T-TOC

Architecture Definition

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Management Summary

Background

In order to realise the benefits of future strategic programmes of work, such as the Smart Motorway and Expressway programmes, Highways England need to ensure that the operational technology it deploys is available and performs to a high standard.
However, a number of key issues currently exist:

- Resolution of technology related incidents is often out-of-step with business priorities and is not consistently applied across regions
- There is no definitive record of operational assets across all business areas
- The status of faults, assets and spares is not accurately reported by maintainers
- Warranty tracking is not well supported by Stores and Logistics systems so is poorly maintained
- Experience and knowledge is not consistently applied to fault investigations, and is not routinely shared across suppliers and regions

As a result it is not always easy to obtain a reliable view of operational assets, in particular their performance and availability, and coordinate the activities necessary to maintain service levels.
The Operational Technology Strategy (ref. [3]) describes how these issues will be addressed through the development of central resources including a dedicated technology management function housed in a Technology Operations Centre (TOC). The T-TOC project is intended to deliver a set of technical solutions to support the technology management function. The project will look to re-use resources and systems from other projects where appropriate.

Proposal

The Operational Technology Strategy represents a shift away from the current distributed operational model, where regional maintenance contractors act independently to meet individual network level KPIs, to a more holistic approach as defined in the Operational Technology Strategy 2015: this describes a new model where operational decision-making is centralised and HE staff take overall control of the delivery and operation of technology, directing service organisations to perform the tasks required. This approach also aligns with the Asset Led Delivery Model (ALDM) being adopted across Highways England and the approach already being taken by Area 7.
In order to deliver this operational model, a Technology Operations Centre (TOC) will be created and will be operational 24/7. It will adopt best practice from other industry sectors which manage significant numbers of technology assets across extensive geographic areas, such as telecommunications and utilities operators, and builds on the approach taken on the National Roads Telecommunications Services (NRTS) contract; also note that it aligns with ITIL service management principles.
Within the TOC, a single service desk will cover all operational technology and co-located staff, with access to a consistent set of information, will enable remedial work to be prioritised and co-ordinated, building intelligence at the centre of HE operations.
T-TOC will utilise CHARM, as it is rolled-out across regions, to monitor operational technology. This will in turn enable the interim TPMS solution (SDS Lite/OpenAssets) and associated Halogen system to be gradually retired.
Going forward industry standard approaches, in particular SNMP, will be used to monitor operational technology directly.
Automated analysis of monitored technology will identify incidents on the network and subsequently generate the workflows required to manage these through to resolution. Since T-TOC will now be providing the workflows necessary to support all of the tasking activities for the TOC, Planned Engineering Works (PEW), the current process support web application, will no longer be required. Similarly, T-TOC will replace the manual fault reporting capability provided by the National Fault DataBase (NFDB), so this too will not be required.
These processes will all be underpinned by a definitive inventory of operational assets, and related content, which is aligned with stores and logistics, and supports a common view of

assets, their status and location. Effective data sharing will ensure that all relevant parties across the organisation will have access to this same consistent set of information.
This approach will improve the performance and availability of operational technology, build capability in a standardised and well governed manner, and allow Highways England to meet the requirements of the Roads Investment Strategy (RIS).

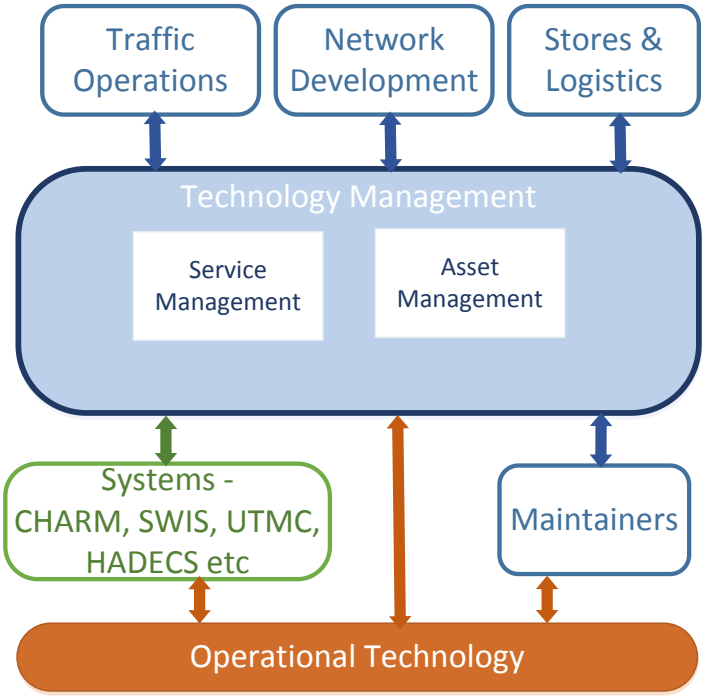


Figure 1 - TOC Context

The management of technology affects business functions and systems across Highways England. Thus T-TOC must support a range of system interfaces and cross-organisational business processes.

Key Dependencies

The proposed approach is dependent on the provision of enterprise-wide infrastructure, specifically an Enterprise Service Bus (ESB) and suitable hosting arrangements. In addition, new governance arrangements will need to be implemented to cover the Highways England ownership and development of the technology architecture.
The new operating model will require many key roles to be in-sourced within Highways England (as per CHARM), which will in turn need to be supported by new management systems.
The benefits of automatic monitoring and analysis will not be fully realised until SNMP compliant technology, which supports remote diagnostics, is widely introduced across the network.
There are numerous interfaces which T-TOC will need to accommodate, such as the exchange of asset configuration details with Stores and Logistics.
The T-TOC programme itself will also be dependent on other planned re-procurements and the extent to which they can support required T-TOC functionality.

Implementation

The steer from the Cabinet Office is to avoid complex bespoke implementations and procure solutions based on Commercial 'Off-The-Shelf' (COTS) products. The recommended approach is to develop T-TOC on COTS products using a series of low risk deployments into operational use.
Until the detailed implementation of the technology strategy can be determined, Highways England will need systems that can easily be configured to handle changes to organisational

structure. Similarly, existing processes and organisation will need to be re-engineered around procured solutions.
Given the multiple dependencies on interfaces and other procurements, with changing timelines and a shifting organisational structure, the recommendation is that an Agile approach should be adopted for the implementation of T-TOC. Although this may have a less clearly defined end point, it will allow Highways England to more easily manage dependencies, mitigate risks, and accommodate opportunities and changes in priority during the course of the implementation. However it should be noted that core functionality must be ready for CHARM when this is first operational (currently expected Summer 2018).

