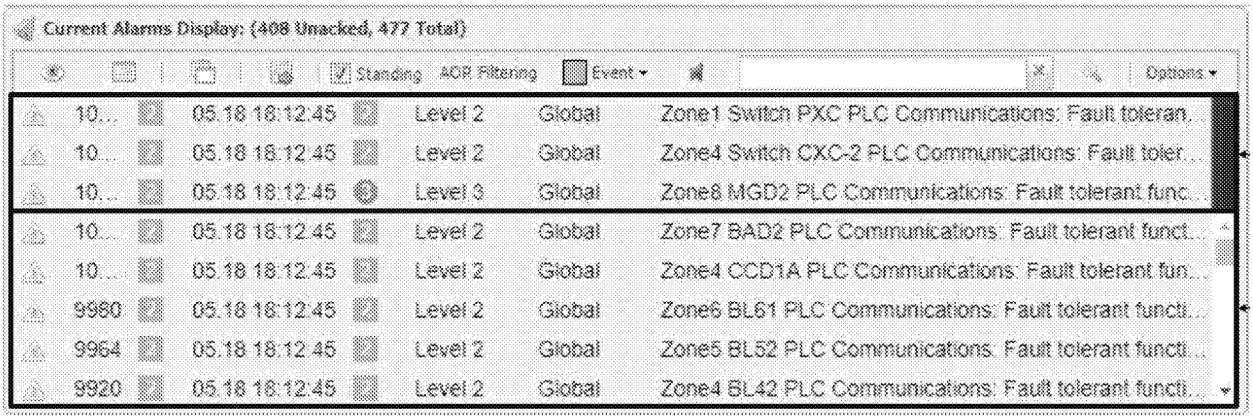

Figure [SEQ Figure * ARABIC]: Current Alarms Display

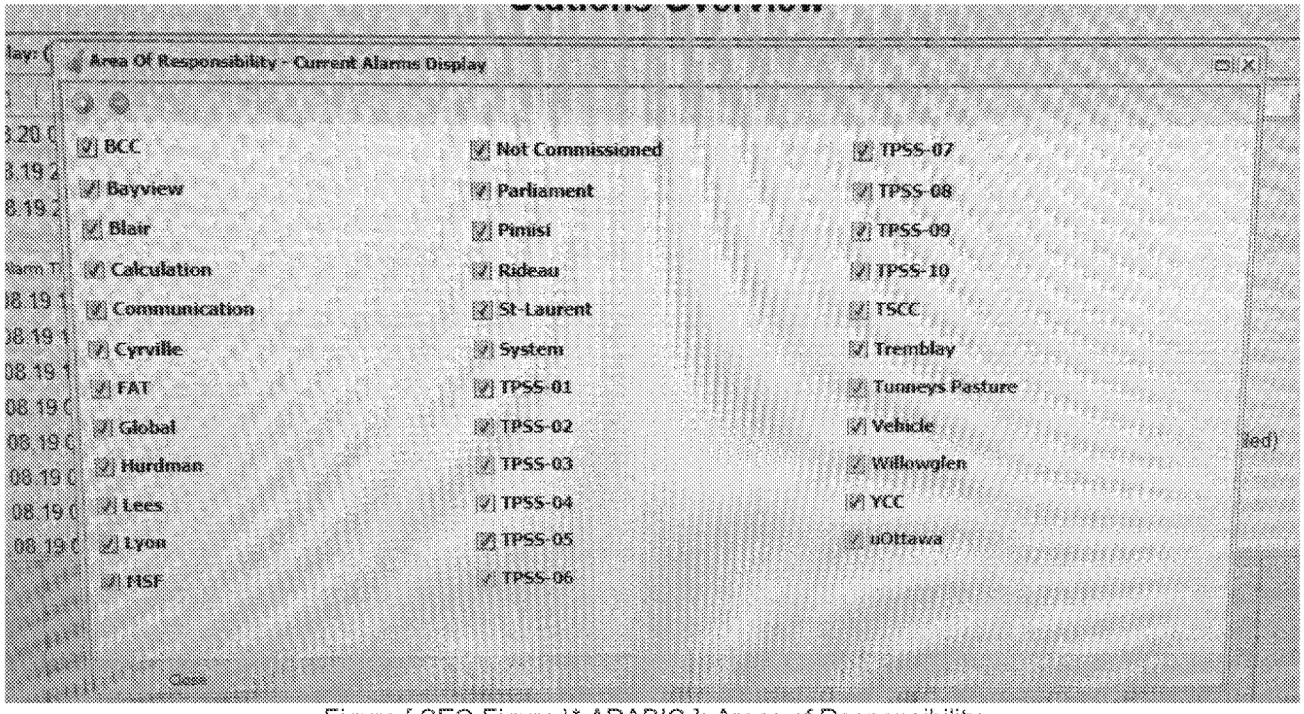

Figure [SEQ Figure * ARABIC]: Areas of Responsibility

5.3 GUI Design

The alarm management cannot be separated from the GUI design. The EEMUA guidelines note that the majority of failures of alarm systems derive from human errors rather than from hardware failures. The probability of success of the human response can be greatly increased by improving the ergonomics of the operator interface; i.e. the GUI that encompasses the alarm list and response capabilities.

