A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT
USER REQUIREMENTS STATEMENT (URS)

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Alternative Train Control System (ATCS)

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1 INTRODUCTION

1.1 Purpose

This document defines the user requirements for the Alternative Train Control System (ATCS) that is suitable and appropriate for the Transnet Freight Rail (TFR) operational environment. The information stated in this document will be used as the basis for subsequent development or procurement activities, technical specifications, system design, sourcing, testing, evaluation and piloting.

1.2 Project Background

The current TFR train control and signalling system is considered a primitive system, and approaching obsolescence since it is currently unable to address the primary requirement of the end-users. The key performance indicators used to measure if the currently deployed system is adequate, include the reliability, availability, maintainability and safety factor. There are currently various train control systems available on the market to address some of the challenges heavy haul railways around the world are experiencing such as PTC, In-Cab signalling, ERTMS, CBA, ETCS etc.

The biggest challenge in the TFR environment is theft and vandalism of the infrastructure and the rolling stock. The lack of discipline and compliance to the SOP's by the Train Control Officers (TCO) and the train crew.

1.3 Business Objectives

The high-level business objectives of the project are to:

- Run trains in a safe manner and be compliant with the expectations of the Railway Safety Regulator (RSR)
- Improve the efficiency of our operations through the utilisation of appropriate technology and train control system
- Increase volumes and revenues through a train control system that caters for longer trains in the section or increase train capacity
- Reduce maintenance cost of the train control and signalling system
- Reduce derailments and collisions associated with the state of the train control system
- Reduce operational costs
- Reduce train delays
- Reduce incidents due to human errors.

1.4 Description of Proposed Train Control System

The proposed train control system shall make use of modern technologies to cater for TFR business needs and address the current challenges. The system shall be appropriate for the TFR environment, and cost-effective to implement for its lifecycle. The architecture of the system shall cover the CTC, train onboard technologies, trackside equipment and communication. It shall be a CBA system to minimize trackside equipment.

- The system shall be suitable for multiple-line utilisation.
- The system shall preferrable use a communication system that has minimal use of copper cabling.
- The proposed system shall be a vital SIL-rated system.
- The proposed system shall have redundancy.
- The proposed system shall have a fall-back method of operation should the primary system be non-functional.
- The system shall have vital automatic train protection with protection of trackside workers and on-track machines.
- The system shall have a seamless transfer of train movement from one CTC to the next as the train moves along the line.
- The system shall effectively operate with electronically controlled pneumatic (ECP) braking and radio-distributed power systems without any interference.

- The system shall be easy to install in the current TFR fleet of locomotives, including electrical and diesel locomotives.
- The proposed system shall prevent train collisions and over-speed-related derailments.
- The system shall protect against movement through switches/points left in the wrong position.
- The system shall enhance operation performance.
- The system shall increase the rail capacity, operational flexibility and improve safety.
- The system shall have the capability to be overlaid to both relay-based and electronic interlocking.
- The proposed system shall use an affordable communication network standard.
- The proposed system shall offer automated operation and easy maintenance.
- It shall be easy to expand and integrate the proposed system.
- The proposed system shall be scalable and adaptable.
- The system shall improve the diesel or energy consumption on the TFR locomotives.

1.5 Users and Other Stakeholders

The group of users identified to have to interact with the system are listed in the table below. The list is inclusive of both internal and external users. The identified group of users is not limited to the operational users, i.e., train drivers and TCO's but also includes the system maintainers and trainers.

Table 1: Train Control System Users/Stakeholders

Users/ Stakeholder	Job Description	Skill Level	Group
Train Drivers	• In charge of and responsible for the working of a locomotive or motor-powered vehicle • Safe Driving of trains • Observe and assess the locomotive for faults	Matric	Train Crew
Supervisor	• A section manager that can download any selected trip data on the ATP and manage the post-trip uploads. Manage the ITP loading on the dongles	National Diploma	CTC
Test Driver	• Test the technology, piloting and mapping the line.	Matric	Projects Crew
Train Control Officer	• Safe train authorisation • Management of certain line jurisdiction of the railway line	Matric	Operations CTC
CTC Coordinator	• Provides a real-time view of the TCO work desk and generates or views reports on stored data for planning and monitoring system status	Matric	Operations CTC
CTC Instructor	• Instructor provides simulation controls and real-time view of the TCO work desk with generating or viewing reports on stored data for training and evaluation	National Diploma	Operations CTC
CTC Technician	• The technician provides a real-time view of the TCO work desk by generating or viewing reports on stored data for planning, monitoring and fault-finding system status	National Diploma	Operations CTC
Signalling Maintenance Technicians	• Maintain the technology in their jurisdiction • Correct and fix faults in the technology • Provide administrative function over the technology relating	National Diploma/	Depot Rail Network

