UNDERGROUND

Deep Tube Programme

DEEP TUBE RAILWAY - GENERIC OPERATIONS AND MAINTENANCE CONCEPT - 2020

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This document reflects ongoing work and discussions within LUL on options for future operation of the London Underground Deep Tube lines. It is not intended to reflect or represent any formal TfL/LUL views or policy. Its subject matter may relate to matters which would be subject to consultation. Its contents are confidential and should not be disclosed to any unauthorised persons.

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REVISION HISTORY

Issue	Date	Revision Overview
A	4th July 2011	Draft of summary sections for review
B	22nd August 2011	Draft Report for review by Development (Specialist) Group
1	30th August 2011	Draft report for consultative review and discussion; including minor modification for quality and to reflect Issue B review comments
1.1	1st September 2011	Draft report for consultative review and discussion and reflecting additional comments
1.2	30th September 2011	Published report reflecting responses to consultative review comments.

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1 Introduction

1.1 Introduction

This document provides a conceptual description of the future the operations and maintenance of the London Underground Deep Tube lines. At version 1, this document continues to reflect an emerging and idealised Concept that will be developed and refined to provide a full generic description of the upgraded Deep Tube Railway (DTR).

The Operations and Maintenance Concept development work stream is part of the Foundation Stage of the Deep Tube Programme and is executed in compliance with the following statements:-

Operations and Maintenance Concept Vision:

“To produce an operating concept for a world class railway founded on unattended train operation”

Operations and Maintenance Concept Strategy:

“To meet the future needs of the business and our customers by delivering a safe, efficient and flexible operating concept which, making the most of available technologies, allows for the highest and most effective levels of automation to be introduced and maintained”

1.2 The Deep Tube Railway

The Deep Tube comprises the following sections of the London Underground network:

- Bakerloo Line
- Central Line
- Victoria Line
- Jubilee Line
- Northern Line
- Piccadilly Line
- Waterloo and City Line

1.3 The Deep Tube Programme

Following the acquisition of Metronet and Tube Lines by London Underground, there is a need to determine how the remaining JNP and BCV upgrades will be executed. In the context of changing economic and environmental conditions there is also a need to apply radical thinking to:

- The nature of the railway that London Underground wishes to create;
- The manner in which services will be delivered;
- The management and maintenance of Deep Tube assets
- The approach that will be undertaken to delivering upgrades both to individual lines and to the Deep Tube as a whole.

The Deep Tube Programme will create a comprehensive upgrade specification that with minimum modification provides the basis for successive line upgrades. Initial focus will be on the:

- Bakerloo Line
- Piccadilly Line

- Waterloo and City Line
- Central Line

In the longer term the DTP may also contribute to the upgrade to the Northern Line.

Note: An upgrade of the Northern Line signalling system is planned and about to commence. If a decision is taken to extend the Northern Line to Battersea then a more extensive upgrade of the Line will be brought forward and will be based on the Deep Tube Concept.

In creating a common template for upgrades, the DTP positions London Underground as both Operator of the Deep Tube and as the Integrator at railway level. The key components of the solution offered by the DTP include:

- The EVO train; a lightweight and energy efficient semi articulated train with a through corridor.
- A comprehensive CBTC based control system
- Integrated Operations and Maintenance Control
- Improved control of the Platform Train Interface (PTI)
- A comprehensive range of applications and high performance telecommunications network.

The Programme will deliver improved journey times and reduce crowding on Deep Tube service patterns. Revenues will be increased through a combination of greater train capacity and more frequent services. Whole life costs will be reduced by designing in reliability and by reducing the requirement for maintenance without compromising asset performance.

1.4 Deep Line Railway Background

The development of London's Deep Tube Railway commenced during the final decade of 19th Century. Lines were extended throughout the 20th Century culminating with the completion of the Victoria Line in 1971, the Jubilee Line Extension in 1999 and Piccadilly Line – the opening of the Terminal 5 Station - in March 2008.

The age and condition of Deep Tube assets varies between the individual Lines. A summary of the status of each line appears in appendix the status of each Deep Tube line.

1.5 Scope and Objectives

This generic Operational and Maintenance Concept describes the future operation of the Deep Tube Railway and covers:

- The Delivery of Planned Passenger services in normal, abnormal conditions;
- The management of the railway under degraded and emergency conditions;
- The operation of stations and of station platforms;
- The operation of Depots;
- The control and maintenance of the assets required to the planned service;
- Management of the Passenger Service Plan;
- The Operation of Trains;
- The Interface with other lines and other transport providers.

The Concept is intended to:

- Encourage cross functional consensus on the scope and nature of future Deep Tube operation;
- Provide a basis for the elicitation of requirements that will support:
  - The specification, acquisition and commissioning of the assets to be progressively deployed on the upgraded Deep Tube lines.
  - The Development of a Railway Control Organization that will deliver the planned service supported by the Upgraded Deep Tube assets.

This is a generic Operations and Maintenance Concept. The principles, assumptions and processes that it contains together with the assets that it describes and which will be made available over time, will be rolled out in the Deep Tube as each line is upgraded. This document will be augmented with Line-specific variations to the generic template. Variation that are applied to specific lines will be minimised and applied only when needed to accommodate physical line characteristics, service level aspirations and cost limitations. In this way it will be possible to ensure that proposed concepts are practical, take advantage of economies of scale and maximise benefits to London Underground.

1.6 Position of this Concept in the Upgrade Process

This Operations and Maintenance Concept provides:

- Key information for the development of:
  - Generic Requirements Specification for the Deep Tube Railway;
  - Generic design of the Deep Tube railway at sub-system level;
  - The development Line Specific Operations and Maintenance Concepts;
- Contextual information for the eventual supplier(s) of the equipment and systems that are acquired in future upgrades of the Deep Tube Lines;
- A key input to the production of the Deep Tube Human Factors (HF) Integration plan and subsequent HF work packages.

The position of the Operations and Maintenance Concept – Generic Deep Tube within the development hierarchy is illustrated in the following diagram. This version of the document will be developed and refined over time and issued in compliance with the agreed DTP document management process in order that all stakeholders remain informed of operational aspiration and intent and are able to contribute to the development process.

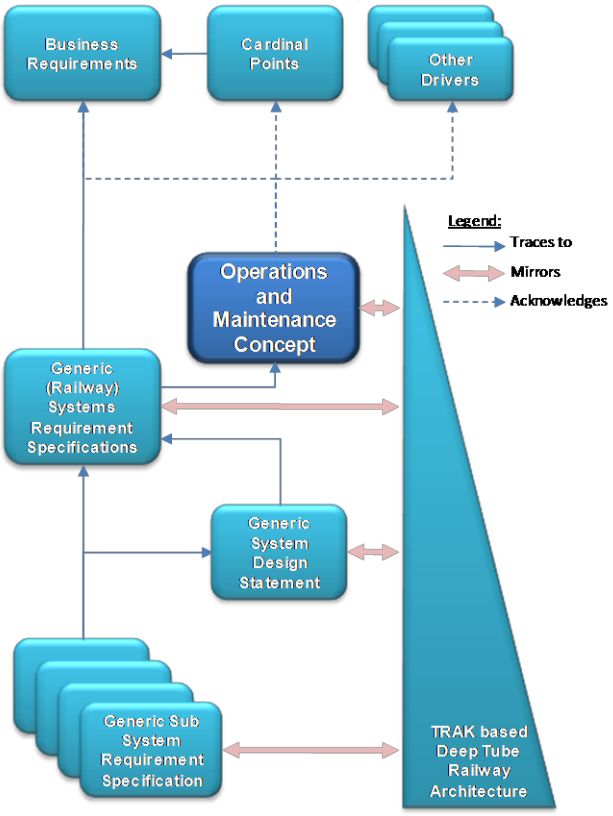

Figure 1-1 – DTP Document Structure

1.7 Operations and Maintenance Concept Development Process

The Development of this Operations and Maintenance Concept has been and will continue to be conducted as a consultative process, led by a Core Group and supported by a group of Specialist advisers who represent a broad range of disciplines and functional areas.

Lists of the contributors in both Core and Specialist Groups appear in the Appendices A and B to this report.

The following schematic indicates the logic of the development process:

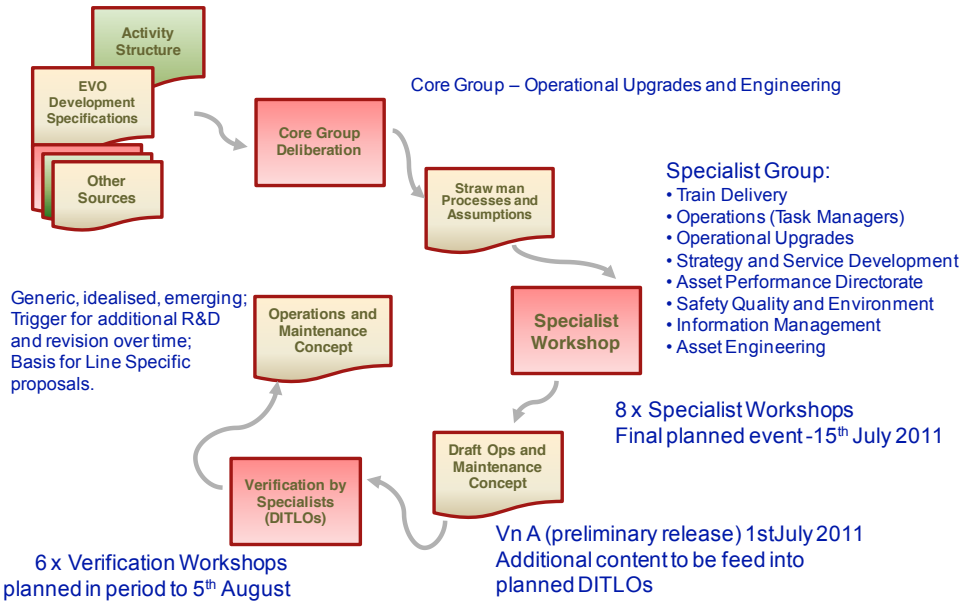

Figure 1-2 – Operations and Maintenance Concept Development Process

All workshops have been convened with stated objectives and methodologies, and with pre-prepared "straw man" materials.

1.8 Style

This document describes a 2020 Vision for the Deep Tube. For this reason it is written in the present tense to place the reader at a point in time when it is possible to observe the assets and operational characteristics of the Deep Tube Railway on completion of the upgrade.

Where something is referred to in the past tense, the reader should construe that the narrative refers to the railway before the upgrade commenced.

2 Document Administration

2.1 Document Management

This Operations and Maintenance Concept will be updated and re-released on an as needs basis. All releases will be constructed, reviewed and published in compliance with both the agreed DTP Document and Change Management Processes.

2.2 List of Abbreviations

Table 2-1 – Abbreviations	
Abbreviations	**Definition**
RCS	Railway Control System
RCO	Railway Control Organization
CIS	Customer Information System
DTR	Deep Tube Railway (Bakerloo, Central, Piccadilly, Jubilee, Northern and W&C lines)
DTP	Deep Tube Programme (Upgrade of Bakerloo, Piccadilly and W&C lines)

2.3 Glossary

Table 2-2 – Glossary	
Term	**Definition**
Light Move	The movement of a passenger train that is out-of-service and which is not carrying passengers.

3 Executive Summary

Building on from the progress of delivering the upgrades to the Victoria, Jubilee and Sub Surface lines, focus moves to the next group of lines to be upgraded. These upgrades are planned to exploit technological advances which were not taken advantage of or were not proven when the original PPP upgrades were designed, and which are now commonplace on other metros around the world. These advances will drive London Underground towards being World Class and bring with them significant opportunities for efficiency.

The *Deep Tube Operations and Maintenance Concept* describes an idealised state for generic service provision across the railway from 2020 onwards. Inclusion of these new characteristics, some of them significantly different to current practices, does not necessarily direct the company to go to those lengths but gives opportunities by describing potential organisational changes and new technologies to develop more efficient working practices, using automation where appropriate, to maximise the benefit realised from our assets and deliver the best possible service to our customers.

There is one key aspect of the document which is over-arching and defined the philosophy to its production – our customers expect a service from a single railway and don't see, nor particularly care about our internal organisational structures. To ensure optimal service provision, getting our people, processes and assets aligned to that common position is critical. As such and by its very title, the merging of Operations (COO) and Maintenance (APD) activities reflects that the two are actually not distinct and need to be interwoven internally just as our customers and stakeholders already perceive them to be.

At a high level, the *Operations and Maintenance Concept* repaints the organisational and technological environment, creating a new Railway Control Organisation which isn't constrained by geographical, organisational or asset boundaries. The introduction of the Railway Control System brings together a number of current disparate functions from across the business in to a single system which, when interfaced with the Railway Control Organisation, provides safe, consistent, reliable and efficient services to our customers as well as significantly improving service recovery times and system availability.

Furthermore, the adoption in this concept of the three new modes of operation – Unattended, Remote and Direct – which can be applied to any asset area and function, provide both depth and breadth to the way the railway is operated, allowing the business to flexibly exploit technologies in line with demand and expectations as and when appropriate to the circumstances. Additionally, initiating with the idealised state of greater Unattended or Remote operations across all asset areas and the railway, gives rise to increased flexibility with staff deployments. By moving to this state it capitalises on the company's ability for our staff to further develop their skills and opportunities whilst efficiently addressing the wider whole-life cost.

Improvements in the asset strategy will see a natural realignment of maintenance activities (planning and asset incident response) in to the traditional operating environment creating an integrated railway level system with common values and goals. This includes best practices being introduced, sustained and exceeded across the railway, reducing time to maintain / repair assets, transparently recovering the service in an acceptable timeframe, being environmentally conscious with the type and quantity of physical components employed and therefore being more cost-effective overall. The introduction of automated maintenance for key activities will ensure a level of

sustainable efficiency and minimising the number of labour intensive tasks, reducing potential for staff error and injury.

This document is only the beginning and refinements should be expected as the Deep Tube Programme Foundation Phase progresses. Further assessment of the potential benefits of the concepts will continue and updates will be made by including any changes, albeit small, to reflect line specific opportunities or constraints on the lines on which it is to be introduced.

In summary, this *Deep Tube Operations and Maintenance Concept* provides a fundamental change in the organisation, processes, procedures, methodologies and assets delivering the service forming new stable foundations on which London Underground can build. Using technology and our people together, a reliable World Class railway that combines future continuous improvement will deliver a legacy our customers and staff can be proud of.

4 Vision for the LU and the Deep Tube

4.1 The Vision for London Underground

"To be a World Class Tube for a World Class City"

The (TfL) strategy for achieving this vision is to combine a reliable train service with the high standards of customer care that are part of London Underground's heritage.

The Mayor's Transport Strategy includes the following policy:

"The Underground's chronic problems of unreliability and overcrowding should be addressed urgently so that the eservice provided to passengers is consistently reliable, comfortable, easy to use, safe and secure. The capacity of the Underground must be increased by bringing the system to a good state of repair and in the longer term through the extension of the network."

In response, London Underground's Strategy states:

"To deliver a reliable train service with high standards of customer care, efficiently, through our people and technology."

"Our strategy recognises that we are part of TfL, a city wide transport authority: we are a project delivery company, we are an asset management company, we are an operating company; but actually what transcends all of this is that we are a customer service organisation, with all that we do focused ultimately on service for the passenger.

The strategy for the Underground can, like our vision, can be broken down into four aspects, each described with specific attributes:

- Customer: the Tube service is reliable, quick and seamless. Not only is the service safe, but customers feel safe, secure and cared for while using the service. The Tube is easy to use, clean and welcoming.
- Delivery: whether of service, projects, maintenance or support activities shares a common intent. Delivery is responsive and systematic; goals are achieved to time, budget, scope and target. We strive to get the most from assets and technology, and all the while we are learning from and becoming comparable with, the best delivery organisation in any sphere.
- People: the people who deliver the service, whether direct employees on the Underground or in any supporting or contracted function, share a passion for the Tube, working flexibly as one team.
- Value: in delivering our service and programmes we are efficient, delivering financially and environmentally sustainable and affordable solutions, resulting ultimately in being trusted to deliver as a good steward of public funds.

This Operations and Maintenance Concept seeks to support the delivery of the Mayor's Strategy and deliver a World Class Railway founded on unattended train operation and the benefits that attend full automation of service delivery. It describes a railway that will meet the future needs of

London Underground and its Customers by defining a safe, efficient, flexible and reliable service delivery capability.