Four sequential stages are identified in the guidelines for the Operator response:

i. Observation (Awareness) – the timely receipt of information. In this step, the likelihood of the operator failing to observe the alarm on the display needs to be assessed. A high priority alarm cannot be masked by a lower priority alarm or event, or the numbers of alarms received should not cause the operator to miss a high priority alarm.

ii. Analysis – using the available information (including probably both the alarm and supporting information from other displays or operations staff) to determine what state the Transit system and the incident subsystems are in.

iii. Decision – using the results of the analysis to decide what action(s) to take.

iv. Action – delivering the action(s) decided upon. This may be through a combination of GUI action, use of other equipment (e.g. radio, or telephone) and by following rules and procedures. Actions may be required from both TOCC personnel and by EROs and field staff.

5.4 Review of Existing Alarms

A 24-hour period of Line 1 alarms was reviewed for August 19, 2019. The period coincided with the trial run period for Stage 1 of the Line 1 implementation. The alarms were filtered according to the Priorities 0, 1, 2, 3 and Normal[]. Over this period 1668 alarms were captured with the distribution as follows:

- Priority 0 – a total of 401 alarms;
- Priority 1 – a total of 119 alarms;
- Priority 2 – a total of 125 alarms;
- Priority 3 – a total of 165 alarms;
- Normal - a total of 858 alarms.

This number of high priority alarms (priority 0 and 1) is not considered to be manageable by a single SCADA position during normal operations.

5.4.1 Priority 0 Alarms

A sample of the Priority 0 alarms is shown below. Of the Priority 0 alarms, 75 are system alarms, with a representative sample as follows:

Table [SEQ Table * ARABIC]: Priority 0 System Alarms Sample

Device	Time	Severity	Device AOR	Alarm Text
18350160:wg_ftp_transfer_application	2019.08.19 23:40:50	Priority 0	System	FTP Transfer Fault Tolerance: Fault tolerance now performed by None (Failed)
18350136:wg_video_driver	2019.08.19 18:59:55	Priority 0	System	Video Driver Module: Fault tolerance now performed by None (Failed)
18350160:wg_ftp_transfer_application	2019.08.19 18:49:55	Priority 0	System	FTP Transfer Fault Tolerance: Fault tolerance now performed by None (Failed)
18350136:wg_video_driver	2019.08.19 18:49:34	Priority 0	System	Video Driver Module: Fault tolerance now performed by None (Failed)
18350160:wg_ftp_transfer_application	2019.08.19 17:37:41	Priority 0	System	FTP Transfer Fault Tolerance: Fault tolerance now performed by None (Failed)

It is not clear that any of these alarms would be useful for day to day operations. Many of these alarms are due to the to the fact that specific systems are not fully commissioned and are not representative of the expected behavior during normal revenue service. The related alarms could be hidden from the operator by not selecting the System AOR in the AOR panel.

The following is a representative sample of non-system priority 0 station alarms:

Table [SEQ Table * ARABIC]:Priority 0 Station Alarms Sample

Device	Time	Severity	Device AOR	Alarm Text
633340116:BAST-DR-01-100-IN	2019.08.19 23:31:52	Priority 0	Bayview	BAST 01-100 IN Service DR LWR Concourse (SW) DoorForcedOpenAlarm Unauthorized Entry
571477945:DWSU-ELEVATOR-05-04-005-ACT-DRIVE-FAILURE	2019.08.19 23:13:35	Priority 0	Lyon	DWSU ELEVATOR-05 (04-005) Activation of drive failure State Yes
633340468:TRST-DR-02-100-IN	2019.08.19 22:56:16	Priority 0	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Unauthorized Entry
633340419:RISU-DR-04-004-A	2019.08.19 21:35:24	Priority 0	Rideau	RISU 04-004A HVAC Room Landing DoorForcedOpenAlarm Unauthorized Entry
633340440:SLSU-DR-01-133	2019.08.19 20:45:08	Priority 0	St-Laurent	SLSU 01-133 Escalator Control Rm (N) DoorForcedOpenAlarm Unauthorized Entry
633340468:TRST-DR-02-100-IN	2019.08.19 19:48:44	Priority 0	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Unauthorized Entry
633340468:TRST-DR-02-100-IN	2019.08.19 19:29:34	Priority 0	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Unauthorized Entry
633340468:TRST-DR-02-100-IN	2019.08.19 19:24:12	Priority 0	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Unauthorized Entry
633340468:TRST-DR-02-100-IN	2019.08.19 19:22:16	Priority 0	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Unauthorized Entry