1. Overview

1.1. Introduction to T-TOC

This discusses and describes the architecture of a capability to provide management of operational technology within Highways England. In the past the project to deliver this capability was referred to SDS Futures, however the project is now called Tools for the Technology Operations Centre (T-TOC), and this term is used throughout the document as shorthand. Annex 1 provides a comprehensive glossary of terms and acronyms used throughout this document Operational technology as a term has historically been used to denote roadside technology, such as signals and MIDAS sites, while excluding the communications infrastructure[1] provided through the NRTS contract. In considering the scope of T-TOC for the purposes of this document operational technology has been expanded to include any ancillary devices, such as video matrices and the large display screens that are used to operate the Strategic Road Network (SRN). This definition accepts that that there may be some ambiguity in this scope but aims to be inclusive to ensure that all of the required capability is identified. Management of the operational technology relates to provision, deployment, monitoring, repair and disposal of the operational technology. The objective of T-TOC is to ensure that the operational technology required to operate the SRN is available when it is needed.
This architectural description is focussed on delivering tools and services to meet the needs of operational technology. However all of these considerations are in the context of other Highways England initiatives and projects. Therefore wherever appropriate the requirements of other business areas have been considered. Specific examples picked out in the text are:

- Service management where products being considered by CHARM and for Business ICT for service management may also be suitable for use by T-TOC;
- Document and record management where the need for referenceable, searchable and governed storage of documents, records, imagery etc. is common across the whole of Highways England.

1.1.1. System Context

In managing that operational technology T-TOC will collaborate with other capabilities including:

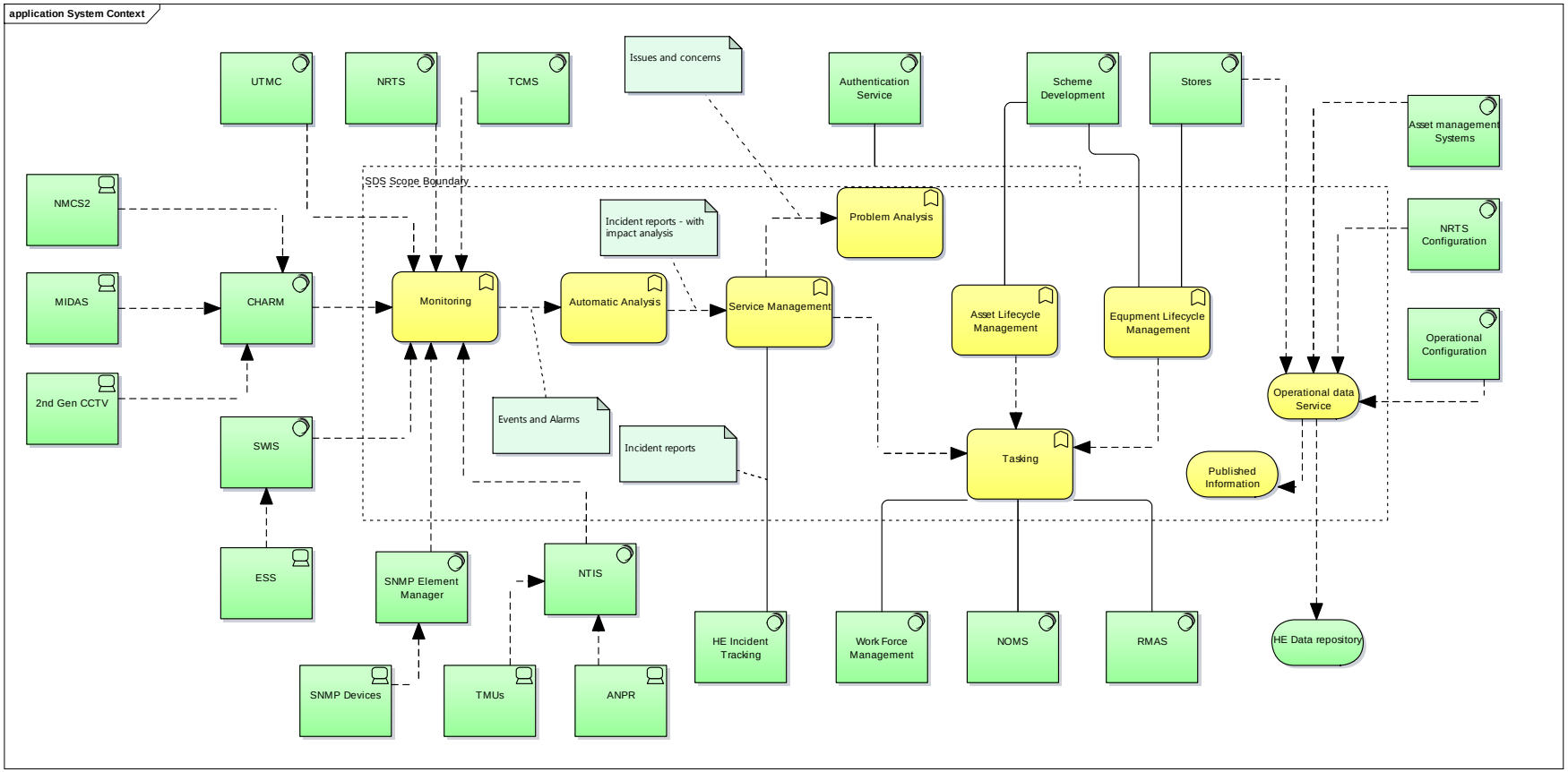
- NRTS providing information about the health of roadside and other communication networks
- Systems reporting on availability of hosting and hosted applications
- Services reporting on availability of office IT, such as mobile platforms
- Stores & logistics for provision of roadside equipment
- Sharing information about fixed assets with Asset management systems
- Interacting for booking traffic management as part of road space booking
- Exchanging information on tasking with systems used to manage on-road and other resources
- Supply all of the collected information to an enterprise wide data repository
- Enterprise wide authentication