4.2 Deep Tube Programme Goals and Key Strategies

The following schematic has been provided by the Sponsor and reflects the Business Objectives for the Deep Tube:

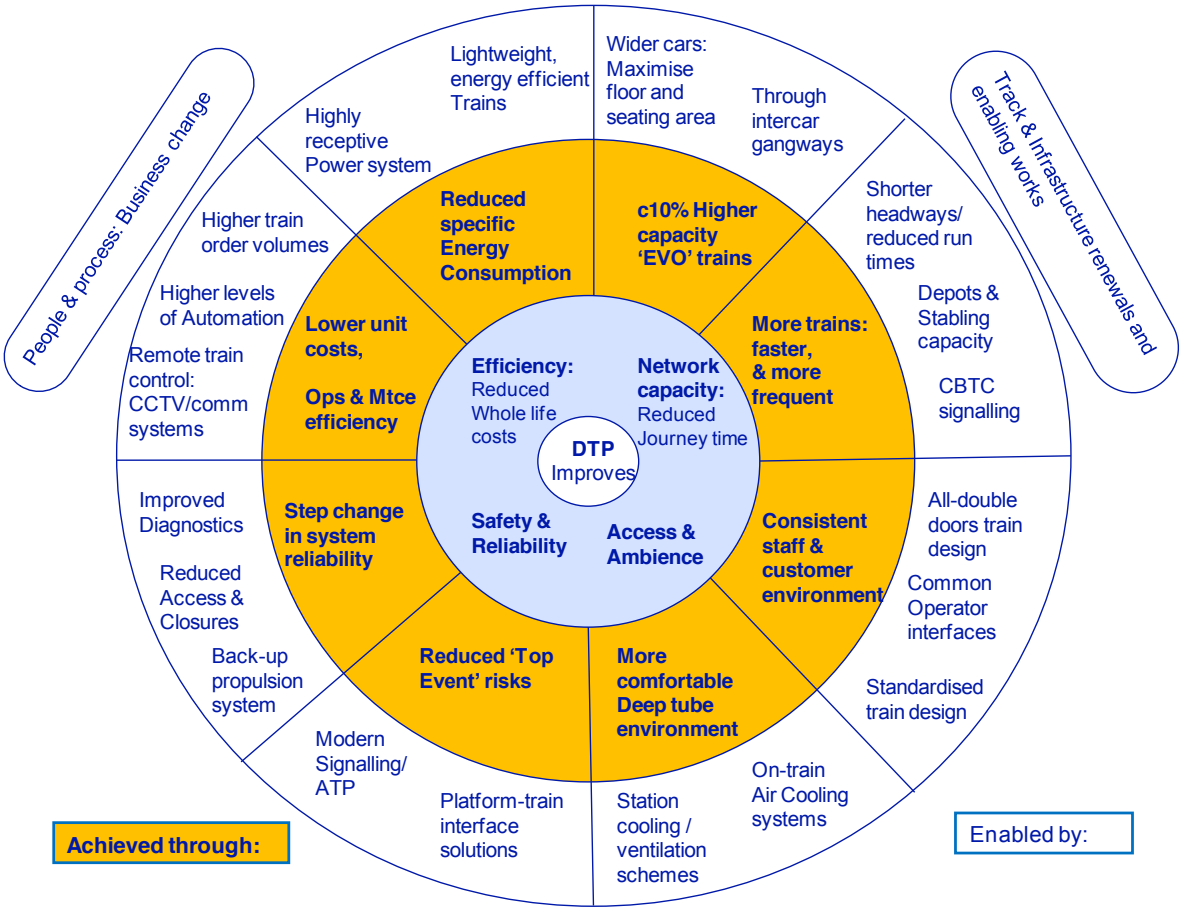

Figure 4-1 – Deep Tube Business Objectives

Note: It is anticipated that this schematic will be revised and up-issued by the sponsor. If this information is critical then the reader should enquire about the availability of a more recent version.

5 Future Deep Tube – Assumptions and Asset Characteristics

5.1 Core Railway Assumptions

This Operations and Maintenance Concept reflects a number of assumptions that are central to the vision described in section 4 of this report. These assumptions are regarded as immutable and influence all of the subsequent and subordinate propositions contained in the document:

Table 5-1 – Core Railway Level Assumptions		
Identity	**Assumptions**	**Comment**
5.1.1	Passenger Services are provided by a fleet of EVO Trains.	The specification of the Deep Tube passenger train will be derived from this Operations and Maintenance Concept and by the subsequent design of the future DTR in generic and line specific forms.
5.1.2	The Train Sets that provide passenger service are capable of operating in unattended mode	

The Concept also reflects characteristics of the future DTR at railway level, about railway assets and about the Railway Control Organisation. These characteristics appear in the following tables and are justified in that they:

- Support or are the 'natural' consequence of Core Railway Assumptions;
- Appear as virtuous features of other Metro systems with which London Underground has had contact;
- Have been identified by the Operations and Maintenance Concept development community as a source of business and operational advantage.

5.2 Railway Level Characteristics

Table 5-2 – Railway Characteristics		
Identity	**Characteristic**	**Comment**
5.2.1	The Deep Tube Railway (DTR) will deliver services to a Service Plan based on headways and branch occupancy and no longer tied to a timetable or duty schedules	The Service Plan reflects: • The frequency of trains through the 'central section' of each line • The rate of ramping up and ramping down in peak off peak and low traffic volume periods • The minimum frequency and pattern of services to branch destinations • Last service and last connection times

Table 5-2 – Railway Characteristics		
Identity	**Characteristic**	**Comment**
5.2.2	The DTR Infrastructure supports Bi-directional train operations.	
5.2.3	Delivery of the DTR Service is the Responsibility of the Railway Control Organization (RCO)	RCO Comprises Central and distributed capabilities. Central capabilities include • Service Delivery • Asset Control • Resource Control • Power Control Distributed capabilities include: • Station Operations (Mobile and assigned staff) • Train Operations (Mobile) • Incident Response (Mobile) • Asset Response (Mobile)
5.2.4	The Railway will have the capability to operate 24/7	
5.2.5	The Deep Tube will be operated as a “railway” and not be divided on the basis of existing asset and management areas.	Subject to further asessment; see section 7.21
5.2.6	Detrainment shall not be to track unless an immediate threat to life (e.g. fire, flood, tunnel collapse) or the Train is physically disconnected from the rest of the railway (e.g. derailment, track severed).	The avoidance of detraining onto the track reduces the risk to passengers and creates the potential for faster recovery from severe disrup tion.

5.3 Train Characteristics

Table 5-3 – Train Characteristics		
Identity	**Characteristic**	**Comment**
5.3.1	The train is capable of operating entirely under the control of the RCS without manual intervention	High performance and resilient comms are present to support interaction between the Train and the vital function of the RCS

Table 5-3 – Train Characteristics		
Identity	**Characteristic**	**Comment**
5.3.2	The Train is capable of operating entirely under the control of the RCS without manual intervention.	Train Operating Mode 1: Unattended This is the normal operating mode of the Train and is the foundation for normal DTR service delivery.
5.3.3	The Train is capable of being driven by a remote operator.	Train Operating Mode 2: Remote In this mode the Train is operated with manual intervention. The intervention is made by an Operator who does not need physical contact with or presence onboard the Train Set. The intervention is made via an interface that is either in a fixed location or which is in the possession of an authorised and competent mobile operator.
5.3.4	The Train is capable of being driven manually by an attending Operator.	Train Operating Mode 3:Direct In this mode the Train is operated by an authorised and competent attendant using the physical controls that are available on board the Train Set.
5.3.5	The Train is not equipped with a cab.	Cab space forms part of the car interior for passenger accommodation but can be used for Direct control.
5.3.6	The Train continually monitors and reports its status and its health in order that the RCS can initiate an appropriate where an abnormal condition is detected	Train borne systems monitor the health of the Train Set and of all train sub systems. On board batteries provide sufficient power to allow this activity to operate continuously including during periods when the Train is shutdown or in standby mode. During these periods the Train continues to make this information available to the RCS in order that its availability is recognised and that appropriate action can be taken by the RCS and or the RCO if availability is subject to change.

Table 5-3 – Train Characteristics		
Identity	**Characteristic**	**Comment**
5.3.7	The Train is equipped with intruder detection.	Intruder detection is effective throughout the interior space of the train and is activated automatically when the Train is stabled or being moved as empty stock. In order to undertake essential work, authorised personnel are able to deactivate intruder detection to access a train while in these modes.
5.3.8	The Train has been designed such that no attended intervention is required when a Train Set is changed from standby to Operational mode.	There is no requirement for technical or operational pre use checks.
5.3.9	The Train is capable of bi-directional operation.	
5.3.10	The Train is fitted with track monitoring equipment.	A number of trains in the Deep Tube Passenger Fleet are equipped to perform routine checks on: • Track geometry • Rail faults (ultrasound). • Track faults (front and underframe mounted cameras) Results are made available to the RCS for analysis and to trigger closer inspection where required. All infrastructure data is associated with accurate positioning references. Note: The proportion of the fleet that are fitted has yet to be determined.
5.3.11	Train Sets is capable of executing remote coupling.	Remote coupling supports: • The recovery failed Train Sets • Passenger detrainment. Note: the need detrainment onto the track is removed except in exceptional emergency conditions.
5.3.12	A Train Set is able to push another Train Set to which it is coupled.	Brake system failure modes and other conditions permitting.

Table 5-3 – Train Characteristics		
Identity	**Characteristic**	**Comment**
5.3.13	Multiple Train Sets can be coupled and moved as a single unit	
5.3.14	The Train has an on board power supply that allows individual Train Sets to move to a station or siding when this cannot be achieved with normal Traction Current	This “Get-Me-Home” facility can be used regardless of the status and availability of Deep Tube Traction Power.
5.3.15	Detection equipment is fitted to both ends of each train set and is capable of detecting obstacles that block or are likely to impede the movement of the Train.	Detectors identify the presence of any object in the front of the Train when travelling in either direction.
5.3.16	When the Train is stationary on the operational railway, in automatic operating mode but has lost all contact with RCS for more than a specified time then it will “creep” forward to the next station platform as long as the movement is safe.	The move would be unsafe if the Train presence detectors identified any obstacle within a specified distance in the front of the Train operating in this mode. The train not initiate a “creep” movement if: • A “Code Red” was received prior to loosing communication with the RCS. •
5.3.17	The Train is capable of auto coupling and is equipped with the means by which customers can move safely between trains when detrainment is required.	Auto coupling facilitates removal of one train by an assisting train. It also supports the detraining of customers to another train and thereafter to a station platform, avoiding the need to evacuate passengers onto the track except in extreme circumstances.
5.3.18	The Train allows detraining to take place from one Train Set onto another coupled Train Set.	
5.3.19	Each carriage unit within every Train Set is equipped for load weighing. Passenger Loading data is continually available to the RCS.	

Table 5-3 – Train Characteristics		
Identity	**Characteristic**	**Comment**
5.3.20	The train allows visual and audible information to be broadcast to all passengers	The train systems support the visual and audible provision of: Routine Service information Disruption information Passenger instructions (emergency instructions) Passenger reassurance including delay explanations and situation reports. Note: This information will also be available to Passengers via their own communication devices.
5.3.21	The Train allows Passengers to contact and interact with a Help facility that is able to answer general enquiries.	Contact is made with the LU Customer Information Centre. See section 7.22
5.3.22	The Train allows passengers to activate an emergency alarm	Contact is made with an Event Controller
5.3.23	The Train maintains a comfortable passenger environment.	This includes temperature, humidity and air quality.

5.4 Railway Control System Characteristics

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.1	The RCS receives and stores the detail of the Deep Tube Service that is to be delivered at any time.	Passenger Service Plan See section

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.2	The RCS automatically adjusts the Service Plan to meet the demand for service at any given time.	See also section 6.2.1 The RCS monitors demand in near real time. It also captures and assesses demand over longer periods. These capabilities support the automatic amendment of the Service Plan to react to short term demand, and to what appears to be measurable changes in demand in longer timeframes. Demand is determined by examination of a number of sources(see section 7. including: • Train Loading; • Platform Loading; • Station Loading; • Gate Line Data; • Changes of Train and platform loading during train stops. • Dwell times
5.4.3	The RCS allows the DTR Service Plan to be amended by authorised personnel within the RCO	
5.4.4	Whenever railway is available the RCS interprets the Service Plan and delivers the DTR Passenger Service without intervention from RCO personnel.	
5.4.5	The RCS controls all train movements on the Passenger Railway and in all Depots and Stabling Locations.	Train movements includes: Start to stop movement of the train between any two points; Train operations during station stops (note that train despatch is fully automated and does not require manual intervention). Stabling locations include sidings and the stabling roads that are located within Depots.
5.4.6	The RCS protects all train moving on, into and out of Depot Maintenance Roads.	

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.7	The RCS system is able to execute and control bi-directional train movements on the DTR	
5.4.8	The RCS is capable of detecting and controlling the movement of engineering vehicles and of Alien Trains on the DTR	Engineering and Alien Trains will be capable of communicating with the RCS. New trains will be fitted and will be fully interactive with the RCS and will be capable of being driven remotely by the RCS. Where vehicles do not have the capability to communicate with the RCS then the movement of those trains will be protected by the RCS and moderated through direct communication between the vehicle operator and the RCO
5.4.9	The RCS automatically notifies an Event Controller when the condition of a Deep Tube Passenger Train or the condition of any Deep Tube Passenger Train sub system detects a fault or detects a condition that falls outside of specified parameters.	The class of notification will be determined by the significance of the fault or condition. The RCS assigns a classification to train faults that are detected.
5.4.10	The RCS maintains a full history of asset condition and maintenance data for a range of Deep Tube assets.	Assets include but are not limited to: • The Train • Track including points • Track Side Equipment • Station Equipment • Railway Control System Note: The full range of assets for which data will be captured and maitained has yet to be determined.

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.11	When the condition of a Deep Tube Passenger Train Set in passenger service requires that the Train Set is removed from service then the System is capable of executing all of tasks necessary to affect the removal and to route the Train Set to an appropriate location.	Tasks include: • Passenger announcement • Notification to appropriate LU personnel • Passenger detrainment • Routing train 'out of service' • Re-establishing the planned service • Delivering planned services to branch destinations • Moving additional Trains Set(s) into service (where available and appropriate)
5.4.12	The RCS maintains a profile of constraints on the availability of each Deep Tube Passenger Train Set	Constraint is a function of: • Train and Sub System Condition; • Planned Service Appointments; • Depot Loading; • Location; • Current assignment; • Prioritised Maintenance requirements for Train Fleet; • Infrastructure conditions that constrain the movement of Deep Tube Passenger Trains.
5.4.13	The RCS generates an alarm when the condition of any monitored railway asset is determined to be worthy of notification.	In this context railway assets include but are not limited to • Track; • Track Side Equipment; • Station Equipment; • Railway Control Systems. Note: The alarm architecture is designed to ensure that alarms are subject to appropriate consolidation i.e. if the Traction Power System fails then there will be "a single rather than multiple alarms)
5.4.14	The RCS maintains record of usage, performance and maintenance for each monitored railway asset.	

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.15	The RCS maintains a profile of the current and planned non availability of railway assets.	
5.4.16	The RCS generates an alarm when the condition of any monitored asset changes such that it affects or has the potential to affect service delivery	
5.4.17	The RCS continually monitors and reports the performance of Deep Tube service delivery	
5.4.18	The RCS continually models the operation of the Deep Tube and predicts where current events are likely to cause perturbation and or a fall in performance over time.	
5.4.19	When the RCS predicts perturbation or a fall in service performance it identifies the most effective recovery strategy and presents it to an Event Controller who is able to confirm or reject it. If confirmed then the RCS automatically implements the proposed strategy.	
5.4.20	The RCS continually generates a forward model of the use and performance of selected assets.	The RCS uses performance data to predict the need for maintenance and or the potential failure of a monitored asset.
5.4.21	The RCS captures and analyses passenger activity.	CCTV images are captured in all Train Sets, stations and in selected other locations. Intelligent systems identify irregular movement and high occupancy levels on trains and in stations.
5.4.22	The RCS raises an alarm when it construes specific behaviours by customers present in stations or trains.	

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.23	The RCS captures and analyses human presence in selected non passenger location.	Human presence and movement is captured and assessed in Depots and stabling areas. Intruder detection is available in Depots, Sidings and in other selected locations within and on the boundary of the Deep Tube.
5.4.24	The RCS monitors loading densities on trains, determines where conditions are crowded and alerts the RCO. Platform information informs customers when arriving trains are crowded.	In the central area a customer information facility can be deployed to advise customers where to stand on the platform for the least crowded carriages.
5.4.25	The RCS monitors current and potential loading densities in stations. Where loadings are assessed to be unacceptable against specified criteria then the RCO is notified in order that action can be taken to direct traffic flow and prevent further access to the station.	
5.4.26	When required, appropriate, clear and timely customer information is broadcast to passengers on board trains, at stations and in selected additional locations within the LU estate.	Compliant with the requirements of law and LU strategy where this exceeds statutory obligation. Passenger information is consistent in form an content throughout the Deep Tube network
5.4.27	The RCS continually generates routine customer information. When the RCS detects an event for which non routine customer information is required it automatically generates and delivers appropriate information.	
5.4.28	The RCS supports the discharge of Current from Traction Power Sections	An authorised user is able to trip Traction Current through the RCS interface. It may also be tripped through devices located on platform headwalls, in station control rooms, in Depots and at track side locations.