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Device	Time	Severity	Device AOR	Alarm Text
633340468:TRST-DR-02-100-IN	2019.08.19 19:18:00	Priority 0	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Unauthorized Entry
633340540:HUST-DR-01-100-A-IN	2019.08.19 19:00:02	Priority 0	Hurdman	HUST 01-100 A Service Door Concourse IN DoorForcedOpenAlarm Unauthorized Entry
633340116:BAST-DR-01-100-IN	2019.08.19 18:55:16	Priority 0	Bayview	BAST 01-100 IN Service DR LWR Concourse (SW) DoorForcedOpenAlarm Unauthorized Entry
633340468:TRST-DR-02-100-IN	2019.08.19 18:49:46	Priority 0	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Unauthorized Entry
581959690:TRST-ELE-01	2019.08.19 18:49:33	Priority 0	Tremblay	TRST Elevator 1 (01-107) PassengerAlarm Yes
571477355:DWSU-ETEL-02-OFF-HOOK	2019.08.19 18:13:24	Priority 0	Lyon	DWSU ETEL-02 Off Hook State Activated
571477355:DWSU-ETEL-02-OFF-HOOK	2019.08.19 18:12:49	Priority 0	Lyon	DWSU ETEL-02 Off Hook State Activated
581959720:DWSU-ELE-06	2019.08.19 18:06:48	Priority 0	Lyon	DWSU Elevator 6 (04-005) IntercomActive Yes
571477367:DWSU-ETEL-ITEL-02-OFF-HOOK	2019.08.19 18:05:37	Priority 0	Lyon	DWSU ETEL/ITEL-02 Off Hook State Activated

This list shows a large number of ETEL/ITEL activations and Door Forced Open alarms which may be due to the ongoing trouble shooting activities in the stations and are not representative of the expected behavior during normal revenue service. The normal use of concourse doors during operating hours should not be classified as an alarm, so some alarm reconfiguration may be required.

5.4.2 Priority 1 Alarms

The following is a representative sample of the Priority 1 alarms:

Table [SEQ Table * ARABIC]: Priority 1 Alarms Sample

Device	Time	Severity	Device AOR	Alarm Text
581959719:DWSU-ELE-05	2019.08.19 23:13:09	Priority 1	Lyon	DWSU Elevator 5 (04-005) NormalOperation No
633340393:RISU-DR-01-036-A	2019.08.19 22:10:36	Priority 1	Rideau	RISU 01-036A Mechanical Closet DoorHeldOpenAlarm Held Too Long
633340413:RISU-DR-02-030-A	2019.08.19 21:58:58	Priority 1	Rideau	RISU 02-030A Elevator Machine Room DoorHeldOpenAlarm Held Too Long
633340412:RISU-DR-02-029-A	2019.08.19 21:57:16	Priority 1	Rideau	RISU 02-029A HVAC Room DoorHeldOpenAlarm Held Too Long
633340412:RISU-DR-02-029-A	2019.08.19 21:54:02	Priority 1	Rideau	RISU 02-029A HVAC Room DoorHeldOpenAlarm Held Too Long
633340417:RISU-DR-03-007-A	2019.08.19 21:43:56	Priority 1	Rideau	RISU 03-007A AUX Electrical Room DoorHeldOpenAlarm Held Too Long
633340415:RISU-DR-03-001-B	2019.08.19 21:43:18	Priority 1	Rideau	RISU 03-001B TPSS DoorHeldOpenAlarm Held Too Long
633340414:RISU-DR-03-001-A	2019.08.19 21:42:18	Priority 1	Rideau	RISU 03-001A TPSS DoorHeldOpenAlarm Held Too Long
633340416:RISU-DR-03-005-A	2019.08.19 21:40:06	Priority 1	Rideau	RISU 03-005A TPSS Entry Room DoorHeldOpenAlarm Held Too Long