T-TOC is intended to manage a wide range of roadside technology, many with long operational lifetimes. The result is a heterogeneous environment which requires a similarly heterogeneous approach. The long term strategy is to use SNMPv3 capable equipment that T-TOC will be able to poll separately for health and other status information, and work has started on the procurement of future devices with this capability. However, for the foreseeable future T-TOC will have to consider each type of device used as operational technology separately. A set of tactical approaches is proposed:

[1] NRTS is responsible for monitoring and managing the communications infrastructure

- Where the device is managed by capable intermediary system, such as an Urban Traffic Management Centre (UTMC) or Tunnel Control and Management Systems (TCMS), T-TOC will exchange incident reports on the health and status of the device with the system rather than individual roadside devices
- For other intermediary systems, such as the Severe Weather Information Service (SWIS), T-TOC will collect health and status information about each device from the intermediary system and generate the incident reports
- Where it is feasible T-TOC will directly poll the roadside devices to collect health and status information. Cameras meeting the ONVIF standards and SNMPv3 capable devices will be polled in this way
- For NMCS2, MIDAS and 2nd generation cameras T-TOC will have to collect the health and status data through an interface to CHARM.
- The future management of devices currently managed through the National Traffic Information Service (NTIS) is undecided but the options include sending health and status information directly to T-TOC, or via the NTIS system.
- Emergency Roadside telephones (ERT) are currently monitored by a standalone CMDTE system. The future of ERTs is still to be decided but one option for health management will be to access the CMDTE database directly from T-TOC.

T-TOC will directly replace or supersede the current Planned Engineering Works (PEW) process support web application and the National Fault DataBase (NFDB) manual fault reporting system.
As CHARM enables the retirement of HATMS within each RCC T-TOC will take on the monitoring of roadside devices through CHARM. This will in turn enable TPMS, and the associated Halogen system, to be gradually retired.
T-TOC monitors devices across the whole of the Strategic Road Network (SRN) with England. This includes some 5,000 variable message signs, ,15,000 signals, 30,000 MIDAS sites (each covering between 2 and 4 lanes), 6000 Cameras, 8000 ERTs, 2500 NTIS traffic counting sites, 1100 Automatic Number Plate Recognition (ANPR) cameras and 400 Environment Sensor Stations (which report through SWIS). Other systems, such as those managing Tunnels, are fewer in number but provide information about a complex set of sensors and actuators.



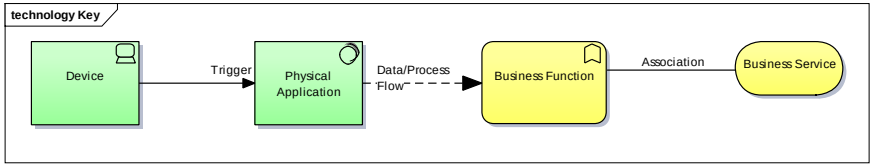


Figure 2 - Simplified T-TOC Context

1.1.2. Key Functions

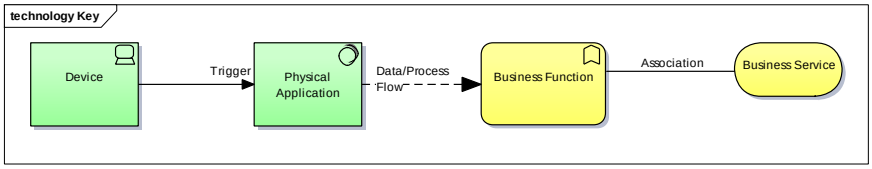


Figure 2 above illustrates a simplified view of the context and architecture of T-TOC.
T-TOC can be considered to be based on a Monitoring service that collects and collates events, alerts and status information to form a coherent view of the status of the operational technology. Data about devices managed by T-TOC is correlated with information from related services. For example a NRTS report of a service failure to an end point will be collated with the status collected by CHARM from the associated NMCS2 device.
The information collected by the Monitoring service is then subject to Automatic Analysis to determine how it affects the services being provided. A service impact will be recorded as an Incident report. The impact of any Incident will then be determined using information about the criticality of each service. Within T-TOC an Incident is a description of any degradation, or potential degradation, of a service being provided. The objective of Automatic Analysis is to reduce the stream of data collected by Monitoring into a manageable set of Incidents for which resolutions can be determined.
Incident reports are passed to Service Management for resolution. The Operational Technology Strategy (ref. [3]) , views this as largely a manual activity with the Technology Operator using their experience, and the collected knowledge base, to assign Tasks to Resolver Organisations. T-TOC will support this activity by providing the knowledge base, templates for common tasks and comprehensive information about equipment and assets.
The Tasking process must consider both simple tasks and more complex work schedules, for example a software upgrade for a particular equipment type. A particular issue is to understand the relationships between Tasks (for example equipment may have to wait for construction activity to be completed). Tasks could be conducted remotely using systems such as RMAS, or require traffic management to be booked through NOMS. T-TOC needs to support interactions with other systems. .
This document envisages that the business processes underlying the Tasking activity will be supported by a set of workflows that will be developed incrementally by Highways England as the processes and systems mature.
Managing technology on the roadside requires T-TOC to consider the lifecycle of the installed devices, for instance its expected life before refurbishment or regular checks. This document has made a distinction between Equipment, the physical technology required, and Operational Assets, which systems such as CHARM control. Therefore there is an Equipment Lifecycle Management function, concerned with activities such as installation and software versions, and an Asset Lifecycle Management function, concerned with activities such as electrical testing and calibration.
All of these functions will be supported by an Operational Data Service that will hold all of the documents and records required to support the services. These will include ensuring that the view of the SRN is aligned with the operational view, NRTS for telecommunications and the Asset Management Systems used by other engineering services.