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.29	The RCS provides positive verification of the status of Traction Power across the Deep Tube network.	This removes the former practice of contacting the Network Power Control Centre to verify power status.
5.4.30	The RCS supports the controlled introduction of Traction Current.	This generally follows a process that turns on power in Traction Current Sections in a planned sequence.
5.4.31	The RCS supports the tripping of traction current by the RCO and by competent personnel in other areas.	
5.4.32	An auditable log is maintained of all operational events, alarms and human interventions that are processed by the RCS.	Logged information is retained and can be retrieved for investigation, business improvement and training purposes.
5.4.33	The RCS maintains a schedule of all planned maintenance.	The plan includes: • Management of the capacity of maintenance roads • Management of the maintenance work bank • Management of depot personnel and available skills • The availability of spares • The availability of plant • The availability of mobile Maintenance Personnel
5.4.34	The RCS automatically schedules the maintenance of assets at the appropriate time or when their condition or usage dictates the need.	
5.4.35	The RCS prioritises maintenance activity where there is conflict.	Prioritisation is based on rules that are maintained within the system. Where resolution falls outside of the scope of the maintained rules then the conflict will be referred to the Maintenance Planning Controller
5.4.36	The RCS supports intervention to amend maintenance activity that is scheduled by the system	

Table 5-4 – Railway Control System Characteristics		
Identity	**Characteristic**	**Comment**
5.4.37	The RCS can be instructed to prevent trains from incorrectly entering a section in which traction power is switched off.	Trains may be prevented from entering sections that are without power but it is possible to operate trains using battery power in these areas.
5.4.38	The RCS continual maintains a record of the location of all Event Controllers.	Locations of Event Controllers are tracked whether working in central, mobile or local modes. The maintenance of location data supports the selection of the most appropriate Event Controller when the RCS raises, assigns and directs event alarms.

5.5 Communication System Characteristics

Table 5-5 – Communications		
Identity	**Characteristic**	**Comment**
5.5.1	The Communications System will support voice, video and data transmission.	
5.5.2	The Communications System will connect with external communications services in order that data can be transmitted into and out of the Deep Tube communication environment without constraint.	
5.5.3	The Deep Tube communications environment shall be seamless in that no organisational or geographical distinction or segregation will be made in design or in implemented.	
5.5.4	Access to the Communications System and to the functionality that it provides will be role driven.	The RCS and the Communications System serves it will recognise individual users, their competence, location at any time, mode of working (central, mobile, local) and the limits of their authority within Deep Tube Operations.
5.5.5	The RCS will also be capable of prioritising communications activity across the system to ensure that no critical message or information is delayed due to high levels of communications traffic.	Critical refers to both to safety critical and to operationally critical messages and information.

Table 5-5 – Communications		
Identity	**Characteristic**	**Comment**
5.5.6	The communications system will ensure that all devices which comprise the RCS will be continually monitored, controlled and administered by the RCS.	The RCS with be constantly updated with: Location, user identity, mode of work and status. The system will also be able to detect third part devices where appropriate.
5.5.7	The communications system will ensure that each class of device which is used within the Deep Tube and to interface with the RCS complies with a single standard.	There will be only one device in each class (i.e. mobile, local workstation central workstation.) All will be capable of receiving and sending data, video and voice; and have a uniform interface (both physical and software driven). All will be capable of being updated in real time with authorised software or any core operating information.
5.5.8	The Communications System will be capable of logging a record of all data transactions for recovery, for replay and for investigation.	It will be possible for an authorised user to replayed events in real time. This will include all voice, data, video and location information held in the system.
5.5.9	The Communication System will support change and ongoing development of the RCS.	This will allow data, data presentation and data volumes to vary over time.
5.5.10	The Communications System will support the continual modification of information that is broadcast by the RCS to meet the operational needs of the railway	The system will be capable of doing this at different locations including trains, stations, station etc).

5.6 Station (including platform) Characteristics

Table 5-6 – Station Characteristics		
Identity	**Characteristic**	**Comment**

Table 5-6 – Station Characteristics		
Identity	**Characteristic**	**Comment**
5.6.1	Stations are comprehensively monitored by CCTV surveillance equipment	A high proportion of each station (inside and outside of the gate line) can be monitored by CCTV. Images that are captured are subject to "intelligent" analysis to identify: • Abnormal passenger behaviour • Crowding • Suspicious objects • Abnormal conditions in the station environment including the need cleaning.
5.6.2	Stations are equipped with travel pass vending equipment.	Travel Passes may be purchased with cash or with credit/debit cards.
5.6.3	Stations are equipped with gate lines that accept all forms of travel authorisation.	Travel may be authorised by: • Prepaid ticket or equivalent • Presentation of an Oyster card with a sufficient balance • Presentation of a debit/credit card where the holder has registered as a "wave and pay" user
5.6.4	Outside of the gate line, stations are equipped with help points that provide customers with additional opportunities to make enquiries about fares, the acquisition of travel passes and more general questions about using the Underground system.	Help points connect customers with an LU operative. In addition or as an alternative interactive help points allow customers to make enquiries and to receive information through a machine interface.
5.6.5	Inside the gate line, stations are equipped with help points that provide customers with additional opportunities to make enquiries about services and to pose more general questions about the use of the Underground system.	

Table 5-6 – Station Characteristics		
Identity	**Characteristic**	**Comment**
5.6.6	Passenger Emergency Alarms allow customers to report events or conditions that are the cause for concern.	A single action raises an alarm with an Event Controller and allows a dialogue to commence between the help point and the Event Controllers communication device. When an emergency alarm is deployed the Event controller is able to view a CCTV image of the PEA location.
5.6.7	All external station doors are alarmed and can be secured	
5.6.8	All office and equipment room doors are alarmed and can be secured	
5.6.9	CCTV images of all secured doors can be viewed by the RCO.	
5.6.10	Secured areas within a station are fitted with intruder detection equipment.	
5.6.11	The public areas within a station are fitted with intruder detection equipment that can be activated to provide notification of inappropriate intrusion or any intrusion.	Intruder detection is able to distinguish between authorised and un authorised access.
5.6.12	Station Platforms allow visual and audible information to be provided to customers.	In Line with LU Guidance. Information is also made available to customer via their personal communication devices.
5.6.13	Assumption removed (protection measures at the platform edge)	See Section 7 Future Enhancement
5.6.14	Stations are constructed such that LU can demonstrate compliance with Rail Vehicle Access Regulations unless appropriate derogation has been obtained.	In an increasing number of locations LU provides step free or assisted access from station entrance to the platform and from platform to the Train enabling Underground journeys to be made by mobility impaired customers.

Table 5-6 – Station Characteristics		
Identity	**Characteristic**	**Comment**
5.6.15	Traction Current to be turned off by authorised personnel from both office and platform locations.	This is in addition to the ability of Mobile Event Controllers to turn traction power off for specified sections through their interface with the RCS
5.6.16	Station escalators can be operated using the controls that are integral to the equipment or remotely through the RCS.	Escalators can be started stopped and their speed varied. They can be set to stop automatically in quiet periods and restart on the approach of a passenger. Audible and visible information is given prior to and during the application of any change. Lifts are equipped with Help Points that
5.6.17	Station lifts can be operated using the controls that are integral to the equipment or remotely through the RCS.	Lifts can be brought into and taken out of service at any floor. Audible and visible information is given prior to and during the application of any change.
5.6.18	Station Lifts are equipped with Help Points that allow Customers to communication with the RCO.	
5.6.19	Station lighting is self cleaning	
5.6.20	Station lighting may be turned on and off and its brightness adjusted with manual or with remote intervention.	
5.6.21	The brightness of section twelve station lighting is adjusted automatically to provide consistent illumination in all conditions	

5.7 Track and Track Side Equipment Characteristics

Table 5-7 – Track Side Equipment		
Identity	**Characteristic**	**Comment**

Table 5-7 – Track Side Equipment		
Identity	**Characteristic**	**Comment**
5.7.1	The Tunnel Telephone System is no longer present in the DTR	The discharge of Traction Current by 'shorting' tunnel wires is redundant because it is normal to operate trains in unattended mode. Station platforms are still equipped with devices that turn off traction power when deployed in the adjacent traction power circuit(s) when deployed.
5.7.2	Surveillance equipment detects obstacles on the track and at station platforms that are located on open track sections.	
5.7.3	Surveillance equipment detects any obstacles between stations within a tunnel section.	
5.7.4	Surveilance equipment detects any intrusion or obstacles on the track at platforms that are in tunnel sections.	
5.7.5	A broad range of track side equipment is self monitoring. Where this is the case the asset communicates its status to the RCS. The information provided varies between assets but generally includes an indication of status and can provide:- usage, performance and condition.	By design, there is the minimum critical provision of trackside equipment throughout the DTR.

5.8 Maintenance Depot Characteristics

Table 5-8 – Maintenance Depot		
Identity	**Characteristic**	**Comment**
5.8.1	Train movements in Maintenance Depots are controlled by the RCS	There is no separate Depot control system. All outstations and specific locations in the depot such as the main yard will also be controlled by RCS but can be overridden to enable shunting activities in depots.

Table 5-8 – Maintenance Depot		
Identity	**Characteristic**	**Comment**
5.8.2	Each depot has roads that are constructed and equipped to deliver specific maintenance tasks	Equipment includes: • Synchronised lifting cranes • Bogie drop facility • Under floor wheel lathe • Cleaning facilities (including train wash plant) • Replenishment of adverse weather consumables • Battery handling • Equipment for automated delivery of maintenance tasks. Example: brake pad replacements
5.8.3	Selected depots will comprise roads for stabling.	
5.8.4	Each Depot will have a reception road or roads to hold trains that are to be moved into a maintenance road.	
5.8.5	At least one reception road will be capable of holding a train comprising two sets to accommodate the situation where a failed Train Set has been recovered by the process of being coupled to and pushed by a following Train Set.	
5.8.6	Each Depot will provide access for road-rail vehicles that need gain access to the Deep Tube track.	
5.8.7	Each depot will provide HGV access to and from the public highway.	
5.8.8	Each depot will provide access for Emergency Services.	

Table 5-8 – Maintenance Depot		
Identity	**Characteristic**	**Comment**
5.8.9	Each depot will provide accommodation for spares and materials.	Storage will be provided for all classes of spares and materials including hazardous materials. Storage will be secure and include: • Appropriate environmental protection arrangements; • Facilities for material handling, • Waste disposal
5.8.10	Depots will provide accommodation in which engineering activities can be undertaken of plant and equipment.	The accommodation will provide adequate space for all classes of engineering activity and will include the provision of clean rooms.
5.8.11	Each depot will include accommodation for personnel and accommodation in which administration and support activity can be undertaken.	
5.8.12	Selected Depots will provide a test track on which trains can be tested and train equipment calibrated.	

5.9 Stabling Road Characteristics

Table 5-9 – Stabling Roads		
Identity	**Characteristic**	**Comment**
5.9.1	The Deep Tube will have sufficient stabling capacity to accommodate all passenger trains and engineering vehicles off the passenger railway.	
5.9.2	Stabling roads are controlled by the RCS	At outstations and primarily specific locations in the depot such as the main yard will also be controlled by RCS but can be overridden to enable shunting activities in depots.
5.9.3	Stabling Roads are secure and monitored by CCTV and intruder detection equipment.	

Table 5-9 – Stabling Roads		
Identity	**Characteristic**	**Comment**
5.9.4	There shall be provision for access to trains when stabled in sidings and depot locations.	Train movements in sidings are controlled by the RCS and routine pedesstrian access in stabling locations is not the norm. See section 7.23
5.9.5	Each depot has the capacity to accommodate additional rolling stock that needs to be stabled from time to time i.e. rail grinders, battery loco's etc.	
5.9.6	Removed – duplicate of 5.8.4	
5.9.7	Trains will be able to stable at platforms (terminii) for ease of ramping up the service.	

5.10 Power Distribution System Characteristics

Table 5-10 – Power Distribution System		
Identity	**Characteristic**	**Comment**
5.10.1	The power system supports the positive verification of Traction Power status in all sections of the DTR.	
5.10.2	Section switches provide protection for personnel that need to access the track.	Protection is provided for personnel that need to access the track at stations or that need more extensive access for maitenance.

6 Future Deep Tube Activity

6.1 Background

6.1.1 The 24-Hour Cycle

The Upgraded DTR is capable of running unattended passenger services during 24 hours of each day. Within the daily cycle there is recognition of:

- Peak periods with high traffic volumes
- Off peak periods during which fewer trains are generally required and during which some sets are stabled or made available for maintenance.
- A period of low traffic demand during which there is a minimal number of Train Sets in service.

Note: In exceptional circumstances and in most sections of the network, services during the low traffic demand period can be delivered with bi directional movements on a single track. This capability is used principally to accommodate maintenance activity when possession of a single track can be granted without having to shut a complete line.

6.1.2 The Railway Control Organisation

The Railway Control Organisation (RCO) includes all of the strategic and tactical resources required to operate the Deep Tube and to deliver Deep Tube Passenger services. It should be noted that the RCO is a collection of people and processes and not to be associated with a specific geographic location or locations. In operating the Deep Tube Railway, RCO resources work both centrally and in dispersed locations. The Scope of RCO is represented in the following schematic:

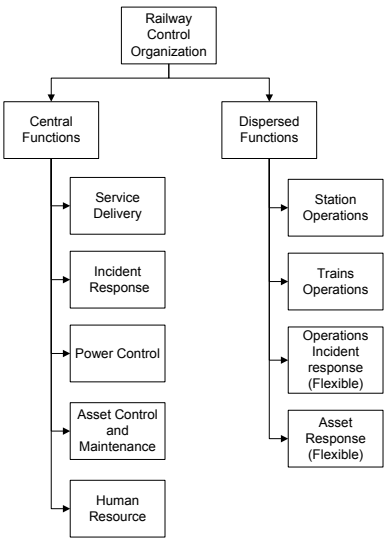

Figure 6-1 – Railway Control Functional Structure

In normal mode, the operation of any specific Deep Tube line is self- controlling and self-regulating.

The Railway Control System (RCS) continually monitors the performance of service delivery, the health of trains and other assets, and applies any corrective actions that are necessary. The former and strict adherence to assigned Areas of Control as the focus for both control and recovery is no longer a necessity. It is used when appropriate and is supported by the Railway Control System (RCS). Following the upgrade there are no train operators or duty schedules and no traditional timetable. Service reformations are no longer necessary and there are no crewing issues to resolve.

The RCO is formed with the following roles:

- Event Controller;
- Asset Planning Controller;
- Railway Manager;
- Mobile Asset Recovery Agent.

6.1.2.1 Event Controller

In addition to monitoring and being aware of the general condition of the railway and of service delivery, the primary responsibility of the Event Controller is to respond to the alarms and alerts that are generated by the RCS and which indicate that action is or may be required.

At any time Event Controllers are deployed in one of three modes:

Central

In this mode the Event Controller takes a broad view of geographic areas, specific locations or specific railway functions. For example, an individual may be responsible for all track defects or traction current events. Alternatively, individual responsibility may be for all events at a particular location or on a defined section of the railway.

Local

A range of railway control activities are discharged at specific Deep Tube locations. Most common is the assignment of an Event Controller to “Station Management”. In this case the Event Controller will be located at a specific station. Assignment also places individuals in Depots and in other locations that require the attendance of an agent who can materially affect the operation of the railway at a specific place. Although based locally, individuals are equipped to deliver the range of RCO activities.

Mobile

Railway control activity may be required at any location across the Deep Tube Railway but the frequency of events and resulting level of activity does not justify the assignment of resource to a specific location. For this reason a portion of the total complement of Event Controllers are equipped and assigned to work as mobile agents. In this mode individual agents are able to undertake the full range of control activities and respond to incidents anywhere across the Deep Tube although for practical reasons, the area covered by an individual can be limited to a define area.

In this mode Event Controllers remain equipped and able to undertake tasks that may be more intuitively associate with central or local working. The RCS is capable of sending

alerts and alarms for a broad range of events to individuals working in mobile mode and in this way the mobile Event Controller can supplement the local Station Management and more general service control activities.

Individual Event Controllers are competent to discharge the full range of operational (delivery, and recovery) tasks. In order to develop and retain skills, Event Controllers are organised to operate in each mode for defined periods on a cyclical basis.

The RCS recognises the current mode in which each Event Controller is deployed and assigns alarms and alerts in every case to the most suitable Event Controller. In this context the RCS processes current mode, location, skill set and existing workload.

While the normal operation of the railway and railway assets is automated (Mode 1); Event controllers are equipped to interact with and to operate assets by remote control (Mode 2). This can be achieved whether an Event Controller is centrally or locally located, or operating in mobile mode.

Event Controllers are competent to operate railway assets using the physical controls of the asset (Mode 3). This includes station equipment, track assets and the Train.

Event Controllers are universally capable of accepting, responding to and resolving operational events that occur.