	to user admission/deletion		
School of Rail Trainers	• Provide training to train drivers • Provide training to train control officer (train the trainer)	Matric/ National Diploma	SoR
Transnet Engineering Artisan/ Technician	• Maintenance of Locomotive • Maintenance of auxiliary equipment inside the locomotive	National Diploma/	TE
Traffic Management System (TMS) personnel	• Ensure TMS communication with interfacing operational technologies • Ensure TMS technology availability • 3rd/4th level maintenance of TMS technologies	National Diploma	Technology Management
OCC	• Operations planning and oversight	National Diploma	TBD

1.6 Policies, Constraints and Identified Risks

1.6.1 Policy

The proposed ATCS shall comply with safety regulations and environmental protection laws. It shall also be compliant with all the RSR requirements and processes for getting it approved. The proposed ATCS shall comply with safety regulations and environmental protection laws. It shall also be compliant with all the RSR requirements and processes for getting it approved. The South African railway industry is regulated by the Rail Safety Regulator (RSR) based on the National Railway Safety Regulation Act No. 16 of 2002 as depicted in Figure 1. The proposed ATCS shall be compliant with all safety regulations as demanded by the RSR. The proposed ATCS shall be subject to approval from the RSR before operationalisation at any level. All environmental protection laws must be adhered to.

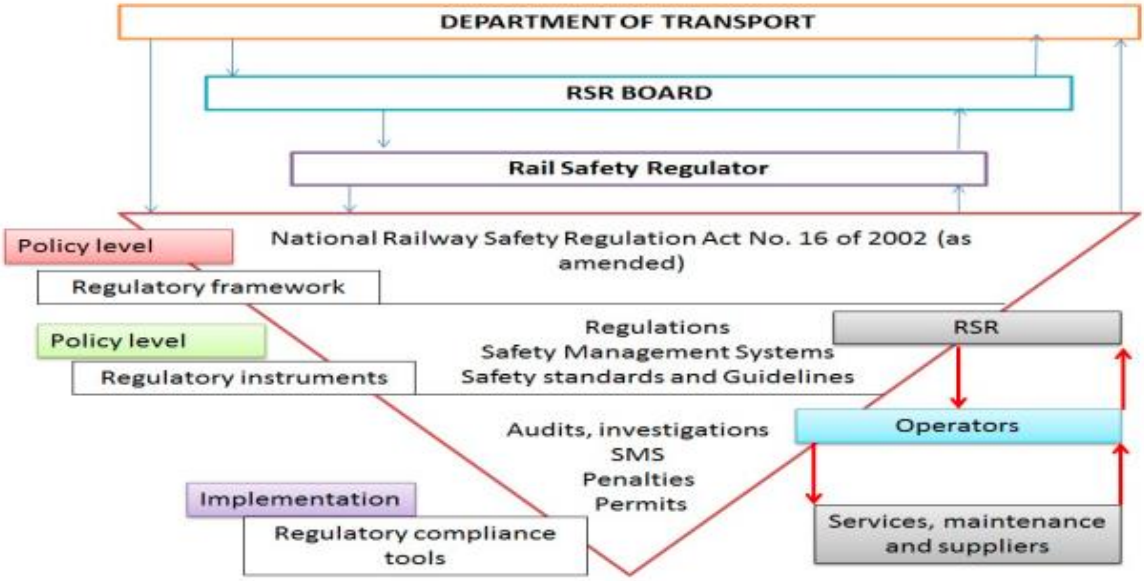

Figure 1: Regulatory role-players in the South African Railway Industry.