1.1.3. Delivery Approach

Many of the capabilities that T-TOC requires are also required by other areas with Highways England, Therefore the approach is to identify coherent business functions within T-TOC and consider how each function could be procured. The expectation is that in some cases existing, or planned to be procured, applications could be used. An example could be Service Management where there are existing products in use for business ICT and CHARM is considering how it will address similar requirements. In other cases there are opportunities to share procurements with other areas. An

example would be a workflow/business process application that could support the T-TOC Tasking function alongside workflows within CHARM for configuration management.
The aim is to minimise bespoke software development but it is likely that in order to accommodate legacy devices, such as NMCS2 signals, it will be necessary to build adaptors. These will convert the status information into standard formats used to report Incidents before processing by the rest of T-TOC. The expectation is that these adaptors will connect to T-TOC through an Enterprise Service Bus (ESB).
The corollary of this delivery approach is that implementation will need to be similarly flexible, aiming to deliver the required capability through the accumulation of smaller steps. Thus an Agile approach is proposed, building in short regular cycles and reviewing the plan on each iteration. This provides the required flexibility, is able to respond to changes in the programmes for other systems and to take opportunities as they present themselves.
It is important that T-TOC is able to provide early benefits and so a series of plateau has been proposed. In TOGAF terminology a plateau is a stable state of the system development, often corresponding to a relase into operational use.

1.1.4. ITIL and ISO 55000

Highways England has made strategic decisions to align with ITIL for service management and ISO 55000 for asset management. T-TOC is affected by both decisions as it is both providing a service and managing assets. As part of the work in preparing the T-TOC architecture both of these were reviewed and a considered view was taken that they do not conflict, but rather complement each other. ISO 55000 leading on what should be done, while ITIL leads on how it should be done. ITIL provides additional detail on managing services, while ISO 55000 provides a stronger lead on lifecycle management. Therefore T-TOC will align with both the ITIL Framework and the ISO55000 standard.

1.2. Document Structure

This document intends to provide a complete view of the architecture of the proposed solution and procurement. The term T-TOC is used throughout to refer to the systems and processes that will be deployed to manage the operational technology.
Each of the chapters is described below.

Section 2 Scope

The document starts by making a series of statements intended to define the scope of T-TOC, that is, the scope of the operational technology management. The products or applications that could be used to build T-TOC are applicable across a much wider Highways England's business. It is a basic principle that wherever feasible T-TOC should re-use applications and so this scope is intended to manage the scope of the requirements rather than be fixed business or contract boundaries.

Section 3 Context

A broad overview is provided of the current system landscape for managing operational technology and of the initiatives, projects and trends that will impact on the management of operational technology.
The described set is not intended to be definitive, or prescriptive.

Section 4 Logical Architecture

The logical application architecture is described, with a brief description of each component grouped within the key logical functions, which are aligned with work areas.
A physical application is likely to have to provide a number of logical applications. The role of the logical architecture is to support the description of the T-TOC functionality and the functionality required from the physical applications and business processes.

Section 5 Data Architecture

A conceptual data model has been produced identifying and describing the data entities to be manipulated by T-TOC processes and systems.
The logical entities may be translated into sets of physical data that may be held across multiple systems.

Section 6 Technology Architecture
This chapter provides a brief description of the technical landscape in which T-TOC will be deployed, including the hosting, service bus and an initial service catalogue.
Annex 1 – Terminology, Acronyms and Architecture Diagram Key
Terms and acronyms used in the document are listed in this annex, together with a key to all of the architecture diagrams.
Annex 2 – Web Service Sizing Calculations
This annex provides the draft workings for deriving the capacity and latencies of each of the services identified in the draft service catalogue, section 6.6.

1.3. References

No.	Reference	Title
[1]	EA-Principles-v2.1 FINAL January 2016	Enterprise Architecture (EA) Principles
[2]	Technical Policies v2.1 FINAL Dated January 2016	Enterprise Architecture (EA) Technical Policies
[3]	Operational Technology Strategy 2015 Dated 18 January 2016 Issue 1.0	Operational Technology Strategy 2015
[4]	http://www.snmp.com/snmpv3/	Simple Network Management protocol (SNMP)
[5]	CH2M ISO 55000 Processes	Asset Management Process Development Pre-Read provided by the Asset Management Programme Delivery Team 2015
[6]	Asset Management v3 Dated December 2015	Asset management – an anatomy Institute of Asset Management Describes the principles of Asset Management as captured in ISO55000
[7]	T-TOC Requirements Catalogue v0.15	Catalogue of captured and review requirements
[8]	High-Level Design Guidance Enterprise Service Bus v1.1 Dated 9th December 2016	Provides guidance on the application of an Enterprise Service Bus (ESB) capability within Highways England

2. Scope

T-TOC is intended to provide a solution, or set of solutions, to manage the operational technology that is currently deployed, or will be deployed in the next 5-10 years, to manage the Strategic Road Network.

2.1. Definition of Operational Technology

The scope of operational technology is partly defined by the scope of other systems and partly by specific statements. Thus operational technology does not include:

- Any data centre hosting
- Any applications hosted in a data centre
- CHARM applications
- Highways England enterprise applications, such as the Enterprise Service Bus and Data Repository
- PCs, tablets or mobile phones
- Any applications hosted on PCs, tablets or mobile phones
- Devices that comprise the NRTS network provision
- Equipment and systems designed for monitoring vehicles (such as fuel levels in grit spreaders), however I2V devices will be included

It should be noted that although the above are not included in the scope of T-TOC monitoring they may form part of the overall T-TOC systems and processes.
Operational technology is intended to include the devices below, although they may not initially be under direct management of T-TOC:

- Traffic Monitoring Units (TMU) and ANPR cameras provided under the NTIS contract
- CHARM interfaces to external systems, such as Airwave and the Emergency Services Network (ESN)
- Ancillary devices, such as DDS controllers, used to manage the SRN that are not specifically excluded from the scope
- Technology installed within tunnels on the SRN, including those controlled by the proposed TCMS
- Technology, such as traffic signals, controlled by Highways England UTMC systems
- Proposed ONVIF capable Cameras and other video equipment
- Emergency Roadside Telephones
- Roadside enforcement systems, such as HADECS locations
- Ramp metering sites
- Signals and indicators, including controllers and displays
- Variable message signs. including controllers and displays
- Traffic counting sites, whether MIDAS or otherwise, including both the detection equipment (such as in-pavement loops) and the roadside electronics
- Environmental Sensor Stations
- Mobile VMS systems

2.2. T-TOC Functions

The functional scope of the T-TOC systems can be defined by the following statements:

- T-TOC will identify Incidents, that is service affecting events or statuses, reported by either the devices or their controlling systems. Incidents will be tracked from identification to resolution.