6.1.2.2 Asset Planning Controller

The Asset Planning Controller (function) is:

- The keeper of the Maintenance Plan for all classes of Deep Tube asset;
- Responsible for assigning priorities when there are conflicting requirements for maintenance capacity;
- The single source of truth on the availability of Deep Tube assets
- Responsible for monitoring the performance and condition of Deep Tube Assets
- The RCO link to the Maintenance Organisation including maintenance contractors
- Balancing the integrity of Deep Tube assets with the operational demand for assets in service.

The asset Planning Controller function is located centrally.

6.1.2.3 Mobile Asset Recovery

Mobile Asset Recovery (MAR) agents provide first line response when the condition or performance of any Deep Tube asset indicates that attention is required. Like mobile Event Controllers. MARs are equipped and organised such that they are able to respond in any location across the Deep Tube railway but their role is to focus on the diagnosis of asset faults the provision of first line asset recovery and the initiation of additional technical support when faults cannot be resolved with the first response.

6.1.2.4 Railway Manager

The Railway Manager function is centrally located and responsible for:

- Deploying the RCO and ensuring that it is operating in a cohesive, effective and efficient manner
- Resolving service delivery conflicts that are not resolved by Event Controllers
- Ensuring that the planed Deep Tube service is delivered to the highest level at all times.

In the case of assets, the “Mobile Asset Recovery” role provides technical support across the

railway.

Figure 6-2 – Railway Control Organisation

6.1.2.5 Interaction between the RCS and the RCO

While in normal, unattended, operations the system controls the railway and delivers the planned service. When the system detects an event that requires human intervention then an alarm is generated and directed to an Event Controller.

For each event the RCS determines the RCO agent who is best able to accept and make a response. To make this determination the RCS considers skill set, work mode (central, local, mobile), location and current workload. The RCS manages the workload for each RCO Agent (MAR or Event Controller). The workload for each Agent takes the form of a task stack. The arrival of an incremental event to the task stack is received as an alert or as an alarm to which the Agent must respond.

Example:

When “sensitive-edge” activation occurs on a specific train door the RCS takes action to prove that the doors are closed and unobstructed. The RCS sends an alert to an Event Controller; for a door event this is usually the most local agent.

If the RCS determines that the door obstruction is false then the Train is dispatched automatically. If the obstruction cannot be proved false then an alarm is generated to the same agent. On receipt of this alarm the agent is required to acknowledge the event and take the appropriate action.

Having acknowledged the alarm the agent is able to obtain additional information about the reporting door including station and platform location, Train Set, and specific train door.

Where an event is covered by a CCTV camera then the agent may request an image of the site to assist with a remote assessment.

For some events example: poor performance: The RCS will provide information to support decision making by describing the courses of action that may be taken and indicating where possible the impact of each.

Rules are specified and maintained within the RCS to define the level to which each agent's task-stack can be loaded. When acceptable workloads are exceeded and when there is an insufficient response to an alarm then the RCS escalates the event and the alarm is passed to the Railway Manager function

6.1.2.6 Amalgamation of Line Specific Railway Control Organisations

Responsibility for the control and management of Operations and Asset Maintenance is being transferred into the single Deep Tube RCO as each line is upgraded.

6.1.3 The Passenger service Plan

DTR Passenger Services are described in a Service Plan that differs from the traditional timetable and specifies:

- Patterns for ramping up and ramping down the number of trains in service;
- The target trains per hour (headway) in the central sections of each Service Pattern;
- The minimum frequency and pattern of services at each branch destination;
- The times of the last services to destination that will not be served during the period of low traffic demand;
- The times of train services which provide "last connections" with other services.

The service plan (or plans) describes the services operated to meet all anticipated patterns of demand. Typically, this includes the services delivered from Monday to Thursday inclusive, on Fridays, Saturdays and on Sundays. However, the absolute flexibility of the upgraded railway has provided the capability to Additional plans or plan variations are made available to provide services for public holidays, special events and for planned changes to the capacity or capability of the railway.

The Railway Control System supports the receipt and storage of the Service Plan which is deployed continuously and automatically as the basis for all service delivery.

The Service Plan describes the target and minimum service to be delivered by the DTR. The actual service varies throughout the day in response to passenger demand (See section 6.2.5; Respond to Falling or Poor Performance) and the impact of perturbation caused by the failure of the railway, by passenger activity or by factors.

In this context the Service Plan can be regarded as being in any one of three states at any given time:

The Published Plan: The description of the planned (normal) Deep Tube Service. This reflects the volume and pattern of service declared to the customer and to other stakeholders.

The Active Plan: The Plan that is selected as the basis for automatic service delivery on any given day. This is generally the Published Plan but may be a variation generated by the Railway Control Organisation to accommodate any changes in the capability of the railway which has not caused the release of a new or special Published Plan.

The Current Plan: The form in which the Active Plan is changed during the day and on which the RCS bases delivery at any time.

The RCS allows the RSO to synthesise the operation of the Deep Tube Passenger Service Plan to support training and the continual development of Deep Tube operational effectiveness.

6.1.4 Operational Performance Classification

Deep Tube operations are commonly assumed to be classified in one of four modes defined in the LU standard Good Practice in Human Factors Integration (G-217) and designated as Normal, Abnormal, Degraded and Emergency (NADE). The following table provides a definition for each of these modes.

Operational Mode	Standard Definition
Normal	State of normal running of railway incorporating minor disturbances and delays to the service in traffic hours and operations during non-traffic hours.
Abnormal	State of continuing railway operations with specific, planned changes to its configuration or equipment (such as special events, engineering works in traffic hours or within station public areas).
Degraded	State of continuing railway operations with significant equipment failures (such as track-related failures and communication system failures).
Emergency	State of the railway in response to a major safety or security related event. Introduction of contingency plans at a moment's notice.

These classifications provide a valuable framework for considering the workload involved in the conventional control of operations but the upgrade has combined new capital assets, technologies and a new railway control philosophy to deliver quantitative and qualitative improvement in Deep Tube services. In the context of the revised railway the additional classification, described in the following table, provides a link between the degree to which the railway is perturbed and Railway Control actions delivered by the RCS and through intervention by the RCO.

Table 11: Classes of Perturbation

Perturbation Level	Railway and Service Condition	Railway Control Action (undertaken by the RCS or by the RSO)	Correlation with Std. Op. Mode Classifications			
			Normal	Abnormal	Degraded	Emergency
P 1	• The railway is available to deliver the Service Plan • Divergence from Service Plan and/or other operational parameters falls below a specified and notionally acceptable level.	Monitor service Automatic Train Regulation continually recovers the Service Plan and/or other operating parameters	✓	✓	-	-
P 2	• Railway available to deliver the Service Plan • Defined divergence from Service Plan and/or from other operational parameters is exceeded	Where it is within the scope of the system The RCS intervenes to recover service The RCO may choose to intervene to recover the service	✓	✓	-	-
P 3	• Railway assets and essential resource are compromised; it is no longer possible to deliver the Service Plan. **Notes:** - Typically, operational capacity is lost in a manner that could not be predicted or mitigated - The Handbook indicates that in this circumstance, assessment and a recovery strategy should be available within 15 minutes.	Determine cause and nature of failure and its likely duration. Manage passenger comfort and safety Continue to deliver services where possible Identify best possible service should loss be sustained Communicate change to passengers	-	-	✓	✓

			Correlation with Std. Op. Mode Classifications			
Perturbation Level	Railway and Service Condition	Railway Control Action (undertaken by the RCS or by the RSO)	Normal	Abnormal	Degraded	Emergency
P4	• Railway remains unavailable for delivery of the Service Plan for a sustained period	Transition to alternative service/Service Plan over affected part of the SRR and Reassign assets and resources Maintain flow of passenger information	-	-	✓	✓

6.1.5 Operation Performance Criteria

The performance of the Deep Tube Passenger Services and of more general railway operations are calculated in real time with information that is captured continually made available to and processed by the RCS. Performance measures are used by the RCS to deliver passenger services automatically and by the RCO to determine if and when any manual intervention is required.

The performance parameters used by the RCS and RCO to control the delivery of Deep Tube services include:

- Journey time
- Platform waits
- Headways
- Trains Per Hour
- Trains in service
- Trains available but not in customer service
- Train loading
- Platform loading
- Station temperature
- Train temperature
- Deviation from the Active Service Plan
- Deviation from the Current Service Plan
- Traction Power Consumption and Energy Usage.
-

Ongoing development will be determine where additional measures are required and add value.

6.2 Deep Tube Railway Processes

This Section provides a summary of processes that contributed to the operation of Deep Tube Services and the maintenance of Deep Tube assets. Future development will refine and increase the richness of narrative to support the development of railway level Requirements and of an initial readiness plan.

This processes narratives that appear in this section should be read in conjunction with the descriptions of upgraded assets that appears in section 5.

The development of the Operations and Maintenance Concept to date has been focused on the following process framework:

- Maintain the Service Plan
- Deliver the Deep Tube Passenger Service
- Ramping Up and Ramping Down the service.
- Monitoring the Service
- Responding to Falling and to Unacceptable Performance
- Responding to Disruption of the Deep Tube Railway
- Manage Customer Communications
- Manage Internal Communications
- Operate the Train
- Operate the Platform
- Operate the Station
- Maintain the Assets
- Manage the Depot
- Manage Human Resource
- Manage Information (?)

6.2.1 Maintain the Deep Tube Service Plan

The delivery of Deep Tube services is automated and driven by the Active Plan. At any given time the Active Service Plan reflects either the published Service Plan or a variation of the published Service Plan.

The RCO is able to receive, store and deploy the valid Service Plan and their variants. The RCS retains all current and historical Service Plans and allows the RCO to:

- Simulate the operation each Plan that is stored
- View and amend the content of Plans to create new variations
- Specify in advance the days/weeks during which a specific Plan will Operate
- Utilise stored service Plans for training and continuing professional development.
- Archive and or delete Service Plans that are no longer current.

By convention the commencement of any newly loaded Service Plan takes place at 0400 on the day of introduction. This falls within the period of low demand for traffic. This is an RCS system

event and requires no intervention. The potential for a change of Service Plan is built into each Service Plan released and into all variants. The new Service Plan is assimilated seamlessly. All trains moving on the Deep Tube Railway are protected and any current trips that need to be changed are changed by the system in compliance with specified rules (example: a minimum lead time or number of stations between announcing a change of destination and the implementation of the change). Passengers on trains that are affected are informed through station and train customer information delivery systems. Once a Service Plan has been introduced it becomes the basis for service delivery for at least 24 hours.

The performance of Deep Tube service delivery is continually monitored (See section 6.2.4; Monitor the Deep Tube railway). The degrees to which service levels meet demand are recorded and are processed over time to produce trends and statistical analyses. Findings are reviewed by the RCO in weekly, 4-weekly and in longer cycles. The Service Plan is amended to meet observed passenger demand. To ensure operability, the amended Plan is tested using the RCS simulation capability.

6.2.2 Deliver the Deep Tube Service

Whenever all the necessary assets and Traction Current are available, the RCS delivers planned Deep Tube Passenger Services automatically without the need for intervention by the Railway Control Organisation.

All trains movements are executed in unattended mode unless on an exceptional basis a decision is made to operate the Train in remote or manual modes. It should be noted that in normal operations all railway assets work automatically and in unattended mode. Authorised personnel can also intervene to operate assets other the Train in remote or direct modes.

The Railway Control System interprets the Service Plan and:

- Activates trains that are stabled or located on the operational railway and in stand-by mode;
- Sets the routes that are required for the planned movement of Train Sets;
- Initiates, controls and protects the movement of active Train Sets;
- Controls all aspects of each station stop;
- Manages the “ramping” up and down of Trains Sets in operation to meet the planned service during peak and off peak periods and during periods of low traffic demand.
- Selects and causes the broadcast of appropriate timely and accurate information to passenger in stations through which Deep Tube services pass, on board Deep Tube trains and through a variety of communication channels to a broader community.

While Passenger Service is being delivered, the Railway Control System monitors passenger demand for service and the loading of both stations and trains in real time. Where demand and or crowding exceed defined levels of the capacity offered by the current service plan then the RCS automatically identifies and amends the Active Service Plan to reflect a service that offers appropriate capacity in each area and to each destination. The RCS alerts an event controller that a demand led adjustment is being made. Generally, the creation of additional capacity involves the reduction of service headways and the introduction additional trains but may also involve the reduction of services to one branch in order to ramp up service to another. The Service plan is only changed when railway can offer the operational capacity; that is when:

- Assets are available to be deployed
- Where minimum service targets are not compromised.

In the circumstance that these conditions cannot be satisfied, the RCS directs an alarm to the Event Controller to indicate that the DTR is unable to provide an appropriate level of service.

Concomitantly, when there is significant under utilisation of the service the RCS acts to reduce the capacity available. This is done to improve energy efficiency and to avoid incurring the marginal cost of running poorly used assets. It is only done when it is possible without creating large gaps in the service and without compromising minimum service targets.

Notes:

- The nature and measurement of passenger demand has yet to be examined.
- Development to date also questions whether savings in marginal cost is a useful driver for services that are demand led in real time. No objection has been noted to using demand analysis to modify the Service Plan in longer timeframes – see section 6.2.1: Manage the Service Plan.

When all assets and resources required to operate the planned service are available and performance is within “acceptable” limits (P1) any minor deviations from the Current Plan are corrected by the RCS. This is generally achieved by adjusting station dwell times and inter-station movement profiles.

When a train that is in passenger service is due to receive Maintenance; the RCS removes them from service at an appropriate point and in a timely manner. The RCS routes the train to the appropriate service facility without any requirement for intervention. An Event Controller is alerted when a trains set is removed from passenger service. If the removal of the train creates a P2 service situation then the RCS responds automatically to recover the planned service (see section 6.2.5; Respond to Falling or Poor Service).

6.2.3 Ramping Up and Ramping Down the Service:

The Deep Tube offers passenger service on a 24/7 basis. The introduction of new assets with high levels of reliability, many with automatic status and condition monitoring capability has removed the need to shut down the network down on a daily/nightly basis. The ability to operate bi-directional movements on a single track allows service delivery to continue when it is necessary to take possession of the adjacent track.

During Off Peak Periods and Periods of Low Traffic Demand, Train Sets are placed in any of the available stabling locations.

RCS maintains an accurate profile of the short and medium term availability of each Train Set in the Deep Tube Fleet. Availability is based on the continual monitoring of the condition and location of, and planned maintenance for each Train Set. The RCS locates and selects train for service delivery in a manner that level and manages the mileage of each train in the context of a fleet in which there is uniform usage of each Train Set.

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When the Current Service Plan requires that an additional Train Set is moved into service, the RCS automatically selects a specific Train Set, assigns it an Automatic (operational) status and moves the train from its stabled location to its first planned stopping location.

In ramping down the service the RCS stables Train Sets in accordance with the specified stabling rules (see note). Any Train Set that has an imminent requirement for maintenance will be diverted and stabled in the most appropriate position for its utilisation at the next ramp up. The selection of Train Sets at ramp up is defined in the Service plan unless a constraint on availability has been imposed during the time that any Train Set has been stabled.

Note to reader: During the development of the Operations and Maintenance Concept there has been discussion about the locations at which trains will be routinely stabled. It has been suggested that Train Sets can be stabled at locations along each Deep Tube line. At publication of this version assumption has been made that (a) there will be sufficient stabling capacity at locations that are off the passenger railway to hold the entire Deep Tube Fleet and (b) that Train Sets will not be "stabled out" on a routine basis.

When the Current Plan requires that a Train Set is to be removed from service, the RCS selects a specific train and when it is free of passengers, removes it from service and routes it to the correct stabling location where a standby status is assigned. A Train Set is removed from service at the last possible location prior to its removal from the Passenger Railway. Passengers boarding a train that is to be removed are made aware that the journey runs from the trains set's previous reversing point to the station at which it will be removed from service. If the train has recently passed a convenient removal point and the time to complete the current trip and return to the depot will compromise the planned maintenance then an alarm will be raised in order that the train may be short tripped.

During any ramp down period the RCS selects trains to remove from the railway, based on the most appropriate ordered for start up. This reflects:

- The usage of each Train Set. Sets with high mileage or with an overdue maintenance requirement are prioritised for removal.
- The minimisation of empty movement between where a Train Set is taken out of Passenger Service and the stabling location.
- Maintenance requirements at or following the next ramp up. Trains are positioned such that they do not obstruct adjacent Sets when those adjacent sets are being moved into service.

The RCS continually maintains the correct stock balance in all stabling locations. The correct stock balance reflects the stabling strategy that is maintained within the RCS and known constraints on the availability of the Deep Tube Train Fleet

6.2.4 Monitor the Deep Tube Railway

To ensure that Deep Tube assets are utilised to maximum affect and that the Deep Tube offers the best possible passenger service, railway operations and the assets that are used to deliver them are continually monitored. The RCS monitors:

- Train Operations;
- Passenger Service Performance;
- Assets Status and Condition;
- Passenger Activity;
- The Integrity and Security of the Deep Tube Railway.