1.6.2 Constraints

a) The system shall comply with all the Railway Safety Regulator (RSR) regulations.

b) The system shall be able to interface with other railway operators both locally and internationally.
c) The number of personnel to operate the system shall not increase.
d) The system shall have the Safety Integrity Levels (SIL) that comply with the SIL4 requirements in accordance with CENELEC standards, EN 50126 (RAMS), EN 50128 and EN50129 derived from IEC 615508, where applicable.
e) The system shall interface with sub-systems of the currently existing system such as VDU/CS90, relay interlocking signalling and our rolling stock.
f) The Train Control and Signalling system shall interface with other Operators such as PRASA where we share the line. PRASA is currently rolling out the ETCS-L2 system on their network countrywide.
g) The system shall interface with the TFR radio communications network. The constraint is that the current GSM communications network is commercial.
h) TFR shares its railway network infrastructure with Private Operators, where slots are made available to them.

1.6.3 Identified Risks

The following risks may impact the operation or viability of the ATCS:

a) Interoperability Challenges: The chosen ATCS may not be compatible with PRASA's train control system, leading to interfacing issues between the two systems.
b) Market Acceptance and Viability: There is a risk that Private Operators may not prefer the proposed TFR ATCS solution or find it financially viable, posing adoption and financial risks.
c) Limited Deployment Scope: The procured system may need to be restricted to specific business units or corridors within TFR, potentially limiting its overall effectiveness.
d) Communication Network Constraints: The availability of a suitable communication network when deploying the ATCS to TFR could be a potential issue affecting system functionality.
e) Funding Challenges: The project may face funding difficulties due to the high anticipated budget and lifecycle costs associated with the system.
f) Project Delivery Delays: The execution and deployment of the project may take longer than planned, leading to potential delays and cost overruns.
g) Derailment Incident Reduction: There is a possibility that the investment made in deploying the ATCS may not result in a significant decline in derailment incidents, raising concerns about its safety impact.
h) Skilled Maintenance Personnel Shortage: After deployment, there might be a shortage of skilled maintenance personnel to ensure effective system operation and maintenance.
i) Interfacing with SADC Railways: The availability of the ATCS in regions where TFR interfaces with other Southern African Development Community (SADC) heavy-haul railways, such as Eswatini Railways, may present challenges or require additional planning.

2 PROPOSED SYSTEM OVERVIEW

The system block diagram in Figure 2 below depicts the major components and sub-systems of a train control system that ensures safe movements of trains. The four major functions of the proposed train control system are train protection, train operation, train supervision and communication. Wireless communication is used between the train, trackside equipment and the CTC.