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Device	Time	Severity	Device AOR	Alarm Text
633340419:RISU-DR-04-004-A	2019.08.19 21:34:24	Priority 1	Rideau	RISU 04-004A HVAC Room Landing DoorHeldOpenAlarm Held Too Long
581959717:DESU-ELE-05	2019.08.19 20:19:54	Priority 1	Parliament	DESU Elevator 5 (02-014) NormalOperation No
633340468:TRST-DR-02-100-IN	2019.08.19 19:18:20	Priority 1	Tremblay	TRST 02-100 Service DR Concourse IN DoorHeldOpenAlarm Held Too Long
633340116:BAST-DR-01-100-IN	2019.08.19 18:56:44	Priority 1	Bayview	BAST 01-100 IN Service DR LWR Concourse (SW) DoorHeldOpenAlarm Held Too Long
581959693:TRST-ELE-04	2019.08.19 18:36:37	Priority 1	Tremblay	TRST Elevator 4 (01-117) NormalOperation No
581959689:SLSU-ELE-04	2019.08.19 18:13:53	Priority 1	St-Laurent	SLSU Elevator 4 (01-119) NormalOperation No
633340543:LBST-DR-01-100-B-IN	2019.08.19 17:46:24	Priority 1	Pimisi	LBST 01-100 B Service Dr LWR Concourse West In DoorHeldOpenAlarm Held Too Long
581959689:SLSU-ELE-04	2019.08.19 17:30:03	Priority 1	St-Laurent	SLSU Elevator 4 (01-119) NormalOperation No
581959689:SLSU-ELE-04	2019.08.19 17:29:29	Priority 1	St-Laurent	SLSU Elevator 4 (01-119) NormalOperation No
581959689:SLSU-ELE-04	2019.08.19 17:28:53	Priority 1	St-Laurent	SLSU Elevator 4 (01-119) NormalOperation No
581959689:SLSU-ELE-04	2019.08.19 17:28:18	Priority 1	St-Laurent	SLSU Elevator 4 (01-119) NormalOperation No

Device	Time	Severity	Device AOR	Alarm Text
633340481:TUST-DR-02-100-B-IN	2019.08.19 16:57:46	Priority 1	Tunneys Pasture	TUST 02-100 B Doors to BRT (NW) In DoorHeldOpenAlarm Held Too Long
581959737:DWSU-ELE-02	2019.08.19 16:55:03	Priority 1	Lyon	DWSU Elevator 2 (02-013) NormalOperation No
571478122:DWSU-ELEVATOR-02-02-013-CAR-ON-INDSRV-OPERATION	2019.08.19 16:55:01	Priority 1	Lyon	DWSU ELEVATOR-02 (02-013) Car on Independent Service Operation State Yes
581959736:DWSU-ELE-01	2019.08.19 16:53:48	Priority 1	Lyon	DWSU Elevator 1 (02-013) NormalOperation No
571478110:DWSU-ELEVATOR-01-02-013-CAR-ON-INDSRV-OPERATION	2019.08.19 16:53:44	Priority 1	Lyon	DWSU ELEVATOR-01 (02-013) Car on Independent Service Operation State Yes

This list shows a large number of Elevator and Door Held Open alarms which may be due to the ongoing trouble shooting activities in the stations and are not representative of the expected behavior during normal revenue service.

5.4.3 Priority 2 Alarms

The following is a representative sample of the Priority 2 alarms:

Table [SEQ Table * ARABIC]: Priority 2 Alarms Sample

Device	Time	Severity	Device AOR	Alarm Text
581959719:DWSU-ELE-05	2019.08.19 23:13:39	Priority 2	Lyon	DWSU Elevator 5 (04-005) OutOfService Yes
571477947:DWSU-ELEVATOR-05-04-005-ACT-CAR-INSP-OPR	2019.08.19 23:13:08	Priority 2	Lyon	DWSU ELEVATOR-05 (04-005) Activation of car inspection operation State Yes
583008263:TP06-NGD	2019.08.19 21:58:49	Priority 2	TPSS-06	TP06 Negative Grounding Device State Close

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Device	Time	Severity	Device AOR	Alarm Text
571474780:TP06-NGD-NEGATIVE-BUS-OVERVOLTAGE	2019.08.19 21:58:47	Priority 2	TPSS-06	TP06 NGD Negative Bus Overvoltage State Tripped
571478143:DWSU-ELEVATOR-03-02-014-HI-TEMP	2019.08.19 18:11:22	Priority 2	Lyon	DWSU ELEVATOR-03 (02-014) Hi Temp State Yes
571478143:DWSU-ELEVATOR-03-02-014-HI-TEMP	2019.08.19 18:10:37	Priority 2	Lyon	DWSU ELEVATOR-03 (02-014) Hi Temp State Yes
571478155:DWSU-ELEVATOR-04-02-014-HI-TEMP	2019.08.19 18:08:59	Priority 2	Lyon	DWSU ELEVATOR-04 (02-014) Hi Temp State Yes
571478155:DWSU-ELEVATOR-04-02-014-HI-TEMP	2019.08.19 18:08:38	Priority 2	Lyon	DWSU ELEVATOR-04 (02-014) Hi Temp State Yes
571478155:DWSU-ELEVATOR-04-02-014-HI-TEMP	2019.08.19 18:08:14	Priority 2	Lyon	DWSU ELEVATOR-04 (02-014) Hi Temp State Yes
571478155:DWSU-ELEVATOR-04-02-014-HI-TEMP	2019.08.19 18:07:03	Priority 2	Lyon	DWSU ELEVATOR-04 (02-014) Hi Temp State Yes
571478131:DWSU-ELEVATOR-02-02-013-HI-TEMP	2019.08.19 18:05:20	Priority 2	Lyon	DWSU ELEVATOR-02 (02-013) Hi Temp State Yes