6.2.4.1 Train Operations and Service Performance

On a continual basis the RCS monitors the position, status and deployment of all Trains running on the DTR including: Deep Tube passenger trains, engineering vehicles and Alien Passenger Trains that operate on the Deep Tube Infrastructure

The RCS continually processes the data it captures to create trends and or absolute values for a range of key performance indicators. Current performance measures include:

- Headways and trains per hour
- Timeliness of branch Service
- Station dwell time performance.
- Passenger loading at stations and on board trains
- Train in service
- Trains available for service
- Train reliability
- Degree to which passenger demand is being satisfied.

Note to reader: The scope and nature of service and asset performance monitoring is the subject of continuing analysis.

The status of the railway and its performance is presented on an Operational Overview that can be accessed by the RCO and by subscription users of the RCS (section 6.2.4.4: The Operational Overview)

The RCS continually models the future operation of the railway. The modelling horizon can be varied but is generally set at 2 hours. It uses the Service Plan, the current state of railway operations the current status of railway assets, to predict the potential for poor performance and disruption. When the possibility of unsatisfactory performance is identified the RCS takes action to minimise the extent of the disruption and deviation from the planned service. An Event Controller is notified of the risk and the action taken by the RCS. If the RCS fails to resolve a predicted service issue then it directs an alarm to the Event Controller in order that manual intervention can be considered.

6.2.4.2 Asset Status and Condition

On a continual basis the RCS monitors the status and condition of:

- The Track
- Traction Power
- Traction Power Supply System
- Track side equipment
- Platform Equipment
- Station Plant and Equipment
- Each Train Set and the sub systems of each Train Set
- The proper Operation of the Railway Control System
- Other Railway Systems including Communications, Customer information and Service Prediction.

The status and condition of railway assets is presented on an Operational Overview that is available to the RCO and to subscription users of the RCS (section 6.2.4.4: The Operational Overview)

The RCS monitors the usage condition and performance of assets to identify when maintenance is required. The scope and purpose of this monitoring is described further in Section 6.2.12: Maintain the Asset.

6.2.4.3 Monitoring Passenger Activity

The RCS monitors passenger activity at all Deep Tube stations and on all Trains.

CCTV images are captured and analysed by the RCS to detect:

- Train and Station loading
- Unusual and suspicious behaviour.

Passenger loading on trains is continually gauged by devices fitted to the structure of the train. Loadings are assessed against thresholds that are specified to reflect low, medium, high and unacceptable loading. High loading is notified to an Event Control. Unacceptable loading causes an alarm to be directed to an Event Controller and triggers the RCS to identify corrective action.

Station loading (platforms and other areas) are monitored through the analysis of CCTV images and reinforced by information that is captured from gate line activity. It should be noted that the potential for more precise numerical modelling of station loading remains out of reach due to the unmeasured interchange of passengers between upgraded Deep Tube Lines and other London Underground lines.

Where abnormal behaviour is detected the RCS issues an alarm to the Event Controller and presents a high definition image of the areas in which the suspect behaviour has been observed. If the Event Controller is unable to respond or if the observed behaviour persists for longer than a specified time then RCS escalates the alarm to the Railway Manager or to a delegated representative. The CCTV allows individuals to be selected and automatically tracked as they progress through a station and where possible throughout their journey.

Users of the RCS can request CCTV images for the purpose of routine (passive) monitoring. Images may be requested at a particular location or a programmed sequence of locations. The authorised RCS user can control camera deployment or chose to accept images that are selected by the system. Images are time stamped, the User is always made aware of the location of each image that is viewed, and is given options to freeze, zoom and replay images.

Captured CCTV images are stored for a limited period which can be extended on request. Stored images can be retrieved for the purpose of incident investigation and operational improvement.

The RCS provides sufficient bandwidth to allow high definition (HD) images to be transmitted and received but allows the RCO to switch between standard and high resolution viewing. HD images can be used for judicial purposes but are not essential for all general automated or manual monitoring and the use of less detailed images places less of a load on the LU data network.

6.2.4.4 The Operational Overview

The RCS provides the RCO with access to an Operational Overview that delivers an animated representation of:

- All train movements on the Deep Tube Railway;

- The presence, availability, setting and condition of all assets;
- An indication of passenger loading;
- The status of the Power supply and the Power distribution system;
- Selected CCTV images.

The overview provides:

- Situational awareness of the Deep Tube and Deep Tube operations;
- Awareness of the current Alarm/Alert stack;
- An interface through which assets can be operated and train operations controlled;
- Support for decision making when manual intervention is required.

The operational overview is available to all authorised users within RCO regardless of their work location. The functionality available to each user is configured to their individual need based on location, working mode, and the limit of their authority to affect the operation of the Deep Tube Railway.

6.2.4.5 Monitoring for Security

CCTV and intruder detection is used to monitor secure areas across the network. Secure areas include:

- Secure rooms at Deep Tube stations
- Stations at times when there should be no presence in the station.
- Station precincts
- Depots
- Remote stabling areas
- The inside of a train when the train shut down or in standby mode
- Other remote locations including substations, staff facilities, point of access to the railway and areas where capital equipment is installed and which may be vulnerable to theft and vandalism.

Doors on the Secure Rooms at Stations, depots and at other locations are equipped to detect tampering and unauthorised entry. The RCO is able to remotely operate and to verify the status of the locks protecting secure areas.

The RCS maintains a profile of locations where there should be:

- No unauthorised presence at any time
- No presence at specific times of day

In each case it is possible to override a “no presence” setting to allow legitimate and legitimate out-of-hours access. Where this is done the RCS monitors the movements of the authorised person(s) but does not raise an alarm.

When an unauthorised presence is detected the RCS directs an alarm to an Event Controller and provides access to a high definition CCTV image of the area in which the intrusion has been detected. A “single click” action can be used to notify the BTP of an intrusion and to provide the detail of any initial response that has been made by the RCO.

When the RCS directs a security alarm to an Event Controller it also provides the location and any standing orders that relate to the focused location. This information is also available to the BTP if the alarm is directed to it.

6.2.5 Responding to Falling or Poor Performance

When the Deep Tube Railway available to run the planned service but performance is falls outside of “acceptable” limits (P2); one of a range of actions may be triggered to automatically recover the Service Plan and to ensure that the highest level of service is provide.

The RCS Continually assesses the service delivery and detects when performance falls outside of acceptable limits. Unacceptable performance may be defined by:

- A single infringement of an absolute value,
- Excessive delinquencies over a period of time
- Excessive number of infringements within a fixed series of events.

In every case the break point between acceptable and unacceptable is defined.

Where the RCS detects unacceptable performance it raises and alarm which is received by the RCO in order that a manual intervention can be undertaken if required. The alarm complies with the DTP RCS norm and is made available to an individual who is competent to deal with the issue and whose workload is such that the alarm can be accepted.

Where the RCS detects unacceptable performance it seeks to correct the issue by executing one of a number of alleviating actions:

- Short trip a train or trains to fill excessive headways on the reverse road. Short tripping will only be undertaken when the action does not compromise last service commitments or minimum service targets for the branch on which the short tripped train is located and when passengers can be given adequate warning of the change.
- Divert a train to address poor servicing of a particular branch destination
- Extend a train trip again to service a destination beyond the planned reversing point of that train.
- Extend the use of train that are due to be stabled during off peak periods and periods of low traffic demand. This action is used to provide additional capacity in periods when demand exceeds the planned service and when for any reason there are insufficient trains in operation to deliver the planned service.

Where corrective action involves a change to a journey the RCO is notified of the change. If passengers are to be affected by a service correcting change then they are informed of the change at the earliest point and are informed of the steps to be taken to continue their journey to their chosen destination.

The RCO is able to intervene and is equipped with high productivity RCS functionality to support alternative service correcting actions when required.

6.2.6 Responding to Disruption of the Deep Tube Railway

In the situation where an equipment or system failure of any other event reduces or removes the capacity of the railway to deliver the Planned Service the actions that are taken by the RCS and the RCO are based on the following priorities:

- Make passengers safe
- Make passengers comfortable
- Determine the nature of the disruption
- Offer the best possible service with the assets that are available
- Resolve the cause of the disruption
- Recover the planned service
- Implement an alternative service where disruption cannot be resolved within a reasonable period.

Note: Current LU rules dictate that a planned response to a service failure must be available within 15 minutes. The plan includes the care of affected passengers, the recovery of the planned service and the implementation of an alternative service if required. The availability of the plan is separate from the decision to implement it. The implementation of the plan is taken after the initial 15 minutes period and is subsequently reviewed with the plan at 15 minute intervals.

There are many failure modes for the delivery of Deep Tube services they include but are not limited to:

- Train Failure
- Track Failure
- Power (Power System) Failure
- Remote (track side) equipment Failure
- Control System Failure
- Communications Systems Failure
- Events that occur near the railway and prohibit operations
- Station Closure
- Passenger action that prohibits train movement(s)

Where the loss of capacity to deliver the service is due to a detected failure then the RCS:

- Takes action to rectify the cause of the failure and undertakes any recovery actions that are within its scope.
- Notifies the RCO that a failure has occurred in order that the need for a manual intervention can be assessed.

Some capital assets have the ability to rectify faults automatically when they occur. For example:

- If a subsystem of the Train or Railway Control System fails then the major system automatically attempts to reboot/reset the reporting element. Dual redundancy in vital assets means that functionality is only lost temporarily if at all before a duplicate unit is automatically initiated. The RCS notifies Railway Control Organisation that an automated recovery action has been taken and informs it of the outcome.
- If the movement of a point fails to complete (i.e. machine does not signal locked condition when expected) then the system will notify an Event Controller and repeat the attempted move a defined number of times. If the point operates satisfactorily then the point will be used. If the point fails to clear then an alarm will be directed to the agent.

Where there is a catastrophic failure of the Communication and/or Railway Control Systems then operations on the affected sections of the Deep Tube Railway fail safely and the RCO is notified in order that a manual response can be initiated.

When for any reason a passenger train service fails the following actions are attempted:

- The train is driven to a platform if that is possible.
- Train is driven to the furthest safe limit of its current movement authority

To protect passengers and railway staff when there is a failure, the railway has been designed such that:

- Passengers are not detrained onto the track except in extreme circumstances;
- Situations where passengers are on services that have been brought to a stand in a tunnel or between stations on open track are minimised.
- Passengers are not held on a failed and stationary service for a period for long periods
- Passengers automatically receive reassurance that their situation has been recognised, the actions being taken to rectify it, and the progress being made.
- When there is any requirement for passengers to undertake specific actions example: to leave a train: Then clear requests are made and instructions given.

6.2.6.1 Actions Taken by the Railway Control System and Train

When there is a failure that affects passenger service delivery, The Railway Control System determines its residual capability to:

- Protect Train(s) while moving
- Direct the operation and physical movement of Train(s)
- Identify and set routes for Train movements.

Where any of these capabilities have been lost then the RCS notifies the RCO in order that a manual intervention can be made.

If Traction Current is no longer available to propel a failed service then the Train coasts and is then propelled by battery power to achieve its target ‘safe’ location.

If communication with the Train has been lost and the Train stops in a location that is not a platform then after a specified period it will activate itself and “creep” forward into the next station using its external presence detection system to verify that the space to its front allows a safe movement to be made.

6.2.6.2 Actions taken by the RCO

On receiving notification that a service affecting failure or event has taken place the Event Controller investigates the cause and likely impact of the disruption in order that any automated response can be verified not to expose passengers and staff to unnecessary risk.

Where the combination of Railway Control and On Board systems cannot rectify the cause of a service failure or bring a stalled train to a place from which passengers can be detrained to a platform then a manual intervention be considered by the RCO. To bring a train to a place of safety the RCO are able to use the following techniques:

- Remote Train operation (Train Operating mode 2 (see Section 6.2.9: Operate the Train)

- Retrieval using an assisting train to push the stalled train to a place of safety
- Attended Train operation (Train Operating Mode 3 (see Section 6.2.9: Operate the Train)

Where a line is blocked by an engineering or alien train and that train is capable of communicating with and being controlled by the RCS then the procedures used are identical to those used for Passenger Trains).

Where a stalled train is not a communicating train then the Event Controller intervenes to effect recovery.

Note: Version 1 - Detail to be completed and inserted covers - Deployment of Event Controllers in each working mode; auto-remote-manual operation of assets; organisation of RCO to manage incidents (teams with hierarchy); redirection of alarms.

6.2.6.3 Recovery of Stranded Trains and Passengers

When a train stalls and it is necessary to detrain passengers in order to remove the stalled unit from the railway then detrainment will take place to a platform. The movement to give access to a platform will be undertaken using one of a number of techniques:

- Battery Power with train operated automatically or remotely
- Train pushed by an assisting train. Normally an assisting train is not carrying passengers but this is not a limitation.

Where it is not possible to move a stalled train into a platform because the platform is occupied by a train that cannot be moved then it is possible to auto-couple the two stalled units to allow detrainment to the platform through the platformed Train.

Where neither remote operation nor pushing is possible then the detraining of passengers will be considered. This can be achieved by:

- Coupling an assisting train to the stalled train and using the “safe detraining” link between the two units

Only in exceptional and extreme circumstances will passengers be actively detrained to the track.

Note: Version 1 - Detail to be completed and inserted covers detrain process and associated customer information

6.2.6.4 Delivery of Best temporary Service

Where a section of the Deep Tube infrastructure is blocked and not available for use then RCS automatically determines the best service that can be achieved with the assets that are available to and located on the blocked line. Techniques that are available to maximise capacity include:

- Establishing shuttles using available reversing points on either side of the block.
- Optimising the shuttle capacity by using the DTR bi directional operating capability to increase or decrease the number of Train Sets on either side of the block.
- Using the DTR bi directional capability to operate a shuttle where a line that is parallel to a blocked line remains open and available to operate passenger service.
- Reducing the number of trains in service by routing them to a stabling location.

In addition to making the best use of assets on the affected line the RCS delivers information about alternative LU services, about the availability of other transport modes and about the current usage of both.

6.2.6.5 Providing an Alternative Service

Where it is established that the loss of railway capacity will be sustained then the measures taken to ensure the best temporary service will be continued.

Off peak periods and periods of low traffic demand will allow the stock available either side of the block to be optimised and for trains with urgent constraints on their availability to be withdrawn.

The basic shuttle arrangements that have been implemented will be automatically modified to incorporate last service requirements and last connection requirements including connections to services that have been arranged or which fortuitously provide relief for the persistent block.

6.2.6.6 Station Closure

Note: Version 1 - Detail to be completed and inserted covers – station closure process and associated customer information.

6.2.6.7 RCO Manual Intervention to Direct Services

In Normal conditions the Deep Tube Railway operates automatically and trains are run in Unattended Mode. Without any need for intervention the RCS acts to correct deviations from the Active Service Plan. However, there remain a number of circumstances in which the RCO will or may chose to act and to direct train movements manually. These include situations where:

- Deviation from the Service Plan falls outside of acceptable limits and the “standard” techniques for recovery that are supported by the RCS do not provide satisfactory or sufficiently timely recovery;
- Where the railway looses its capacity to run the Planned Service and the RCO determines that train movements are required that have not been requested by the RCS.
- Where the RCO wishes to instigate an unplanned movement such as the movement of an Engineering vehicle or the movement of a stabled train to a Depot when there are no other triggers for the move.

In these and any other circumstances that arise the RCS allows the RCO to intervene in one of two ways.

- By specifying a path that will be set automatically by the RCS, or
- By manually setting routes and points at the device level.

In both cases the RCS will recognise the route that has been set and the train movement will be authorised and controlled accordingly.

Manual route-setting at the device level, is generally restricted to short and simple, movements that involve a limited number of control devices. They are generally used for the immediate movement of a specific train unit. The Event Controller selects and specifies the settings for the devices that will control the move in front of the train. The RCS confirms that each instruction has been accepted and that the equipment settings have been applied.

When a route is set manually by either means and the route is in conflict with an existing movement authority, the Event Controller receives an alarm and the request to set the route is not applied until the prior route has been reset. An alarm is also given when there is no actual conflict, but the requested path threatens to delay a pre existing movement. In this circumstance the route is set unless the Event Controller withdraws the request. Once a route has been set the train is moved by the system, unless the train is being driven either remotely or directly. The RCS automatically re-sets a route that has been set manually on completion of the train movement.

The specification of the route is achieved intuitively with point-and-click instructions applied through the RCS Human Computer Interface. The Event Controller selects the train that is to be moved when it is located at the start of the proposed move.

6.2.7 Manage Customer Communications

The provision of information that is both timely and relevant is a characteristic of the Upgraded Deep Tube Railway (DTR). Information is actively made available to customers between their entry into and exit from the DTR. Customer information and the systems through which it is broadcast are designed to be compliant with current legislative and regulatory requirements and to ensure that Customers:

- Are able plan their journey
- Select and pay the best fare
- Complete journeys in a satisfactory manner;
- Respond effectively when events disrupt a planned journey;
- Act correctly in any emergency situation.

Journey information likely to affect travel on the DTR can also be obtained before entry through the internet, from external organisations and through a variety of mediums (examples: SMS text messages and email) that receive information from a subscription service that LU feeds without charge.