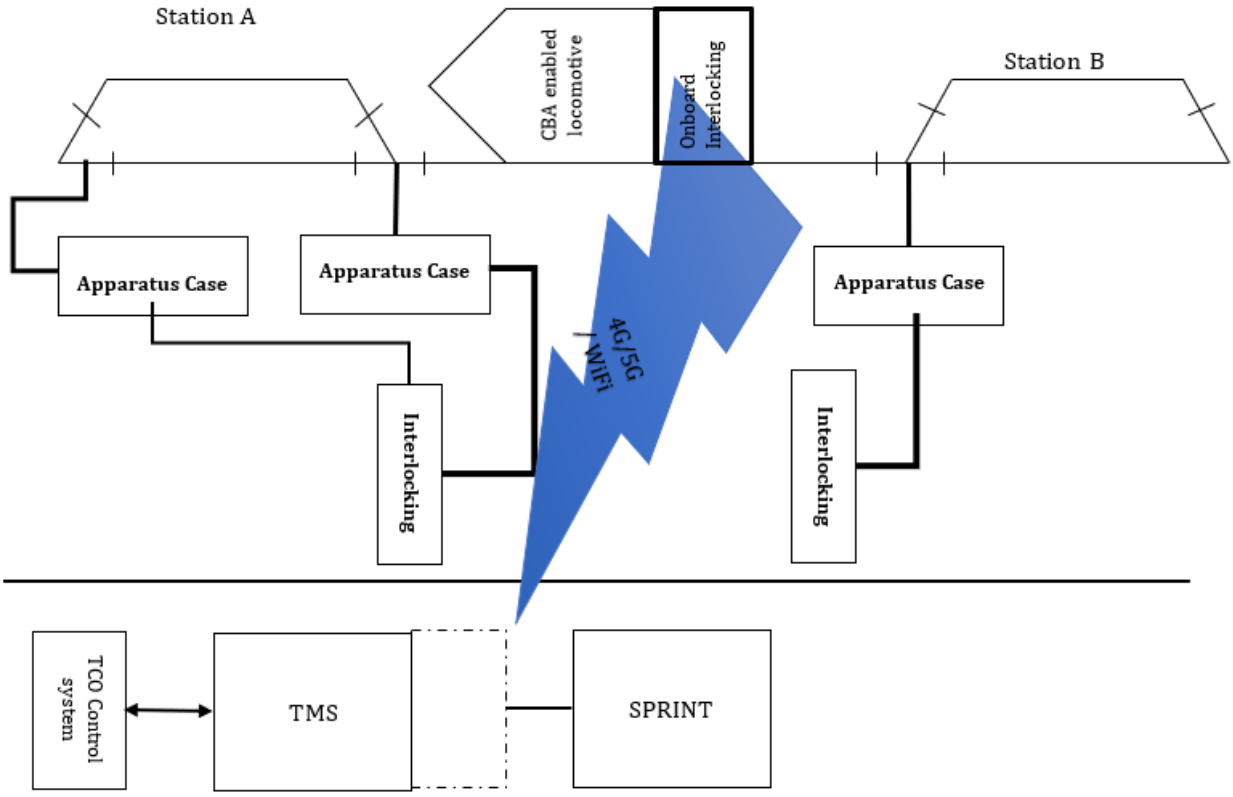

Figure 2: Major components and sub-systems of a train control system that ensures safe movements of trains.

3 PROBLEM STATEMENT

3.1 Security Challenges

The organisation has been suffering a lot of disturbance due to the dramatic increase in theft and vandalism incidents over the past couple of years. This is theft and vandalism of the infrastructure and rolling stock assets with all the current security interventions in place. The normal operations of the business are impacted and such rendering the currently deployed train control systems ineffective to mitigate the risk of theft and vandalism.

3.2 Power Challenges

The train control systems have intermittent power loss due to copper cable theft, persistent load-shedding and other reasons causing faulty indications on the TCO panel.

3.3 Crew and TCO Training and adherence to SOP's

The train handling of the train drivers is sub-optimal. There is manipulation of time booking. The crew rostering is out of synchronization with the scheduling. The train driver performance monitoring is not automated and is misaligned with the train driver/TCO allocation of minute delay causes.

3.4 Infrastructure and Rolling Stock Maintenance

The rolling stock on-board systems and infrastructure have not been maintained to standard due to the maintenance budget, availability of spare components, and maintenance personnel. The level of reliability, maintainability and availability of the system shall be aligned with the maintenance resources for the system to be sustainable over its lifecycle.

3.5 Telecommunication Infrastructure

The current radio network for communication has challenges with power connectivity. This impacts the issuing of train authorities where the radio with voice recording logger cannot be used. On the track warrant sections, the radio is the only technology available for issuing authorities and this system has no redundancy built-in to it.

The fallback method of operation when the radio network is not available is the use of a cellular phone which does not have the same level of safety integrity as the radio system.

3.6 Data Integrity

The requirement is to have slot utilisation information based on train position history and network occupation, with integrity to share with 3rd party operators.

3.7 Derailments and Collisions

There is an increase in derailment and train collision incidents. This is evident from the statistical data provided by the Corporate Safety Office (CSO). The biggest contributor of volumes, revenue loss and the overall poor performance of the business can be associated with derailments. The root causes of these derailments vary but the non-operational signalling and train control systems are one of those. The ETMA's, SPAD's and runaway trains account for the majority of derailments that we are experiencing. The problem is amplified by the manual authorisation due to the unavailability of the signalling system for train authorisation and the use of the fallback method of operation.

3.8 Enforcement of SOP's

The enforcement of the SOP's has been a challenge and the manual capturing of data and the human intervention in the system introduces the human error factor. The SOP's are well defined perhaps in some areas may need to be revised and training conducted but compliance shall be enforced to close the gaps.

4 USER REQUIREMENTS

4.1 The capability to track the train position within the Colour Light sections where the conventional track vacancy detection is unavailable.

a) A requirement is proving the train position tracking as part of the Train Authorisation System to be redundant with the traditional signalling system track vacancy detection technologies such as the track circuits and axle counters.
b) It is currently not possible to accurately locate the train route within a station.
c) The track circuit vacancy detection technology is currently vulnerable to theft as it contains a high content of copper.