- T-TOC will enable and support Technology Operators in creating, scheduling and supervising Tasks to resolve those Incidents.
- T-TOC will provide lifecycle management of Equipment Items and Operational Assets, optimising their use for operational management of the Strategic Road Network
- T-TOC will support and maintain the relationships between Operational Assets, as identified by CHARM devices, and the Equipment Items deployed to deliver the required service.
- T-TOC will support and maintain the relationships between NRTS communication services, as identified by NRTS Service Delivery Points (SDP), and the Equipment Items connected to those services.
- T-TOC will support and maintain the relationships between Fixed Assets (such as gantries), as identified by Asset Management Systems and the Equipment Items located on or in those Fixed Assets.
- T-TOC will share information with logistics & stores systems to track Equipment Items from initial delivery to stores, installation at the roadside, during repair and to eventual disposal.

2.3. Data and Information

T-TOC will maintain current status information for all of the Operational Assets and Equipment Items in its inventories. It will also hold all currently active Tasks and Incidents.
It will retain sufficient historical information to support the day to day operation of the system. This does not mean that information will only be held for one day. The detailed retention policy could incorporate statements such as:

- Status records will be held over a sufficient period to enable Technology Operators to assess whether the status is within normal bounds, perhaps 3 months
- Task information and records will be held until a sufficient period after the completion of the Task as required to ensure it has successfully been completed, perhaps 2 months

Management information, analysis or reporting on periods greater than the working day will not routinely be produced using data held by T-TOC. To support that processing all data generated and collected by T-TOC will be exported to a Highways England Data Repository facility.

2.4. Business Processes

To support T-TOC functions, there is an expectation that the following information will be provided to T-TOC by external systems at the point it is created/
. Thus the following expectations apply:

- Procurement Records for Equipment Items will be collated as part of the procurement and supply process and be available to T-TOC when the Equipment Items enter the stores & logistics systems.
- All Equipment Items will have a machine readable unique identifier allocated, preferably, before the Equipment Item is put into store, and definitely before it is issued for installation.
- Procurement Records for Operational Assets will be collated as part of the scheme design and planning, and available to T-TOC as part of the scheme development interface.
- The physical locations of Equipment will be derived from the physical location of the Fixed Asset with which they are associated, and thus provided by Asset management Systems, not by individual collection of information GPS locations at the roadside when the Equipment Items are installed. Although GPS locations will be used in the absence of accurate information from other sources.

T-TOC will not directly manage faults with Equipment Items. It will manage service impacting Incidents. If a fault status is being reported from an Operational Asset that will be taken into account in determining the resolution. This is because fault information is not necessarily related to the reporting device, and may not be the underlying cause. Equipment Items are not usually repaired at the roadside, usually being sent back to a repair facility managed by the stores & logistics business teams.

Although not all equipment faults directly or immediately impact they should either degrade the level of service or carry a risk of degrading the service. Where the Equipment is faulty, but service is not currently affected an Incident would still be raised but as a potentially degraded service. If an issue or status reported has no effect, or likely effect on a service there is no reason to respond to it.

3. Context

The sections below described the business context in which the T-TOC systems will be deployed, in particular the projects that will impact on that deployment and ongoing operation.

3.1. Current Systems

Highways England already has systems and processes to manage the existing operational technology. However they will not be able to meet the challenges of the next few years. The sections below describe some of the issues affecting particular systems in use today.

3.1.1. Overview

The current systems are focussed on the NMCS2 roadside devices, MIDAS sites and 2nd generation cameras that form the core technologies in use on the motorway system.
NMCS2 and MIDAS devices are monitored by the HATMS systems and fault logs transmitted to the Halogen system. Halogen collates and collects fault logs, and other operational records, and holds them in a Data Warehouse. Fault logs are also sent on to Technology Performance Management Systems (TPMS) which analyses the logs and generates “Trouble Tickets” for resolution by RTMC users.
2nd generation cameras generate their fault logs, that are sent to Halogen and processed in a similar way to NMCS2 logs.
There is also a manual fault reporting system, National Faults Database (NFDB), which is used primarily to report issues with systems.
In addition a bespoke workflow application, Planned Engineering Works (PEW), is used to collect permissions for work to be carried out.
All of this activity comes within the remit of the T-TOC project.

3.1.2. Halogen

Halogen was designed to accept operational and fault logs from HATMS and store them in a data warehouse. That data warehouse is then used to generate a range of reports using a set of reporting tools. For example there is a “Roadside Fault Display” used by maintainers to display the current state of devices.
Halogen is also the source of some key performance reports, in particular the device availability reports.
The current 2nd generation CCTV systems send Halogen fault and operation logs in a similar format to the COBS logs. Halogen also stores these logs.
Halogen passes on the fault logs it receives to TPMS.
The Halogen operational reporting capabilities will be superseded by CHARM, as that system is rolled out but there is a need to continue to provide the device status reporting that Halogen currently provides.
Similarly Halogen will not receive fault logs from CHARM; T-TOC will have to provide an alternative route.

3.1.3. TPMS

TPMS is designed to perform a number of tasks. These can be categorised as follows:

- Maintain an inventory of equipment
- Analyse fault logs and generate appropriate “Trouble Tickets”. Trouble Tickets are similar to incidents.
- Enable Trouble Tickets to be assigned to individuals for resolution
- Measure the performance of maintainers in maintaining equipment in service
- Scheduled asset lifecycle tasks, such as electrical inspections

TPMS takes faults from Halogen for NMCS2, MIDAS and 2nd generation CCTV devices. It also records faults for ERTs based on a feed from the Centralised Maintenance Depot Terminal (CMDTE).
In order to support maintainers in the field TPMS includes a handheld device, running an embedded Windows application that provides information about devices and trouble tickets. It also has online forms used for checklists.
It should be noted that once the SDS Lite project starts its operational phase Highways England intends to use the TPMS name for all of the systems it includes.