6.2.7.1 Routine and service Disruption Information:

Subject	**Locations**	**Delivery Mechanisms**
Fares and fare payment Use of the Underground Tube	Station Concourse	• Printed information • Audio-Visual • Station Operator • Help Point
Platform loading	Station Concourse	• Audio-Visual • Station Operator • Help Point

Subject	Locations	Delivery Mechanisms
Service Status	Station Concourse	• Audio-Visual • Station Operator • Help Point • Subscription Service • Broadcast Media
Next Train Departures (destination + time to next train) Train Loading (incoming trains)	Station Concourse Platform	• Audio-Visual
Notification of disruption on the Deep Tube	Platform On Board Train	Audio-Visual
Occupation of platform (management of distribution on platform) Notification of Arrival of Train Destination of trains arriving at platform Instruction on allowing passengers to alight Instruction on boarding train Warning of closing doors (notification and count down timer with audio alert)	Platform	Visual Display Audible announcement
Service Information	Platform Station Passageway Train carriage	Help Point

Subject	Locations	Delivery Mechanisms
Service Destination Next Stop "Local" Information Door opening (Side) Line Map (dynamic) Occupation of carriage Instruction on alighting and leaving platform at each station. Connecting Lines and other transport Services	Train	Audio Visual
Reassurance about and explanation of short non station stops Reassurance/explanation during recovery long no station stops. Reassurance/explanation to support train and passenger recovery procedures Instructions during support for train and passenger recovery	Train	Audio Visual Voice announcement (Remote and On-board Event Controller)
Reassurance/explanation/ instruction during station incident and in the event of	Platform Station Concourse Station Passageways Escalators (Digital Advertising Displays taken for Passenger information)	Audio visual Live voice announcement by Event Controller, Station Personnel or Emergency Services

6.2.7.2 RCS Support for the Delivery of Customer Information

The information provided to passengers is consistent and co-ordinated in all locations.

The information provided on board trains is relevant in terms of the train's destination, direction of travel, position on the line and progress between planned station stops.

Distinct and appropriate styles of delivery reflect the class of each message being delivered i.e. Routine travel information, reassurance is delivered in a calm and welcoming tone, explanation of any is calm but authoritative but instructions are terse and dictate compliance.

Deep Tube Passenger information is informed by and consistent with information provided by other LU Lines and by other interconnecting transport services.

Customer information is highly automated and is based on a rich library of standard messages and message components. The library supports the delivery of audible and visual information to all locations. The maintenance of the library is supported by a highly productive RCS tool set. The Customer information Library provides a single source of support for broadcasts made to both stations and trains.

All routine and most disruption information is triggered automatically by events that are detected by the RCS. Where this is not the case then appropriate messages are selected or generated by the RCO using the RCS tool set. Information can be directed to specific locations and audiences and the duration, pattern and general priority of each broadcast can be specified.

6.2.7.3 Customer Access to Information

The Upgraded Deep Tube Railway allows Customer information to be broadcast to all station and to all passenger trains.

So far as it is practicable all information is provided simultaneously and in a form that is both audible and visible.

Trains are equipped extensively with visual display equipment. The line map in each carriage area is displayed digitally and can be changed dynamically. This allows individual trains to be used on all routes across the Deep Tube Railway and to reflect only the detail of the trip currently being operated.

The screens that support on board advertising are also used to deliver inform to passengers. Circumstances where this is the case includes:

- During station stops when information about exiting train and platform is provided
- Direction of customers from a crowded portion of the train to a less crowded area
- The delivery of instructions during any incident or recovery process.

In addition to direct contact with a human operator, Help Points provide interactive maps and multi lingual enquiry facilities.

6.2.8 Manage Communications

A communication system that supports the transmission of vast quantities of data is critical to the effectiveness of the Deep Tube Railway.

The RCO communicates internally and with all necessary external personnel and organisations through a single interface which supports person-to-person voice communication using radio and telephone technologies; and interaction with the Railway Control System. These capabilities are supported whether transacted through the standard Desk-based of portable RCS Human Computer Interfaces.

Specific external (non RCS) agents are also required access the RCS and communicate using radio and telephone links into the Deep Tube domain.

Note: Assumptions about the Communications component of the RCS are provided in section 5.5: Communication System Characteristics.

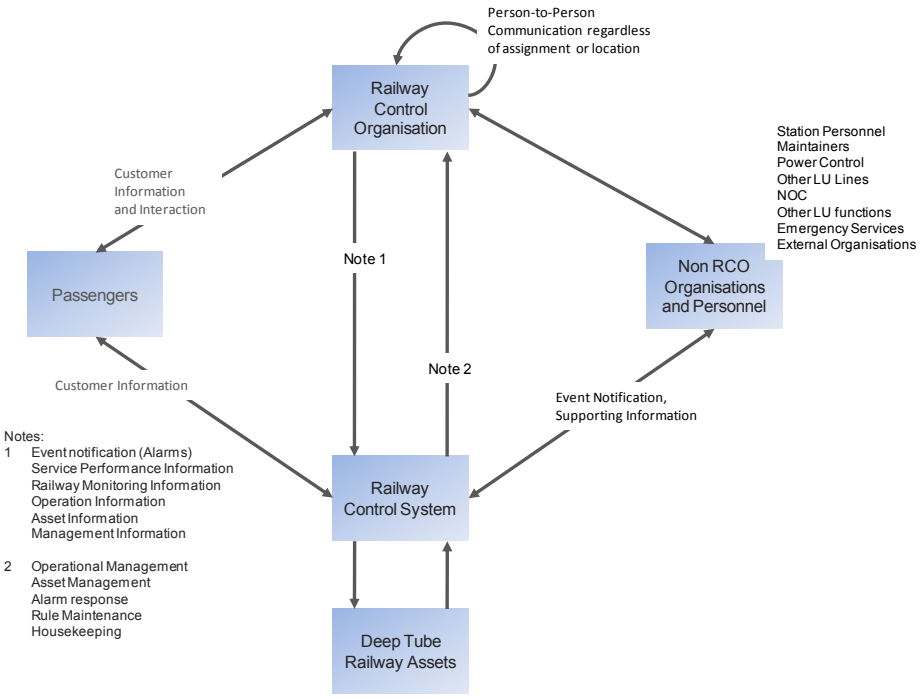


Figure 6-3 – High Level Communicates Concept

6.2.9 Operate the Train

Note: Version 1 - Detail to be completed and inserted covers – 3 modes of working; status settings for train; energy efficient operation; adjusting train performance to deliver service.

See sections 5.3.2; 5.3.3; 5.3.3 – Unattended, Remote and Direct train operation.

6.2.10 Operate the Platform

The platforms at Deep Tube stations are equipped to facilitate the operation of unattended Train Sets without compromising the safety of passengers

Passengers at a Deep Tube Platform are able to see the interval to:

- The arrival of the next three trains
- The arrival of the next train to each destination served from the platform
- The arrival of the next train to a destination combined with a calling pattern (fast, semi-fast) where the destination is served by more than one pattern.

Some Deep Tube platforms continue to be staffed by SATs who are able to give the destination of the train, request that people board in the required manner, offer advice to alighting Passengers and provide a warning of that the DOORS will close.

Where a SAT is not available the same information is delivered with a recorded voice. Where this information is given automatically; passengers joining the train and those alighting will notice that train and platform information is coordinated to provide a seamless message that is relative to their position when inside or out of the train. The urgency to board quickly is reinforced by a count down clock located near to each door and an audible signal that pulses and rises in both pitch and frequency culminating in a continuous tone as the doors close.

Where SATs are present the station stop broadcast and the door closing tone but not the count down clock is suppressed. Suppression is controlled through the RCS.

Note: Version 1 - Detail to be completed and inserted covers – train stop cycle; customer information; incident handling (PEA, evacuation)

6.2.11 Operate the Station

This section describes the activities that are undertaken in Deep Tube stations, the manner in which they are resourced.

Station activities include:

- Retail (ticket sales)
- Customer support - General Enquiry
- Customer support - Physical Support
- Managing Station Security
- Managing Station Plant and Equipment
- Managing Station Cleanliness and Hygiene
- Opening and Shutting Stations
- Responding to Incidents on a Station

The stations that are managed as part of the Deep Tube Railway are capable of operating continuously to support the delivery of 24-hour passenger service.

The introduction of the RCS and the RCO have created more flexible operating practices that make more efficient use of skilled LU personnel without compromising service. A range of tasks are completed automatically or by remote control and there is considerable flexibility to change between fully partially and non-staffed modes of operation.

The staffing of Deep Tube stations is consistent with London Undergrounds duty of care to the public and compliant with prevailing legislation. However, some stations outside of the central London area are unattended during selected hours. In the central area, support is consistently available especially at stations with a heavy footfall and which have a high proportion of *visiting* customers.

6.2.11.1 Retail (ticket sales)

Deep Tube stations no longer have traditional glass-barriered ticket office. The collection of fares and the sale of physical travel passes have been automated and are achieved through:

- "Wave and Pay" machines for contactless payment by a debit, credit card and in the near future by smart-phones.
- Oyster top-up points
- Pay machines that issue passes and which accept both cards and cash

Note: Travel passes can be obtained at a wide range of outlets and fare payment is no longer restricted to underground stations

In all staffed locations retail support operatives provides:

- Information about fares and the acquisition of travel passes;
- More general information about the Underground and how to use the system;
- Information about other TfL services;
- Assistance with the operation of payment machines including the resolution of instances when payment machines fail to work as planned.

In unstaffed locations support is given via Help Points that are integral to the fare payment machines and which are located in area of the outer station that are well lit and which can be monitored remotely by CCTV. When deployed the help point connects the customer with the LU Customer information Centre.

6.2.11.2 Customer support - General Enquiry

Inside the gate line of attended station personnel are available to provide a response to general enquires and to respond to request for physical support.

Passengers requiring support and who cannot readily identify a member of staff may use the Information Help Point to make their needs known and the LU Customer Information Centre will log an 'event' in the RCS that will result in a request being directed either to a station based operative or to an RCO Mobile Operator. An operative who best qualified, able and located to deliver the requested support will be the recipient of the request. When a passenger makes a request he/she will be given an explanation of the response and an expectation of the response time. If the passenger repeats his /her call then the CIC is able to trace and provide a progress report on the original call.

6.2.11.3 Customer support – Physical

Customer with mobility or sight related needs can be request assistance remotely and before entering a Deep Tube station. Contact can be made by phone or through the internet.

Customers requiring physical support but who have not made prior arrangements are able to contact by phone or through a Help point on arrival at a station.

The RCS directs and manages the deployment of the local or mobile resource that is best positioned to deliver the support that is needed.

6.2.11.4 Managing Station Security

Station security includes management of the following issues:

- The integrity of secure areas and enclosures;
- Unauthorised intrusion in any station area

- Detection of and response to inappropriate behaviour that threatens safety or the fabric of the station;
- Detection of suspicious objects

The application of technology has reduced - but not eliminated - the need for continuous observation and routine physical checks.

A high proportion of the space in every station can be monitored with CCTV. Images that are captured are analysed to detect abnormal behaviour and unauthorised presence in secure areas. This capability has significantly reduced the time previously spent on routine surveillance. When any abnormal activity is detected an alarm directed to an event controller who, after assessment can redirect the event to a mobile or local agent or to the Emergency services. Where staff presence and activity levels allow station images can be monitored passively by local, central or mobile staff.

Sensors on doors and where appropriate on the perimeters of secure areas detect the integrity of and any attempt to gain unauthorised or inappropriate access to those areas. When an incursion is detected an alarm is raised and directed to an Event Controller. A CCTV image of the site of the suspected incursion is also made available.

Secure areas are locked and unlocked locally but the RCS supports the remote operation of locks.

When a security risk event is reported by a member of staff, observed by local personnel or by mobile staff then an event is raised and the RCS supports dissemination of the event to all appropriate stake holders in the approved sequence.

The routine manual patrolling of stations continues to be undertaken at a number of Deep Tube stations. This is generally undertaken by Local or Mobile Event Controllers but in specific locations or at specific times of day by external security service providers. External providers are subscription users of the RCS and as such receive the information and have access to the functionality necessary to discharge their role.

6.2.11.5 Managing Station Plant and Equipment

Key station assets can be controlled remotely by the RCS and in direct mode through local controls. The RCO is able to view the status and condition and control the operation of key station assets and services including but not limited to:

- Escalators
- Lifts
- Station Lighting
- Gate lines
- CCTV equipment
- Power supply
- Off-Line Battery system

The RCO is able to vary the speed of escalators remotely in response to incidents or crowding and may reduce the speed to zero. When the speed of escalators is to be changed a visual and audible warning is given and the remote operator is presented with a CCTV image of the escalator that is being addressed.

To maintain and safe, pleasant and energy efficient passenger environment, the RCS continually senses lux levels in passenger areas and varies the level of illumination provided by the station lighting to provide consistent luminous intensity. The RCO is also able to adjust luminous intensity remotely.

The operational status of lifts and the setting of gate lines can also be adjusted remotely. When any station asset is addressed through the RCS then a full warning is given and the change operates such that there is no risk implication for passengers on, in or near the asset.

6.2.11.6 Managing Station Cleanliness and Hygiene

General and emergency cleaning at stations is contracted to external service providers.

When a requirement for emergency cleaning is observed, reported or detected then the event is passed to the cleaning organisation. Detection may be by the RCS or by human observation: If by human observation then the Event Controller will record the event in the RCS.

6.2.11.7 Shutting and Re-Opening Stations

When a station is closed to the public in normal circumstances the process is supervised by a Local or Mobile Event Controller. The RCS provides the time at which the last passenger train will call at the station and subsequently confirms that the stop has been completed. The Event Controller shuts the gate line to incoming customers a specified time before the departure of the last train service. This is achieved either manually or remotely using the RCS. Wherever the event controller is located it is possible to access CCTV images of the station concourse and to observe customer activity. Once the station shut down has commenced the RCS bars further passenger trains from calling the station.

Prior to commencement passengers and staff located within the station are informed that shut down is imminent. After the last train has stopped the shutdown is announced and any passengers on station premises are requested to leave by the quickest means. This information is provided audibly and visually and is broadcast on advertising display screens in addition to normal station display screens.

The Event Controller responsible with other personnel that are assigned to assist with the shut down, “sweep” the station using a combination of CCTV and physical checks. The integrity of secure areas is validated through the RCS and lights are dimmed remotely as each area of the station is confirmed clear. On completion of the sweep the gate line is shutdown and the Boswick gates closed to secure the station. The station is set as being closed on the RCS.

If authorised personnel are present in a station after the completion of a shut down then their presence is declared to the RCS which monitor movements but will not raise an alarm. The Railway Manager or an appointed Event Controller will be notified of station that are closed but which have personnel located in them. Non passenger trains can be routed to call at a closed station to pick up or set down personnel.

If the station is subject to an emergency closure then a similar process is followed but no ‘advanced warning is given and the audible and visual information given to staff and customers requests action in a more immediate tone. When an emergency closure commences the RCS prohibits any further train stops at the platforms at that station. However, an Event Controller are able to override the block and force a stop if doing so if this is the best means of removing passengers from the Deep Tube.

6.2.11.8 Responding to Incidents on a Station

Any incident detected by the RCS or by other means causes an alarm to be sent to an Event Controller working either in local or mobile mode. The assigned Event Controller is given access to real time CCTV images of the areas where the incident has occurred. Before arriving at the incident the Event Controller is able to operate plant and request any support that is required. An Event Controller receiving an incident alarm is able to make a "single click" request to have another Controller to assess the incident and take initial action while he/she proceeds to the site of the location.

6.2.12 Maintain the Assets

The scope of Deep Tube Railway Control incorporates the planning and control of Deep Tube asset maintenance. The integration of this function provides continuous clarity of asset status and availability and is a major contributor to the delivery of consistent and resilient Deep Tube Services.

Deep Tube maintenance supports Deep Tube business objectives of:

- Reducing Whole Life Cost
- High Asset and Service Reliability; with the opportunity for continual improvement
- Efficient Use of London Underground resources
- Consistent, predictable and high levels of asset availability

Following the Upgrade a broad range of Deep Tube Railway assets are able to monitor their status and communicate with the Railway Control System (RCS). Additionally some assets are capable of providing information about their operation on continual basis. The data provided varies between assets but can include measures of usage, condition and performance.

This section describes:

- Management of the Asset Maintenance Plan
- The capture of asset status, usage and performance information
- The execution of Planned and Reactive Maintenance

6.2.12.1 Creation of the Asset Maintenance Plan

An Asset Maintenance Plan is maintained for all Deep Tube Railway assets. The Deep Tube Maintenance Plan (DTMP) continually represents the availability and any constraints on the availability of railway asset by virtue of their being subject to current and or future maintenance.