This list shows a large number of Elevator alarms which may be due to the ongoing trouble shooting activities in the stations and are not representative of the expected behavior during normal revenue service. It is questionable whether these alarms should be presented to operations or should instead be dealt with directly by the maintenance organization.

5.4.4 Priority 3 Alarms

The following is a representative sample of the Priority 3 alarms:

Table [SEQ Table * ARABIC]: Priority 3 Alarms Sample

Device	Time	Severity	Device AOR	Alarm Text
571476113:HUST-DIGITAL-SIGNAL-PROCESSOR-A-PA-FAULT	2019.08.19 23:54:54	Priority 3	Hurdman	HUST Digital Signal Processor A PA Fault State Fault
571475911:CYST-DIGITAL-SIGNAL-PROCESSOR-B-PA-FAULT	2019.08.19 23:54:48	Priority 3	Cyrville	CYST Digital Signal Processor B PA Fault State Fault
571476817:LEST-DIGITAL-SIGNAL-PROCESSOR-B-PA-NAC-2-FAULT	2019.08.19 23:48:35	Priority 3	Lees	LEST Digital Signal Processor B PA Fault State Fault
653262849:IOS Transfer	2019.08.19 23:40:54	Priority 3	Communication	IOS Transfer CommunicationStatus Response Timed Out
654311427:IOS FTPConnection Retrieval	2019.08.19 23:40:46	Priority 3	Communication	IOS FTPConnection Retrieval CommunicationStatus Response Timed Out
571477286:RISU-PA-RACK-NAC-3-FAULT	2019.08.19 23:24:43	Priority 3	Rideau	RISU PA Rack NAC- 3 Fault State Fault
571476602:SLSU-PA-RACK-NAC-1-FAULT	2019.08.19 23:24:32	Priority 3	St-Laurent	SLSU PA RACK NAC-1 FAULT State Fault
571477441:TUST-DIGITAL-SIGNAL-PROCESSOR-A-PA-FAULT	2019.08.19 23:21:38	Priority 3	Tunneys Pasture	TUST DIGITAL SIGNAL PROCESSOR A PA Fault State Fault
571476603:SLSU-PA-RACK-NAC-2-FAULT	2019.08.19 23:12:47	Priority 3	St-Laurent	SLSU PA RACK NAC-2 FAULT State Fault
571477442:TUST-DIGITAL-SIGNAL-PROCESSOR-B-PA-FAULT	2019.08.19 22:39:43	Priority 3	Tunneys Pasture	TUST DIGITAL SIGNAL PROCESSOR B PA Fault State Fault

Device	Time	Severity	Device AOR	Alarm Text
571477286:RISU-PA-RACK-NAC-3-FAULT	2019.08.19 22:33:42	Priority 3	Rideau	RISU PA Rack NAC- 3 Fault State Fault

This list shows a large number of PA system alarms which may be due to the ongoing trouble shooting activities in the stations and are not representative of the expected behavior during normal revenue service. It is questionable whether these alarms should be presented to operations or should instead be dealt with directly by the maintenance organization.

5.4.5 Normal Alarms

The following is a representative sample of the Normal alarms:

Table [SEQ Table * ARABIC]: Normal Alarms Sample

Device	Time	Severity	Device AOR	Alarm Text
571476113:HUST-DIGITAL-SIGNAL-PROCESSOR-A-PA-FAULT	2019.08.19 23:54:54	Normal	Hurdman	HUST Digital Signal Processor A PA Fault State Normal
571475911:CYST-DIGITAL-SIGNAL-PROCESSOR-B-PA-FAULT	2019.08.19 23:54:48	Normal	Cyrville	CYST Digital Signal Processor B PA Fault State Normal
571476817:LEST-DIGITAL-SIGNAL-PROCESSOR-B-PA-NAC-2-FAULT	2019.08.19 23:48:37	Normal	Lees	LEST Digital Signal Processor B PA Fault State Normal
653262849:IOS Transfer	2019.08.19 23:41:12	Normal	Communication	IOS Transfer CommunicationStatus Normal
654311427:IOS FTPConnection Retrieval	2019.08.19 23:41:08	Normal	Communication	IOS FTPConnection Retrieval CommunicationStatus Normal
633340116:BAST-DR-01-100-IN	2019.08.19 23:31:58	Normal	Bayview	BAST 01-100 IN Service DR LWR Concourse (SW) DoorForcedOpenAlarm Normal