3.1.4. PEW

PEW is a bespoke workflow that collects key information and authorisation for work to be carried out both in control rooms and on the roadside. The focus is on more disruptive work, such as schemes. It is not generally used for the fault fixing work undertaken by RTMCs, unless the work affects a wider area or devices other than those which are faulty.
PEW's bespoke nature means that it is not easy to develop the workflow for new processes and roles. It is also not linked to TPMS tasks or to important areas such as road space booking.
T-TOC will have to provide workflows that link to the Tasks and which support all of the activities of the Technology Operations Centre and so PEW will be retired.

3.1.5. NFDB

NFDB is a database application that enables users to report faults manually against a range of equipment, including systems that are not within the scope of either Halogen or TPMS.
As with PEW the workflow and database structure within NFDB is bespoke and not easy to develop. T-TOC will have to provide manual entry for faults but NFDB does not offer a suitable platform for this and so will be retired.

3.1.6. SDS Lite/OpenAssets

In order to continue to support the technology when the current TPMS is retired Highways England will have deployed an interim solution using a product called OpenAssets[2]. This product will provide an inventory with some asset management capabilities including customisable workflows for incident management.

3.1.7. Other technology to be monitored

There are some significant omissions in the devices monitored by Halogen and TPMS. Some of the devices appear in the TPMS database, with incidents being manually entered. Others devices and systems are managed separately. The first category includes ESS and Ramp Metering sites. The second category includes traffic lights managed by UTMC systems and roadside enforcement sites.

3.2. Highways England Enterprise Architecture

Highways England has a set of architectural principles and associated policy set that is intended to guide decision making on IT.
The Enterprise Architecture principles (Ref. [1]) and the Technical Policies (Ref. [2]) have been a significant input to the requirements for T-TOC; while the assessment criteria will be aligned with the relevant policies. In particular the procurement will aim to use COTS products and to ensure that vendor lock-in, especially for bespoke customisation, is minimised.

3.3. Operational Technology Strategy

Highways England has an Operational technology Strategy (Ref. [3]) that outlines the future operating model for technology management. This architecture builds on that operating model, further refining roles and the logical functions it must perform.

[2] http://www.capita-software.co.uk/solutions/asset-management

The stratagems that have the most significant impact on the systems and solutions proposed by T-TOC are:

- The creation of a Technology Operations Centre providing 24/7 support of the technology, which is better aligned with the use of that technology
- Direct management of the technology by Highways England, including a new Technology Operator role

Both of these initiatives change the focus of technology management from fault fixing service to service and asset management. This is in accordance with Highways England's policy of aligning with ITIL for Service Management and ISO 55000 for Asset management, something which has been reflected in the Business Architecture below.

3.4. Business ICT

Traditionally within Highways England business ICT was managed separately from operational technology. This division is being reduced, partly by the convergence of the director level management of these areas and partly through a convergence of the technologies, although significant differences remain.

ITIL is a framework that has been developed within business ICT, a much larger market than operational technology, and there are a wide range of products with an equally wide range of capabilities. There is an expectation that service management products within that market sector will be able to meet a significant number of the identified requirements for T-TOC.

There is an aspiration that the support for business ICT should be using the same tools as operational ICT. However there may not be any tool that meets both sets of requirements and so there is a requirement to exchange incident information with any business ICT service management, as well as other service management arrangements within Highways England.

3.5. CHARM

The CHARM project is replacing all of the operational instation systems, essentially replacing HATMS, Command & Control and the CCTV instation. It will transform the use of technology by operators in the RCCs. However it is not replacing roadside technology.

The most significant impact of CHARM on T-TOC is that an Enterprise Service Bus (ESB) is being procured under that contract which will be used to orchestrate services and share data across all Highways England applications. This document includes sections describing the services it will present on the ESB. As the design of the ESB is not yet ready for publication this document also identifies a set of information that will be needed from the ESB team to guide the deployment of those services.

Another significant impact of CHARM on the T-TOC project is in changing the access to health, performance and status information for the NMCS2, MIDAS and 2nd generation CCTV equipment. Currently this data is all received via the HATMS COBS and Halogen. CHARM will be providing this data directly, via the ESB, to T-TOC.

The number of devices that will be monitored by CHARM for onward reporting to T-TOC will be very significant, and represent the most critical devices. Any T-TOC solution could not be considered fully operational until those devices are under full service and asset management.

3.6. SNMP v3

Highways England has decided to standardise the management of roadside devices using SNMP v3 (Ref. [4]). The first stage is to include a requirement for SNMP v3 support in all new devices. Once the relevant Management Information Bases (MIB) have been defined and deployed the aim is to gradually, as equipment is replaced on the roadside, to use SNMP for all roadside infrastructure. This process is likely to take more than 10 years, because the life of roadside equipment is considerable.

3.7. Asset Led Delivery Model

The business model for fixed infrastructure is being radically changed to put Highways England staff as the decision makers, with service organisations performing directed tasks rather than meeting targets for network level KPIs.
This reflects a similar approach in the Operational Technology Strategy that addresses service organisations on the technology infrastructure.

3.8. Better Information Management (BIM)

The BIM project is working to improve the quality of the data held about Fixed Assets. As part of that project an Asset Delivery Management Manual (ADMM) has been developed. The ADMM includes a chapter for technology, which is currently blank, that could be taken from the Conceptual data Model described in chapter 5. This would enable some issues around technology specific terms used for fixed assets, for example for cabinets, to be resolved by aligning the terminology in both areas.

3.9. Other Projects

A number of existing technology management solutions have not directly monitored the status of associated devices deployed to the roadside, although some are included in the inventory so that manual faults can be raised. These systems and devices have included:

- Ramp Metering
- UTMC control of traffic signals
- Tunnel control systems
- Environmental Sensor Stations (ESS) also known as weather stations
- Devices managed by NTIS
- Emergency Roadside telephones

All of these systems are the subject of projects that are considering their future development. T-TOC should provide a flexible platform that will enable them to be managed effectively. In some cases SNMPv3 will be the enabler; in other cases it may be appropriate to connect them to CHARM via an adaptor connected to the ESB to monitor their status.