The plan reflects the loading of both planned and reactive maintenance activity onto Deep Tube maintenance capacity including the consideration of:

- Capital facilities
- Plant
- Human resources
- Spares and Materials

Wherever the capability of the assets allows, the plan is loaded and maintained automatically by the RCS. The RCS continually monitors asset information to detect the need for maintenance. This need is indicated by:

- A fault (requiring immediate attention)
- A series of faults comprising separate events that individually do not require action but which collectively have passed a specified threshold of *acceptability*
- Usage that indicates the need for preventative maintenance
- Condition: Where a physical property of an asset has fallen outside of acceptable limits
- Performance: Where a measured factor has fallen below a specified level or outside of an acceptable range.
- Predicted failure or the predicted and unacceptable decline of an asset based on the observation and project of change in any of the previous elements of this list

The RCS is continually updated with the status of maintenance work-in progress and completed such that it continually reflects the availability of capacity and any change in the planned availability of Deep Tube assets. When the execution of maintenance work diverges from the plan and as a consequence the availability of capacity changes then the RCS automatically re works the plan and issues notification of the changes to all stakeholders. The plan remains continually flexible in order that demand for reactive/emergency work can be accommodated and that no bottlenecks are created.

The maintenance plan is continuously available to inform the RCO. It is also available to Maintenance delivery organisations (Maintainers) which are *Subscription* Users of the RCS. Subscription users are those users who have controlled access to information provided by the RCS and where required to specific elements of RCS functionality.

When processing the Maintenance Plan the RCS is fully interactive with LU asset management applications ensuring that data costs are minimised and all LU processes are supported by a single source of data.

The RCS allows the RCO and Subscription Users to access a profile for each asset. This profile includes but is not limited to:

- Current status
- Location/current location
- Technical specification
- Maintenance and modification histories
- Usage
- Condition
- Performance
- Fault history
- Outstanding faults

The accuracy of asset profiles is continually maintained and available to support decision making, the acquisition of asset knowledge and the continuing improvement of asset regimes.

When the Maintenance Plan indicates that maintenance capacity is fully loaded the RCS automatically amends the plan using specified rules to accommodate high priority tasks and to defer less urgent work. When such action is taken then the defined set of stakeholders are automatically informed.

For assets that continue to be maintained on a timed/periodic basis, the RCS automatically plans maintenance for each asset at the appropriate time and issues a notification to the Asset Planning Controller.

Where any automated loading of the plan cannot be completed by the RCS then an alarm is generated to an Event Controller to initiate a manual intervention can be made. The RCS supports the manual loading and adjustment of the plan with high productivity tools.

Where assets have been run to the acceptable limit of the window in which maintenance is required then the RCS alerts an Event Controller raises the priority of the asset in the Maintenance Plan and takes measure to minimise the use of the asset in service.

6.2.12.2 Maintain the Train

The Train continually monitors its condition and the condition of the sub system of which it is comprised. Faults are made available to the RCS which makes appropriate provision in the Maintenance plan. Where action falls outside of the scope of the RCS, an alarm is generated and directed to an Event Controller. The appropriate provision is determined by the category of fault/event that has been detected (see RCS Characteristics section 5.4)

To remove the need for former periodic inspections, the exterior configuration of the train is monitored automatically by track side equipment. Checks include:

- Confirmation that the configuration of the underside of Train Sets
- Confirmation that the condition of the upper exterior portion of sets is acceptable
- Measurement of brakes and of wheels.

External checks are achieved using imaging technology that compares a captured image with an ideal/acceptable master. The assessment of brake pads and wheels is achieved with imaging that calculates the physical dimension of the focused parts. These checks are made on a routine basis with equipment located at the ends of lines and in depot entry areas. Modifications to the fleet or to individual Train Sets are reflected in the library of masters that are used.

Trains that are required for Maintenance after having been stabled are stabled such that there is the minimum of movement from the stabling location to the Maintenance facility in which the work is to be carried out and minimum obstruction of other trains in the stabling location. Train Sets awaiting maintenance in a maintenance road are held in a Quarantine Area before being moved into the appropriate road.

With the exception of some internal cleaning activity (litter pick and emergency hygiene matters) all maintenance activity is carried out in Depot Maintenance Roads. The Train does not require routine (daily) preparation. Maintenance is not undertaken in stabling roads except in exceptional circumstances when it is planned through a manual intervention.

Litter picking and emergency cleaning tasks are completed on the Train while it is service and at reversing locations. When the need for emergency cleaning is recognised (observation by a person or detected through the analysis of CCTV images) a request is transmitted automatically to a maintainer/cleaner whose position and current workload will provide the best response.

Within the Maintenance roads, the execution of some maintenance task is completed with robotic equipment and with either zero or minimal human intervention (See Depot characteristics Section 5.7).

6.2.12.3 Maintenance of the Infrastructure

In this context the infrastructure includes but is not limited to the following asset groups

- Track
- Points
- Wayside equipment
- Power Distribution System

When a fault is detected the RCS will automatically take any action that falls within its scope to recover the safe operation of the reporting asset. If the asset cannot be recovered then an alarm will be directed to an Event Controller who will manage the impact of the failure including issuing a request for maintenance if required. Where maintenance is required the RCS will direct the request to the Mobile Asset Recovery (MAR) agent who is best located, qualified and able to respond. If the first response is unable to resolve the issue then a request will be re directed to the maintainer using the RCS.

The RCS continually monitors infrastructure assets. The information captured for each depends on the asset but can include usage, condition and performance. Based on specified rules the need for routine maintenance is loaded automatically into the maintenance plan.

Where maintenance dictates the need for possession (by the maintainer) of any section of the Deep Tube Infrastructure it is normally planned to take place during the period of low traffic demand - nominally between 0100 and 0500 hrs although this is not a restriction and a decision can be taken to take a possession at any time during the traffic day.

The RCS supports the possessions by allowing a Route Block to be applied. A Route Block prevents any RCS controlled train movement in the blocked section. Route Blocks are only imposed when there is absolute certainty that there are no stationary, Non Communicating Train in the target section. Note: Non Communicating Trains are able to move under their own surveillance and may represent a danger to track workers. Where a Route Block is considered the RCS is able to indicate the last known position of each Train Set as an aid to identifying whether a train is or is likely to be present. However, it is normal to impose the block after running a train through the section that is to be to be secured; closing the section to traffic after the “sweep” run has commenced. An alternative means of securing a possession is to use stationery trains that are positioned at either end of the closed section. In this case the Train used to form the block can be used to convey personnel to the worksite and provides a sweep of the work area.

Note: Version 1 - Detail to be completed and inserted covers –Protection implemented by a single authorised person.

6.2.12.3.1 Track

The need for manual track inspection is reduce by the presence of recording equipment fitted to over 30% of the trains in the Deep Tube Fleet.

Track monitoring equipment provides a continually updated record of the geometry of the DT Track. The RCS analyses this data and generates an alarm when the configuration of any section of track falls out of compliance with specified tolerances.

Rail monitoring equipment continually scans Deep Tube Rails and makes the data that is generated available to the RCS. Where any fault is detected an alarm is generated.

An alarm that signifies the presence of poor track geometry or rail defect is issued to an Event Controller in order that the appropriate actions can be taken and maintenance actions can be both planned and requested.

6.2.12.3.2 Maintenance of Track Side Equipment and Other Assets

In this context the other asset include but are not limited to:

- Power Distribution Equipment
- Communication Equipment
- Control Systems Equipment
- Information System Equipment
- Surveillance Equipment on board trains
- Surveillance Equipment in Stations and in other operational areas
- Surveillance Equipment in Depots and administrative areas.
- Stations Plant and Equipment
- Platform Train Interface Equipment
- Flood gates
- Sumps and Pump
- Tunnel Linings

When a fault is detected in track side equipment or an asset fails to communicate the RCS generates an alarm and directs it to an Event Controller.

Support for the routine inspection of trackside equipment is provided by the imaging equipment fitted to Deep Tube rolling stock. The track side equipment introduced during the upgrade was design to give high levels of reliability and a level of redundancy was designed into the total provision and fitting of equipment across the geography of the Deep Tube Railway. As a consequence the requirement for routine inspection of trackside and other assets has been reduced. To support the routine action that is still required the RCS collates the collective requirement for all works and proposes the timing and physical extent of required possessions as a basis for location specific maintenance “campaigns”.

6.2.13 Manage the Depot

In the context of the Deep Tube Railway, Depots are secure areas that provide the following services to the Deep Tube Railway:

- Train access to and from the passenger railway;
- Stabling for passenger trains;
- Stabling for Engineering vehicles;
- Roads that are individually equipped to deliver some aspect of train maintenance;
- Reception Roads on which trains can be held prior to being moved into a maintenance roads;
- Accommodation for spares and materials;
- Accommodation for testing and calibration of Railway Equipment;

- Accommodation for Depot Personnel;
- Accommodation for the administration associated with maintenance and with depot operations;
- Access to railway for road/rail vehicles;
- Access to the public highway.

Notes to reader:

For the purposes of this Concept, the accommodation of activities other than those listed at Deep Tube Depots (e.g. training) is coincidental.

The provision of stabling at depots allows LU owned land to be used effectively. Stabling is not a mandatory feature of a depot area.

For the purposes of this Concept the infrastructure with in the depot comprises the following areas:

- Depot Access Roads that connect the Depot to the Passenger Railway.
- Stabling Roads
- Maintenance Reception Roads available to hold trains that are moved from the Passenger Railway or Stabling Road into a maintenance Road
- Maintenance Roads each of which is constructed and equipped to allow specific maintenance tasks to be completed

6.2.13.1 Traffic Control in the Depot

Unattended automatic train operations can be executed throughout the Depot area including in the Maintenance Roads.

The following table indicates the manner in which traffic is and can be managed within the depot:

Note: In this table “stabling location” refers to the stabling roads that are located within a specific Depot. It excludes other Deep Tube stabling roads and the Stabling Roads in “other” Depots.

Movement	Protection	Normal Driving Mode
Passenger Railway to Maintenance Reception Road. And reverse movement	RCS • Route set by system or by Event Controller.	Unattended (May be remote or manual)

Passenger Railway into Maintenance Road	RCS (Including all maintenance roads) • Route set by system or Event Controller to handover point. • Route set by Event Controller from handover point to maintenance position.	Unattended to handover point on maintenance road then remote Notes: From handover point movement may be: • Unattended but requires safety assessment and confirmation • Manual but this is not the norm as it requires that the operator accesses the Train from the trackside.
Stabling location to Maintenance Reception Road.	RCS • Route by Event Controller prompted by system.	Unattended or remote;
Stabling location into maintenance road	RCS (Including all maintenance road) • Movement prompted by system • Event Controller to handover point. • Route set by Event Controller from handover point to maintenance position.	Remote:
Maintenance Reception Road into Maintenance Road And reverse movement	RCS (Including all maintenance road) • Movement prompted by system • Event Controller to handover point. • Route set by Event Controller from handover point to maintenance position.	Remote; Notes: May be: • Unattended but requires safety assessment and confirmation; • Manual but this is not the norm as it requires that the operator accesses the Train from the trackside.

6.2.13.2 Track Access in the Track

There is no routine access to the track that forms:

- Entry to and exit from the Depot;
- Stabling Roads;
- Maintenance Reception roads.

When access is required to these areas for maintenance or for any other purpose, it is made under the protection of a possession.

6.2.13.3 Depot Security

Each Deep Tube Depot is equipped and operated as a secure facility. Authorised personnel must present a valid pass at a security gate to enter a Depot. All other pedestrian and vehicular access is subject to a security procedure at a manned or monitored entry point.

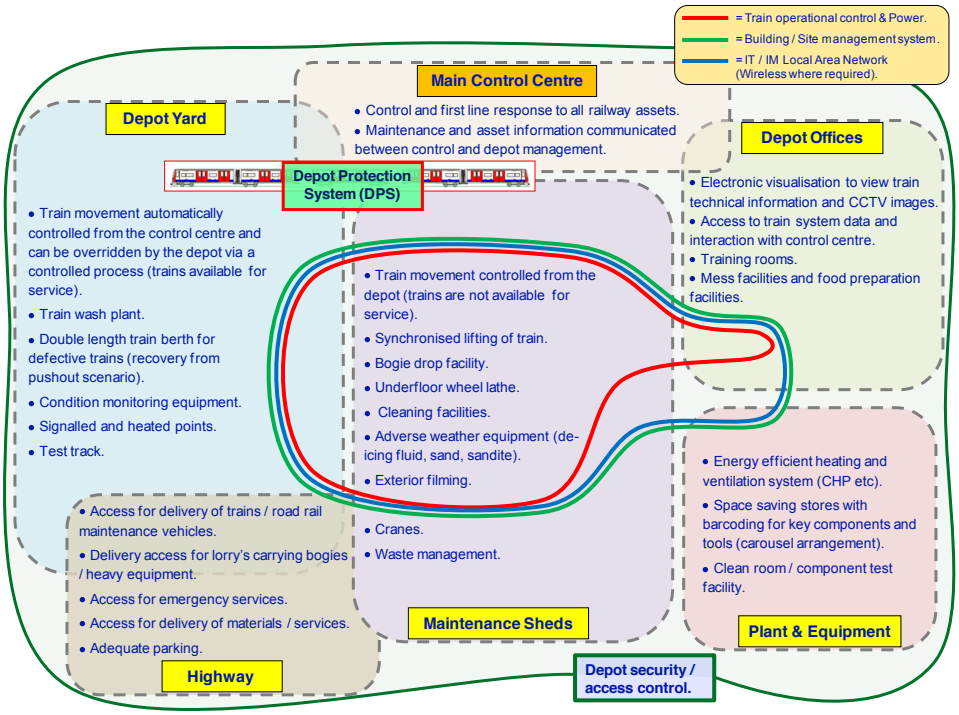


Figure 6-4 – Depot Composition

Note: This schema has been provided by Peter Turrell; Train Systems & Upgrades.

6.2.14 Manage Information

A single and alarm and event logging mechanism integrates the RCS, the RCO and the delivery of Deep Tube services. The details of a specified range of events that occur in the operation of the DTR are captured, stored and made available for immediate, and short and long term use. Events include:

- Operational events;

- Equipment events;
- System initiated events;
- User initiated events.

Event data is used by a range of external LU systems and for the creation of both standard and ad hoc management reports.

The RCS captures high volumes of event data and automatically makes it available in real time to other LU systems on a subscription basis. The RCS stores the data that is captured such that they can be interrogated by routine and ad hoc reporting programmes.

The RCO and authorised personnel from other are able to build and where appropriate to maintain enquiries, analyses and reports that support Operation control and management and the continuing development of all aspects of Deep Tube Railway operation.

The RCS provides a “black box” recording facility that allows operational events to be retrieved and used to replay deep Tube operations. This facility supports incident investigations, the development of RCO skills and the more general development of a broad range of Deep Tube processes.

6.2.15 Training and Continual Improvements

London Underground maintains a high quality training capability for personnel engaged in:

- The control and recovery of Deep Tube services
- The management and maintenance of Deep Tube assets

Training incorporates the acquisition, development and retention of skills.

6.2.15.1 Training for Service Delivery

The acquisition and subsequent development of operational control and recovery skills is based both on formal and informal learning.

For formal learning, structured syllabuses are supported by a comprehensive and flexible RCS simulation capability. Simulations of Deep Tube operations allow Event Controllers to gain experience of a wide range of Deep Tube operational scenarios that occur in the various states (P1, P2, P3 and P4) of the railway. The simulation supports the development of the skills necessary to operate in each working mode i.e. Central, Mobile and Local.

The RCS allow operational scenarios to be programmed, stored and executed on demand. The system provides a realistic and challenging working experience in terms of:

- The events/scenarios that are synthesised
- Interaction with the RCS through each form of RCS Human Computer Interface
- Timing, Task arrival rates and workload.
- Interaction with passengers, with other LU personnel and with other constituents in the railway environment example: Contractors and BTP.

The RCS simulation capability supports both formal and informal training. Formal activity is normally delivered in a specially constructed classroom environment. The RCS also allows authorised personnel to reinforce their skills by accessing simulator and learning aids during ‘quiet

periods' and in the normal working environments. In both cases the simulation is supported by a rich seam of screen based study and knowledge and performance assessment aids

6.2.15.2 Training for Asset Maintainers

Training for maintenance personnel continues to use traditional training facilities that provide hands on experience. Demand for the amount of time that is spent in these facilities by the introduction of an extensive range of screen based maintenance task simulation tools, study aids and knowledge and performance assessment tools.

These measures allow maintenance personnel to develop and reinforce knowledge and skills that are relevant to a broad range of assets that include: The Train, Track, and Track-side and Station assets.

Maintenance simulation and screen based training is generally used in a classroom environment but can be accessed for continuing professional development in a less formal environment.

6.2.15.3 Certification of Competence

The mechanisms that support training in the Operations and Maintenance domains also support the assessment and certification of individual competence. Once achieved, certification is verified by a competent and qualified person and used subsequently by the RCS when assigning events/alarms to individual members of the RCO. Where certification is subject to renewal on a timed basis and an individual is due to be re-certified then the RCS notifies the individual and competent person responsible for verification.