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Device	Time	Severity	Device AOR	Alarm Text
571477286:RISU-PA-RACK-NAC-3-FAULT	2019.08.19 23:24:49	Normal	Rideau	RISU PA Rack NAC- 3 Fault State Normal
571476602:SLSU-PA-RACK-NAC-1-FAULT	2019.08.19 23:24:32	Normal	St-Laurent	SLSU PA RACK NAC-1 FAULT State Normal
571477441:TUST-DIGITAL-SIGNAL-PROCESSOR-A-PA-FAULT	2019.08.19 23:21:43	Normal	Tunneys Pasture	TUST DIGITAL SIGNAL PROCESSOR A PA Fault State Normal
581959719:DWSU-ELE-05	2019.08.19 23:13:40	Normal	Lyon	DWSU Elevator 5 (04-005) OutOfService No
581959719:DWSU-ELE-05	2019.08.19 23:13:39	Normal	Lyon	DWSU Elevator 5 (04-005) NormalOperation Yes
571477945:DWSU-ELEVATOR-05-04-005-ACT-DRIVE-FAILURE	2019.08.19 23:13:36	Normal	Lyon	DWSU ELEVATOR-05 (04-005) Activation of drive failure State No
571477947:DWSU-ELEVATOR-05-04-005-ACT-CAR-INSP-OPR	2019.08.19 23:13:08	Normal	Lyon	DWSU ELEVATOR-05 (04-005) Activation of car inspection operation State No
571476603:SLSU-PA-RACK-NAC-2-FAULT	2019.08.19 23:12:52	Normal	St-Laurent	SLSU PA RACK NAC-2 FAULT State Normal
633340468:TRST-DR-02-100-IN	2019.08.19 22:56:24	Normal	Tremblay	TRST 02-100 Service DR Concourse IN DoorForcedOpenAlarm Normal
571477442:TUST-DIGITAL-SIGNAL-PROCESSOR-B-PA-FAULT	2019.08.19 22:39:49	Normal	Tunneys Pasture	TUST DIGITAL SIGNAL PROCESSOR B PA Fault State Normal
571477286:RISU-PA-RACK-NAC-3-FAULT	2019.08.19 22:33:47	Normal	Rideau	RISU PA Rack NAC- 3 Fault State Normal

This list generally shows the return to the normal state of the Priority alarms listed above. In many cases these alarms could be auto-acknowledged, or otherwise filtered or redirected.

5.5 Alarm Management Strategy

Based on the alarm management principles described in section [REF _Ref17232321 \r \h], a review of the current alarm configuration, and the SCADACOM functionality, the following recommendations are proposed:

5.5.1 Alarm Steering Committee:

It is recommended that an alarm steering committee is appointed for alarm management throughout the SCADA system lifecycle, including upgrades or replacements. The committee should include:

a) Representative(s) from the ERCs and the Control Room Superintendents;

b) TOCC Manager;

c) Rail Operations management;

d) RTM and other Maintenance Organizations as appropriate;

e) Chief Safety Officer or safety representative;

f) OT and IT (groups managing the systems and the networks);

g) A dedicated SCADA/alarm specialist.

The role of the alarm steering committee will be:

a) To continuously monitor and manage the alarms according to the lifecycle flow diagram in [REF _Ref17123711 \h * MERGEFORMAT], and [REF _Ref17122057 \h * MERGEFORMAT] also taken from the EEMUA guidelines.

b) To be involved in design reviews, and acceptance testing for the Line 1 and 2 extensions and upgrades.

c) To define, review and update KPIs as necessary.