4.2 Central Control Centre (CTC)

a) The train control system shall manage train movements according to the train plan. The control system shall be integrated or interfaced with the train schedule i.e., Integrated Train Plan (ITP).
b) The train control system shall manage infrastructure maintenance on and next to the line. The system shall manage both planned occupations and unplanned occupations. The system shall generate reports on asset failures and inefficiencies.
c) The train control system shall make provision for different types of operational desks as required for specific users in the train control environment as follows:
    - Train Control Officer Desk
    - Coordinator Desk
    - Viewer Desk
    - Instructor Desk
    - Technician Desk
d) The train control system shall enforce user access control to the work desk. It shall allow for sign-in with credentials verification and linked to the TFR system sign-in credentials.
e) The train control system shall have the capability to uniquely identify trains and maintenance vehicles. The system shall utilize the unique 16-digit train number.
f) The train control system shall have the capability to manage train crew information. The system shall provide a train information register that includes train, driver, radio and handling information.
g) The train control system shall display a graphical layout of the station in the controlled territory. The station with all the related signalling objects on the graphical station layout is a static layout with object status according to predetermined display colours on the specific objects. The control territory shall be displayed on an overview window with an enlargement of each station in a detail window.
h) The train control system shall manage train incidents within the control territory. The system shall detect when a train passes a signal at danger (SPAD). The system shall automatically detect when a driver reports the train position within the authority limits (ETMA). The train control system shall automatically detect over-speed in Colour Light Signalling and Dark Territory.
i) The train control system shall manage the points automation system. The system shall be interfaced with the yard automation system.
j) The train control system shall allow for the management of train compilation within the control territory. The system shall provide the facility to couple two trains and set train numbers as defined by the user.
k) The train control system shall keep records of all the events on the system. The event logging system shall include status changes of signalling equipment, operator commands, and alarm indications are all to be time stamped and recorded in non-volatile memory, a disk drive or a Cloud facility, to allow for fault and traffic event analyses.
l) The control system shall report the train movements to Condition Assessment Systems (CAS). It shall report the train number when a train moves past a rolling stock condition measuring site.
m) The control system shall report the train movements to Vehicle Tracking System (VTS). It shall report the train number when a train moves past a vehicle tracking measuring site.
n) The train controller shall manage conflicting operation protection. It shall provide conflict authority protection by preventing conflicting authorities. It shall provide an alert of authority abnormal conditions.
o) The control system shall manage Level Crossing regulations. It shall be an interface to the level crossing and display flashing lights/robots with or without booms for the level crossing.
p) The train control system shall manage the emergency traction power switch-off. It shall provide for the emergency traction power shutdown. It shall control and monitor the emergency electrical shutdown.
q) The control system shall provide for a system recovery after failure. It shall restore previous authorities, pending ETMA's, pending over-speed alarms and unclosed reminders.
r) The control system shall manage fringe station information transfer. It shall provide the control TCO a display of the line to the fringe including the route and overlap to the next signal.
s) The control system shall provide a playback system event function. Playback previous log events and display them on the station layouts to represent the status of the system at any given time.

t) The control system shall make provision for a supervisory system monitoring function. The system shall be accessible simultaneously by multiple users, producing real-time status updates on the graphical station layouts, on-demand tables, maps, and charts based on historical data.
u) The train control system shall manage user training. It shall provide a train simulator, driver simulator, Train Protection System simulator and signalling systems simulator capabilities.

4.3 On-board Automatic Train Protection (ATP)

a) The Automatic Train Protection (ATP) systems shall provide the Train Driver with a graphical view of the track profile ahead.
b) The ATP system shall monitor the actual speed of the train using GPS and display this in real-time to the Train Driver in the leading locomotive cab. The system shall provide an audible and visual means to alarm the Driver when the train is outside of the safe speed envelope and transmits an over-speed transgression to the Train Control Officer (TCO) under higher-level incidents.
c) The ATP shall bring the train to a controlled stop in a safe manner when the transgressing Train Driver has not brought the train's speed under control in a predefined period, or where the train's speed has been allowed to increase beyond a predefined set limit.
d) The ATP system shall send the physical location, speed and identification of the leading locomotive of the train to the CTC and display this graphically at the control centre.
e) The ATP system shall provide a post-train trip report consisting at least of the train's actual position, the train's speed, the brake pipe pressure, the locomotive notch setting, the dynamic braking and overall fuel consumption.
f) The ATP systems shall provide a facility for the downloading of post-train trip events from the onboard equipment to the USB memory stick (otherwise referred to as a pen drive) and passing this data on to a "central" server or cloud facility.
g) The ATP system shall make provision for speed control in yards.
h) The ATP system shall allow for a shunting movement and still offer train protection.
i) The ATP system shall make provision for a Temporary Speed Restriction (TSR) where the condition of the track is poor, or personnel is doing maintenance on the track in the section.
j) The on-board system shall have the ability to provide a simulator mode for both training and laboratory testing of the system. This functionality shall mimic the on-board system functionality with scenarios and simulation of locomotive peripheral interfaces (e.g. uDAQ etc.)