3.10. The Internet of Things (IoT)

There is a great interest around new technologies for managing networked devices of which the most relevant to is the Internet of Things (IoT). Currently it is difficult to be sure which standards and technologies will be more widely adopted. As the technologies around the Internet of Things (IoT) mature it is possible that SNMP may also be retired, or superseded. However the depth of the current SNMP market means that is likely to take a number of years.
The approach of using COTS products with APIs connected to an ESB supports an approach whereby new roadside technology (e.g. IoT devices without SNMP) can be supported by connecting them to a new COTS platform rather than modifying whatever management tools that have been procured to manage SNMP devices.
Going forward T-TOC may have to support new protocols and IoT architectures. Therefore the solution must be a flexible platform that evolves to support changing requirements.

4. Logical Architecture

4.1. Overview

The sections below describe each of the logical entities in the Logical Architecture in *Figure 3* below. They have been grouped into larger functional groupings, which will also be used to discuss the work areas and market assessments. This grouping is:

- Monitoring and Automatic Analysis – the initial collation of health and status data and the generation of Incidents
- Service Management – management of Incidents as part of ITIL service management
- Analysis and Reporting – general capability to analyse data, including regular reporting, dashboards, visualisation and ad hoc reports
- Workflow – capability for automated and supported workflows focussed on Tasking
- Document and Record Management – capability to hold and retrieve documents and records of all varieties. Including a full search capability.
- Asset Management – Inventory, records management and lifecycle management to manage assets
- Common Capabilities – capabilities provided by T-TOC applications that are used across T-TOC, such as GIS.

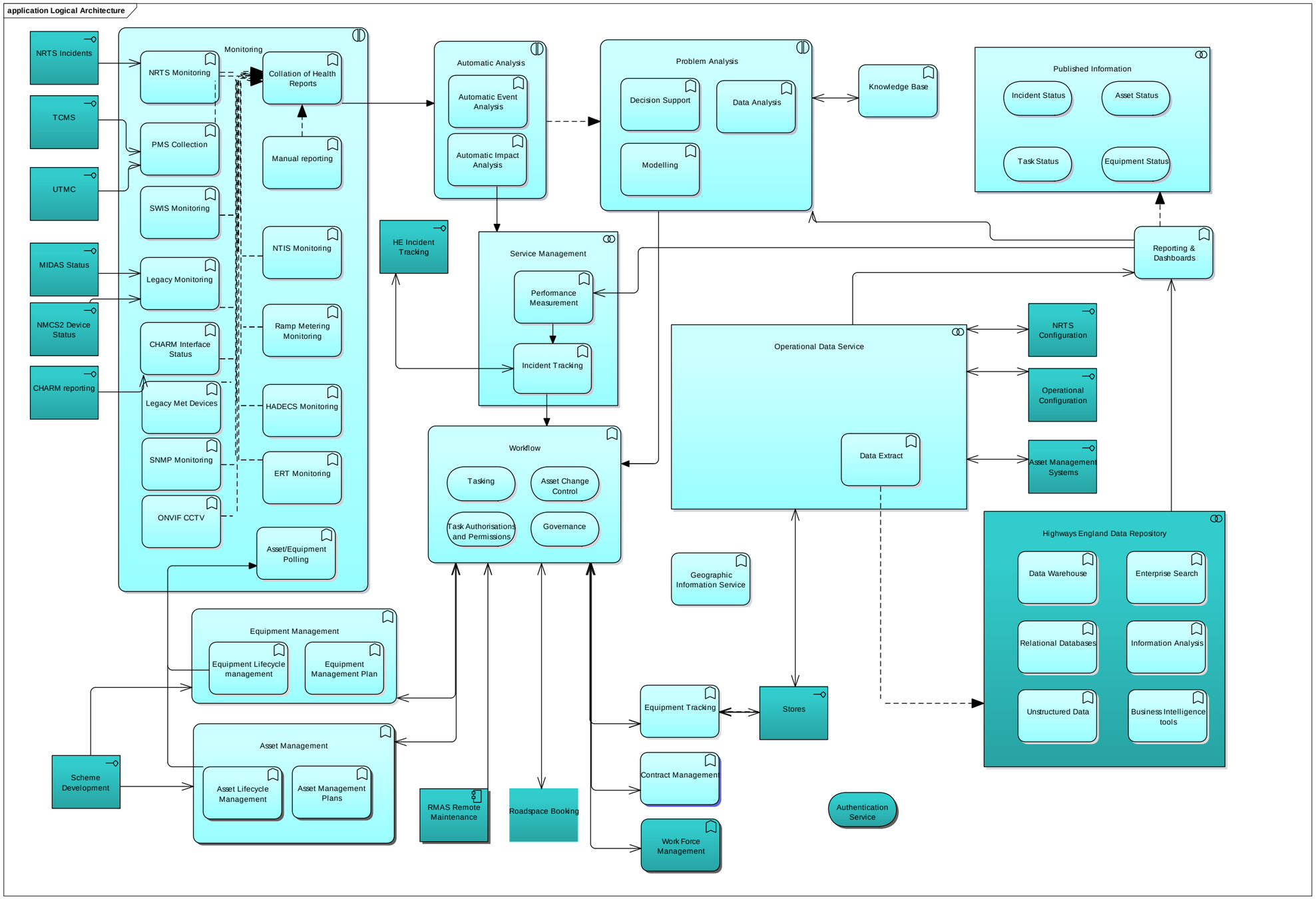


Figure 3 - Logical Architecture

4.2. Monitoring and Automatic Analysis

4.2.1. Asset/Equipment Polling

This function will be responsible for requesting information from Equipment Items, whether to collect further diagnostic information or to refresh status information.
Depending on the Asset Management Plan, these requests could be on a regular process or as required.
This function is likely to be limited to devices using open standards such as SNMPv3 devices or ONVIF cameras.
It should be noted that where devices are being polled by both T-TOC and an operational system the polling intervals must take into account the need to avoid adversely affecting the service levels. As part of that consideration the configuration should consider real world response times by Technology Operators to roadside faults. This likely outcome is that polling intervals will be greater than one minute, rather than the much shorter periods required to provide adequate responses to operational use of the device.

4.2.2. Automatic Analysis

This function is a grouping of the Automatic Event Analysis and Automatic Impact Analysis functions aligned with the products on the market.