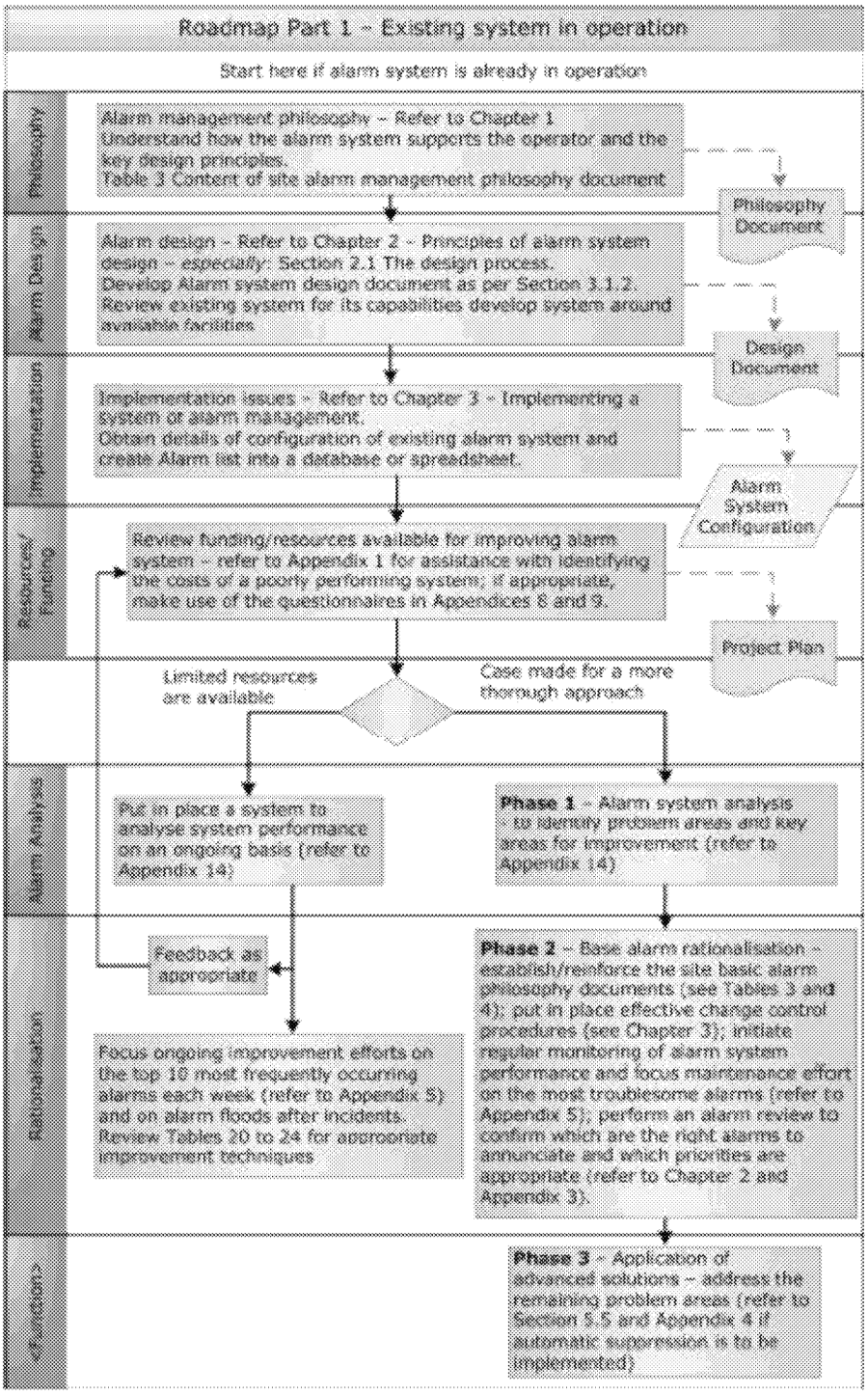

Figure [SEQ Figure * ARABIC]: Alarm Management Roadmap for an existing SCADA system

5.5.2 Alarm Design

The design of the alarm system for future phases of the O-Train and modification of the existing alarm system should include the following steps:

a) Risk assessment:

   This examines the risk to operations or safety of an equipment failure or other event. Even if there is no risk, an alarm may be required to initiate a maintenance response. If it is detectable by SCADA, then it should be added to the SCADA points list at the design stage or it may be added at any time through the life of the system as a field change.

   The risk assessment may involve the review of hazard analyses to determine the effect of faults or failures and the operational response required. E.g. a GIDS failure may require additional vigilance or the dispatch of staff to attend the subject platform.

b) Generation or update of alarm lists.

c) Structuring of alarms by the severity outlined above.

d) Adopt a user centred design for the GUI.

e) Design for operability – focused on the operations and/or maintenance response required.

It should be noted that adding an alarm point as a field change can be expensive, and therefore it is necessary to also follow configuration and change management practices, to make sure that the reasons for the change, and the change itself are properly documented, and that the cost impacts are also assessed.

5.5.3 Alarm Priorities

Alarms should be assigned one of four levels as follows:

- Priority 0 – this should continue to be reserved for safety, security or operationally critical alarms requiring an immediate operations or maintenance response.

- Priority 1 – High priority. These alarms should be routed as appropriate to the SCADA consoles in the TOCC and if it requires a maintenance response, to the Maintenance SCADA workstation in the YCC. For example, a GIDS intrusion event would not require a maintenance response, but certain failures of the TVS would require both an operations and maintenance response.