7 Future Enhancement

This Operations and Maintenance Concept provides a conceptual view of the future Deep Tube Railway. It is not intended as and should not be construed as a statement of requirements or an authorised view of the composition and operation of the future service. The OMC describes the future Deep Tube in terms of the processes, assets and organisation deployed to deliver the Deep Tube service. In developing the Concept, assumptions have been made about tools, techniques and other enterprise characteristics about which out knowledge in incomplete and for which justification has yet to be considered. In this context both the future development of this OMC and the Design and Specification of the Deep Tube Railway will be informed by R&D activities that will clarify and either justify or question the propositions that have been documented.

At publication of this version of the Operations and Maintenance Concept, the following matters require further investigation and development:

7.1	The requirement for and extent of interoperation with other LU Lines and with the Overground Railway. Example: Bakerloo Line trains are controlled by Network Rail when moving North of Queens Park;
7.2	Protection at platform edge (PEDS, presence detection, nothing or other?);
7.3	Composition and management of the Service Plan;
7.4	Examine the feasibility, implications and benefits of demand led adjustment to the Service Plan in near real time and in longer cycles;
7.5	Degree to which COTS control systems that offer fully automated service delivery, and smart service recovery and optimisation may be anticipated or influenced by 2020;
7.6	Unattended operations – technologies, asset design, operational issues and consequences;
7.7	Control of Depot movements with using the control system that also controls passenger service;
7.8	The degree to which aspiration for a single “massively versatile” COTS Railway Control System interface device can be made available to remote agents outside of an office environment;
7.9	The security of railway operations when executed through mobile interfaces;
7.10	Clarification of the concept for the “central” Control location:
7.11	Development of the concept for railway control back up;
7.12	The case for train “creep” - in terms of safety and of the technologies involved;
7.13	The degree to which station and infrastructure assets can be reengineered to support remote operation and monitoring. Note this affects maintenance, staff deployment and security.
7.14	Cooling the Deep Tube: Conventional air conditioning, an alternative technology or a combination of the two.

7.15 Integration of Power Control into the RCS; Determine the degree to which control of the Traction Power Supply is or can be available to the RCO.

7.16 Mobile telephones and WiFi access in the Deep Tube as a basis for extending the reach and the richness of passenger information.

7.17 The implications of introducing bi directional operating capability in terms of the Traction Power System, track layout, service viability and other matters that pertain.

7.18 The planned future offering of the Railway Control System supply industry must be both tracked and influenced to ensure that proposed functionality and technologies can be acquired; acquired as far as reasonably possible as “standard product”; integrated into the fabric of the overall Deep Tube enterprise; maintained and kept current for the life span of the upgraded railway;

7.19 The potential for creating more efficient station operations (process and organisation) given the proposed capability to operate in automated and remote as well as direct mode. As a part of this investigation it is appropriate to explore the potential for dividing and or sharing station operation processes between the Station Organisation and the proposed RCO.

7.20 Clarity on the future technologies that will support the collection or prepayment of fares. The potential of new technologies and the innovative use of current technologies (debit card, mobile phone etc) have the potential to effect on the need to vending equipment and retail facilities.

7.21 The degree to which it is desirable to remove or reduce the current separation of Deep Tube Lines. This investigation will include the operations, assets, organisation and management of the individual lines.

7.22 The organisation implications of providing Customer Information when customer Help Points are used. Work content, skill profiles and work load must be examined to determine whether Customer support is provided by the SCO or by a separate functional entity.

7.23 The means by Train Sets can be accessed safely when located in Sidings and Depot locations and which are controlled by the RCS.

7.24 Examination of the work undertaken by Event Controllers when working in Mobile mode and when the Railway is operating without perturbation and without any requirement for intervention.

7.25 Creation of a Stabling Strategy that balances: Energy Use, Security, Infrastructure and Train Maintenance, and 24/7 service capability. Note: this strategy should consider the possibility and extent of out-stabling along the line.

7.26 Consider the case for creating a 24/7 capability.

The Deep Tube Programme Engineering process will ensure that each R&D activity that is undertaken shall support the design of the future railway by:

- Determining the feasibility suitability of proposed technologies and techniques;
- Identifying the full implication of using new tools and techniques;
- Justifying or alternatively questioning the concepts that have been offered;

- Informing the railway design process of current and future supply side offerings;
- Utilising the lessons learned from previous upgrades;
- Utilising insights captured from investigation of other successful metro systems.

The engineering process will ensure that requirements are prioritised and justified as they are formed at each design level.

8 Appendices

8.1 Appendix A: The Core OMC Development Group

Table 8-1 – Participants in the Development of the Deep Tube Operations and Maintenance Concept		
Function	**Name of Participant**	**Group**
Upgrade Development Manager - BCV Operational Upgrades, Chief Operating Office,	Michael Milner	Core
Project Development Manager, Operational Upgrades, Chief Operators Office	Alex Bennett	Core
Project Devlopment Manager, Operational Upgrades, Chief Operators Office	Bill Welbank	Core
Principle Human Factors Engineer – Railway System Engineering	Jon Wackrow	Core
Principle Systems Architect – Railway System Engineering	Colin Wood	Core
Project Devlopment Manager, Operational Upgrades, Chief Operators Office	Michael Cowland	Core
Systems Engineer– Railway System Engineering	Russ Holland	Core
Fleet Product Introduction Team Manager, Railway System Engineering	Leon Hall	Core

8.2 Appendix B: The Specialist OMC Development Group

Table 8-2 – Participants in the Development of the Deep Tube Operations and Maintenance Concept		
Function	**Name of Participant**	**Group**
Contract Reviews Investment Appraisal, Reviews and Legal	Will Adeney	Specialist
Senior Planner - Operational Strategy & Commercial	Julia Allaway	Specialist
Upgrades Planning Manager (BCV) Operational Upgrades, Chief Operating Office	Alistair Baily	Specialist
Senior Planner, Transport Planning, Strategy & Commercial	Charles Baker	Specialist
Maintenance Introduction Manager, Chief Maintenance Office	Matthew Barr	Specialist
Operational Task Manager, Operational Upgrades	Ray Barrett	Specialist

Table 8-2 – Participants in the Development of the Deep Tube Operations and Maintenance Concept		
Function	**Name of Participant**	**Group**
Infrastructure Lead, Deep Tube Programme SSR Upgrade Programme	John Bentley	Specialist
Fleet Manager, Victoria & Bakerloo Lines Finance - Maintain	Ian Bromilow	Specialist
Rolling Stock Project Engineer Trains Delivery, Tube Lines Limited	Andy Burke	Specialist
Systems Modelling Engineer, Train Systems Engineering	Martyn Chymera	Specialist
Operational Task Manager Operational Upgrades, Chief Operating Office	Cary Clark	Specialist
Operational Task Manager Operational Upgrades, Chief Operating Office	Michael Coultharde-Steer	Specialist
Information Architecture Manager Strategy and Innovation	Jeremy Davis	Specialist
Head of Asset Condition, Maintenance Engineering	Stephen Foot	Specialist
New Stock Engineer Train Systems Engineering, Capital Programmes Directorate	Simon Ford	Specialist
Fleet Upgrade Engineer, Asset Performance Development Team - Fleet	Leke George	Specialist
Operational Task Manager Operational Upgrades, Chief Operating Office	Pete Goulding	Specialist
Fleet Product Introduction Team Manager Chief Maintenance Office	Leon Hall	Specialist
Information Architecture Manager Strategy and Innovation, Information Management,	Alison Jennings	Specialist
Business Manager Strategy Programme Delivery	John Lichnerowicz	Specialist
New Stock Engineer Train Systems Engineering, Capital Programmes Directorate	Claire Maclean	Specialist
Operational Task Manager Operational Upgrades	Ian McCrory	Specialist
Strategy Development Manager Strategy, Strategy & Commercial	Joseph Martin	Specialist
Operational Task Manager Operational Upgrades	Alastair Montgomery	Specialist
MeMet - Process Manager Fleet Metropolitan Management	Steve Murray	Specialist
Operational Task Manager Operational Upgrades, Chief Operating Office,	Paul Newman	Specialist

Table 8-2 – Participants in the Development of the Deep Tube Operations and Maintenance Concept		
Function	**Name of Participant**	**Group**
Strategy Manager Strategy and Innovation, Information Management	Martin Osborne	Specialist
Rolling Stock Engineer Station Assurance, Tube Lines Limited	Mark Sherborne	Specialist
Rolling Stock Senior Project Engineer Trains Delivery, Tube Lines Limited	Phil Shrapnell	Specialist
Depot Sponsor, Train Systems & Upgrades	Peter Turrell	Specialist
Upgrades Delivery Manager, BCV Operational Upgrades	Graham White	Specialist
SQE Manager Safety, Quality and Environment, Safety	Roan Willmore	Specialist
Operational Task Manager Operational Upgrades, Chief Operating Office	Paul Wood	Specialist
Strategy Development Planner Strategy, Strategy & Commercial	Samantha Wylie	Specialist

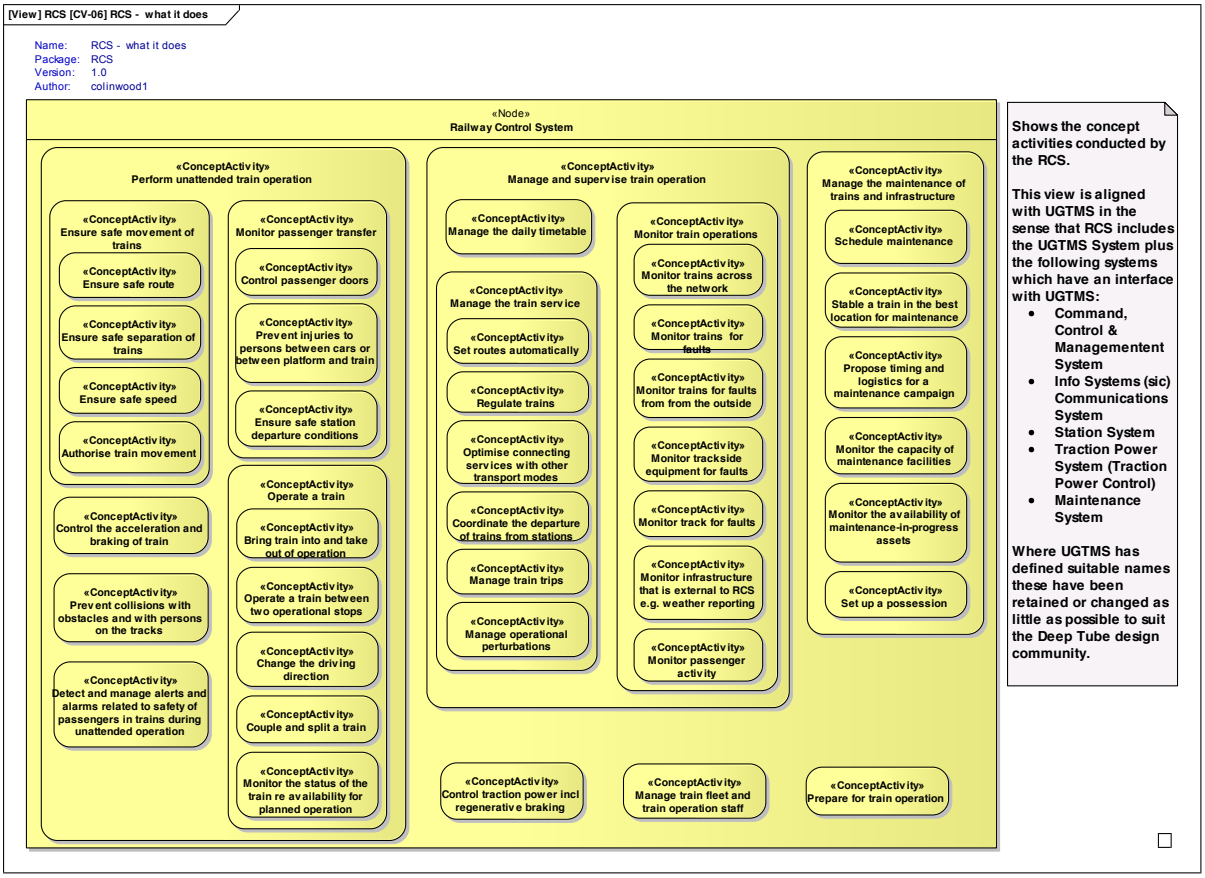
8.3 Appendix C: Engineering Tools and Approach

Note: Version 1 - Detail to be completed and inserted covers – Next steps – The development of Railway requirements – TRAK and Enterprise architecture.

Authoring (and reviewing) narrative descriptions of complex systems – and this document is an example - is notoriously taxing without modelling the content to some extent. Given that the concept of operations is a key early work product in the project lifecycle and has far reaching influence to subsequent processes and work products, it is really important that its content can be re-used and shared without confusion or misconceptions.

The programme has chosen to ensure consistency by statically modelling parts of the concept of operations. TRAK – a simple and pragmatic open source architectural framework – will provide the controlled vocabulary and grammar required to promote consistency and exchange.

In this document evidence of modelling will manifest itself in diagrams (see example below) that illustrate the narrative, providing consistent executive summaries of the concepts. Diagrams are drawn from a model created by the Sparx EA modelling tool which helps to control the hundreds of elements such that they are used consistently across diagrams.



The real benefit of modelling however is less visible. The model is used to test the rigour of the narrative as it unfolds across the pages. It reveals inconsistencies in naming and relationships between elements which are then corrected at an early stage to avoid carrying misconceptions forward. The document will be progressively enriched with diagrams as the concepts mature and consensus about them and their structure and interactions is reached.

8.4 Appendix D: Platform Edge Protection Strategies

This concept neither advocates nor dismisses the use of any or any specific platform edge protection mechanism. LU's deliberation in this area is ongoing. Recommendations and any subsequent decision will either be recorded in a revision of this Concept or introduced in DTR requirements later in the DTP lifecycle. The use of PEDS was considered during the OMC development process favourable comment included:

- Passenger protection
- Passenger environment (reducing the effects of air movement)
- Protection against littering
- Protection against trespassing.

Unfavourable comment included:

- Cost of maintenance

- Source of service affecting failure
- Extension of dwell times
- Passenger risk

Other options were considered including (track) obstacle detection and the rejection of any protection system.

8.5 Appendix E: Summary of Deep Tube Line Asset and Upgrade Summary

The following table provides an indication of the relative size of each Deep Tube Line and a summary of their recent upgrade history.

Table 8-3 – Deep Tube Line Summary

Line	Asset Summary
Bakerloo	Track kilometres - 23.2km Tunnel kilometres 11 km No of Stations served - 25 Tube Stock - 72TS Fleet Size - 36 Summary of last/recent asset upgrades: • Fleet modernisation in the 1990's.
Central	Track kilometres – 74km Tunnel kilometres – 23 km No of Stations served - 49 Tube Stock – 92TS Fleet Size - 85 Summary of last/recent asset upgrades: • 92TS refresh (ongoing). • ATP introduction; 1996.

Table 8-3 – Deep Tube Line Summary	
Line	**Asset Summary**
Victoria	Track kilometres – 21km Tunnel kilometres – 21 km No of Stations served - 16 Tube Stock - 09TS Fleet Size - 47 Summary of last/recent asset upgrades: • Full line upgrade including new rolling stock, signalling assets and service control facility. Ongoing – scheduled completion; 2013
Jubilee	Track kilometres – 16km Tunnel kilometres – 12.4km No of Stations served - 27 Tube Stock – 96TS Fleet Size - 63 Summary of last/recent asset upgrades: • Jubilee line extension; Completed 1999. • 7th car project. In December; 2005, • The Jubilee line upgrade – replacement of signalling and train control; 2011
Northern	Track kilometres – 58km Tunnel kilometres 39 No of Stations served - 50 Tube Stock – 95TS Fleet Size – 106 Summary of last/recent asset upgrades – • The Northern line Upgrade delivering Transmission Based Train Control (TBTC) and a new train control system; Scheduled Completion is end 2014. • New train fleet; 1995-1998.

Table 8-3 – Deep Tube Line Summary	
Line	**Asset Summary**
Piccadilly	Track kilometres – 71km Tunnel kilometres – 21 km No of Stations served - 53 Tube Stock - 73TS Fleet Size – 86.5 Summary of last/recent asset upgrades: • Terminal 5 link and station opened in March 2008. • The extension also includes a junction to connect to the existing Piccadilly line west of Terminals 1, 2 and 3 as well as additional sidings west of the new Terminal 5 station. • Kings Cross St. Pancras underground station. In September 2010 the station is the 62nd Tube station in London to become step free, and is part of redevelopment work that quadrupled the size of the station, easing congestion and making journeys better for the 300,000 daily passengers.
Waterloo & City	Track kilometres – 2.37 km Tunnel kilometres – 2.37 km No of Stations served - 2 Tube Stock 92TS Fleet Size - 5 Summary of last/recent asset upgrades: • In 2006 the line underwent major upgrade works which included: - new track, improved (conventional) signaling and refurbished trains. The line saw a 25% increase in peak service