4.4 OCC and RTC&C Requirements

a) Fully-Fledged Traffic Management System
b) The integration of the current business, the end-user must be specific on the current business systems they are referring to, systems to the Train Authorisation System (TAS, CS90 / VDU).
c) The train authority system must be automated and integrated to other business systems to allow for a resuced number of authorities that the TCO has to execute, this shall improve efficiency and reduce the TCO's workload.

4.5 Signalling and Interlocking

a) The ATCS shall have minimal trackside equipment and physical copper cabling.
b) The ATCS shall not utilise physical crank handles.
c) The ATCS shall have an effective lightning protection system.

5 NON-FUNCTIONAL REQUIREMENTS

5.1 Train Registration Systems shall report similar information (such as ID, Location and Time) for the same train events.

a) The systems and applications used for capturing the train information such as SPRINT, IATMS and CS90 VDU are not reporting singularly on the same events.

5.2 The voice communication system and devices shall allow for caller ID and position information.

a) The voice communication open and closed channel does not provide caller identification, or position information, as a result, a manual process to validate authenticity between caller and receiver is required.
b) Migrating voice communication to a digital platform that will enable caller ID, caller location/train may be a solution.

5.3 There is limited data available at the CTC level and the process of extracting the data from operators is manual which opens it to contamination.

a) The data flow shall be integrated between the business systems and Train Authorisation Systems to allow for the TCO to access the information such as vehicle list, Train Crew Time and Occupation Notices.
b) This information shall be accessible to the TCO via the VDU.

5.4 A Train Control System that has a simulation function that shall be used for training of TCO's is required.

a) The CS90 VDU train control system has a simulator function that is used for training the TCO's. The system does not have the capability to produce assessment reports and a record of the training events.
b) The assessment reports shall have also the scoring to evaluate the candidate's performance.

5.5 The environmental condition assessment systems shall be integrated into the Train Control system to allow for the TCO to run safe trains.

a) The environmental condition assessment systems and the track condition monitoring system are not integrated into a Train Control system HMI for the TCO to safely authorise and operate trains.
b) The weather conditions have a great impact on train operation and may result in Temporary Speed Restrictions (TSR's) and even cancellation of trains.
c) The condition of the track is also critical to the operations of the train and may as a result require the application of TSR's.

5.6 A workforce productivity tool for the TCO's is required integrated into the Train Control system.

A.1. Acronyms and Abbreviations

ATCS	Alternative Train Control System
ATP	Automatic Train Protection
CS90	Control System of the year 1990
CTC	Central Train Control centre
CAS	Condition Assessment System
CSO	Corporate Safety Office department
CBA	Communication-Based Authorisation
CBTC	Communication-Based Train Control system
ETMA	Exceed Train Movement Authority
ETCS	European Train Control System
GPS	Global Positioning System
GSM	Global System for Mobile communication
ICASA	Independent Communications Authority of South Africa
ITP	Integrated Train Plan
ISD	Integrated System Display
LAN	Local Area Network
MAS	Maximum Allowable Speed
OBC	On Board Computer is an inclusive term for both the LOBC and the SOBC
OEM	Original Equipment Manufacturer
OCC	Operational Control Centre
PTC	Positive Train Control
PRASA	Passenger Rail Agency of South Africa
RSR	Railway Safety Regulator
SOBC	Screenless OBC is an OBC unit without an integrated screen and keypad, compatible with the IOOS environment
SPRINT	Operations Business Tool for capturing train information
SPAD	Signal Passed At Danger
SOP	Standard Operating Procedure
SoR	School of Rail department
SoE	School of Engineering department
TCO	Train Control Officer
TFR	Transnet Freight Rail
TE	Transnet Engineering
TSR	Temporary Speed Restriction
uDAQ	Universal Data Acquisition Unit
USB	Universal Serial Bus
VDU	Visual Display Unit
VTS	Vehicle Tracking System