- Priority 2 – Medium priority. This is assigned to alarms requiring a response within operating hours. These generally do not require an operations response and for such alarms it is therefore not necessary that they be routed to or displayed at the TOCC SCADA console. These alarms should be routed to the Maintenance SCADA workstation in the YCC.

- Level 3 – Lowest priority. These are assigned to alarms requiring maintenance action during engineering hours. It is therefore not necessary for such alarms to be routed to or displayed at the TOCC SCADA console. These alarms should be routed to the Maintenance SCADA workstation in the YCC.

- Normal alarms. These alarms should be routed according to their causal alarm and in many cases could be auto-acknowledged.

5.5.4 Alarm Management

Alarms should be filtered at, or directed to each position within the TOCC, the BCC and the YCC to only show those alarms necessary for the functional responsibilities of each console position.

Alarm filtering or segregation should consider the following perspectives:

a) From the operations perspective, the alarms presented to the ERC should be limited to those necessary for the ERC to take the necessary action to ensure the safety of the system, the passengers or O&M staff, to maintain the present service levels, or implement the fallback or degraded modes of service.

b) While many alarms and events may not directly impact passenger service, they may be of interest to operations since they may provide indication of possible future service impacts.

c) From the maintenance perspective, the alarms presented at the YCC console should allow the YCC operator to respond to failures, faults or events in order to direct maintenance of recovery actions.

Various techniques described in the SCADACOM User Manual can be used to improve alarm management as follows.

5.5.4.1 Flood Management

At times the operator may be unable to manage the numbers of alarms occurring. This is termed flooding. Often a failure will result in several alarms, for example:

- A power failure may lead to a communication system failure which may lead to other failures;

- There may be a cascade of failures for everything that shares power or comms through a failed point.

Solutions include:

- Alarm groups may be defined to group alarms together;
- Auto-ack or auto-shelve of secondary alarms or auto-change AOR;
- Operator must ack primary alarm;
- Auto-ack secondary alarm (if not already auto-acked).

If a specific group of alarms is known to be problematic due to commissioning or other activities, then these can also be shelved temporarily until the problem is resolved when they can then be un-shelved.

5.5.4.2 Changing Areas of Responsibility

The AOR functionality may be used to create additional areas, with additional alarm panels to discriminate between alarms by function, subsystem or geographic area.

For example:

- The mainline SCADA Operator may not need to see the Yard TPSS status or alarms if it does not impact mainline operations.
- TPSS or station alarms may be segregated so that the Maintenance console only sees alarms of relevance for maintenance and the Mainline SCADA console only sees alarms of relevance to operations.

5.5.4.3Changing or adding levels of User

Additional levels of user can be added, e.g. to define both Mainline Operator and Yard Operator as users each with different areas of responsibility more appropriate to their roles.

5.5.5 Develop and Follow KPIs

The following [REF _Ref17127932 \h * MERGEFORMAT], based on the EEMUA guidelines includes several KPIs recommended as a starting point.

Table [SEQ Table * ARABIC]: Recommended KPIs

What to measure	Type of measurement	How
Performance during a major upset	Quantitive	Measure major System upset alarm rate per 10 min. period during upset
Performance during normal operation	Quantitive	Measure average alarm rate. Per X time period/number of 10 min. periods
Alarms which are occurring most often (and hence causing most problems)	Quantitive	Measure individual alarm frequency per X time period
The distribution of alarm priorities	Quantitive	Measure percentage priority distribution of all alarms on the system
Alarms which have been active on the system for a long period	Quantitive	Measure the number of alarms which have been active for X period
Number of alarms configured	Quantitive	Measure total number of alarms on the system
Operators general satisfaction with the system	Qualitive	Operator questionnaire
Operators view of how useful the individual alarms are and the quality of the alarms	Qualitive	Alarm usefulness questionnaire
Operator response time	Quantitive / Qualitive	Measure time
General performance during a service affecting failure	Qualitive	Recording and analysing alarm data when a service affecting failure has occured

The SCADACOM system provides an Alarm History Function described in the User Guide section 5.5. Several features are provided, enabled through tabs within the Alarm History Window. These provide useful tools to develop and track KPIs that correlate with the guidelines:

- Search Tab - Provides an interface to define the search criteria and to initiate a search.
- Results Tab - Provides a results grid to view the raw alarm records returned from a completed search.
- Severity Distribution Tab - Provides a way to view the alarm severity distribution of the alarm records in the results grid.
- Top 10 Bad Actors Tab - Provides a ranking of the alarm objects that are responsible for most of the alarm records in the results grid.

- Frequency Distribution Tab - Provides a histogram with time interval bins of the search time range for the results grid conditioned upon a particular alarm record property.
- Metrics Tab - Provides a view of various measurements and the status of each measurement for the current alarms records in the results grid.