4.2.3. Automatic Event Analysis

This function processes the status changes, alerts, incident reports and service status information collated by the Monitoring. Using business rules it generates an update or a close Incident. The business rules will initially be based on the TPMS rules.
Incidents will be raised against Operational Assets, with any status, fault or service reports attached as additional information.
The aim of Automatic Event Analysis is to process information received from Equipment Items and to produce a manageable set of Incidents to resolve. In many cases this can be achieved by grouping reports together because they have a common cause.

4.2.4. Automatic Impact Analysis

This function assigns an impact to each Incident based on information about the criticality of the Operational Asset collected at Procurement and updated at Deployment. For example Signals are generally more critical than Variable Message Signs (VMS) and the criticality assigned at Procurement should reflect that. However as part of their role within an operational regime a VMS may be assigned a higher criticality.
The assessment of criticality will initially be based on the implicit criticality expressed in the current RTMC contracts. By including in the T-TOC data that criticality can be amended as HE's experience of operating the assets grows, rather than being bound by the contract.
The impact assessment will be presented to users to support their assignment of Tasks.

4.2.5. CHARM Interface Status

This function collects information from CHARM on the status of key interfaces, such as Airwave, ESN or PSN/P. It then presents it in a standard format to be collated with health reporting from other systems.
It may also be used to report other internal statuses of value to the management of the technology, such as a failure of the NMCS2 adaptor.

4.2.6. Collation of Health Reports

This function collates health and status reports from all of the monitoring functions and presents them in a standard format for analysis by T-TOC.

4.2.7. ERT Monitoring

This function will interface with any systems monitoring the Emergency Roadside Telephones to generate events, alarms and incidents as part of the Monitoring collaboration. Currently ERTs are monitored by the CMDTE system.

4.2.8. HADECS Monitoring

This function will interface with any systems monitoring the HA Digital Enforcement Camera Systems (HADECS) to generate events, alarms and incidents as part of the Monitoring collaboration.
The level of processing required will be determined by the ability of HADECS to generate data in a suitable format.

4.2.9. Legacy Met Devices

This function will interface with any systems monitoring the dedicated devices currently managed by the Met Subsystem to generate events, alarms and incidents as part of the Monitoring collaboration.

4.2.10. Legacy Monitoring

This function interfaces with CHARM to generate events, alarms and incidents, as part of the Monitoring collaboration, for NMCS2 devices, MIDAS devices and 2nd generation CCTV equipment.
CHARM will provide the status information through the NMCS2 and MIDAS Device Status service.

4.2.11. Manual reporting

This is a facility enabling users to report incidents in a standard format. Users should be able to report a degradation of, or risk to, a selected service. In many cases this will be a particular operational asset but it could be an application or control room service.

4.2.12. Monitoring

This collaboration encompasses all of the logical applications for taking status, health, alarms, events and other reports from operational systems and collating them into a set of Incidents for analysis.
It is expected that the approach to generating Incidents will vary depending on the information available from the Operational Asset being monitored. Examples of the diversity of that Monitoring must support include:

- Status information provided in a single byte from NMCS2 devices
- Datex II publications from SWIS
- Service level reports from Ramp Metering
- Manually entered Incidents

There is a strategy to move to SNMP v3 reporting from all devices, but the life cycle of roadside equipment means that it may take 5-10 years before a substantial number of devices are able to report through SNMP.
In the meantime Monitoring will take a system by system approach, using frameworks to align the reporting of Incidents from all of those systems based on the concepts described elsewhere in this document.

4.2.13. NRTS Monitoring

This application interfaces to NRTS management systems to collect incident information such as the status of telecommunications services to be collated and presented for automatic analysis.

4.2.14. NTIS Monitoring

This application interfaces to NTIS to collect incident information to be collated and presented for automatic analysis. These devices include Traffic Measuring Units (TMU) and ANPR cameras.

Currently these faults can only be entered manually. It is not clear whether NTIS is able to report Incident information, or at what level. It is clear that any collection of this information while it remains under NTIS management would require changes to NTIS.

4.2.15. ONVIF CCTV

This application represents the collection of Incident Information from cameras using the ONVIF standard which Highways England is proposing to deploy as the new CCTV standard.
The technical details of health monitoring will need to be discussed when the architecture of the new system is decided.

4.2.16. PMS Collection

This application presents a standardised service issue/Incident reporting interface to systems that are able to report in this way. Examples could include the Tunnel Control and Management System (TCMS) and UTMC (for traffic signals).

4.2.17. Ramp Metering Monitoring

This function will interface with any systems monitoring the health of Ramp Metering installations to generate events, alarms and incidents as part of the Monitoring collaboration. The level of processing required will be determined by the ability of Ramp Metering systems to generate data in a suitable format.

4.2.18. SNMP Monitoring

Highways England has decided to require new roadside devices to include SNMP monitoring. The aim is to build a standardised monitoring service.
SNMP monitoring provides alerts and access to Management Information Bases (MIB) held on the device that provides a set of status and quantitative measurements. This logical function will have to transform that information into Incidents for collation and analysis.

4.2.19. SWIS Monitoring

The SWIS system monitors ESS, collecting information in a Datex II format. SWIS adds further information, including the diagnosis of more complex faults, but does not currently publish that data.
T-TOC needs to build a function that is able to interpret that Datex II information and generate appropriate Incidents for collation and analysis.

4.3. Service Management

4.3.1. Contract Management

There are many suppliers offering a Contract Management solution. It represents a capability to bring together contract documents, performance management reports and management records into a single interface. This function identifies that capability for inclusion as a candidate solution.
However it may be out of scope with Contract Management better as a standalone offering to Contract Managers or Stores Managers.

4.3.2. Incident Tracking

This function presents a set of incidents to appropriate users to enable them to decide how to resolve the incidents, and whether to close an incident.
The function tracks the activities associated with the Incident, such as initial identification of the Incident, creation of a Task to resolve the Incident and the reasons for closing an Incident.

4.3.3. Performance Measurement

A logical application that provides information as part of Service Management on the performance levels of Operational Assets, and Equipment Items.
Since T-TOC Service Management is focussed on the services provided by Operational Assets, Performance Management will be similarly focussed. Certainly measuring Equipment Item performance is best delivered through reporting and dashboards using data collected over several months.
Within T-TOC, Performance Management measures which services are available for use, which are degraded and which are at risk, rather than quantitative assessments such as throughput.

4.3.4. Service Management

This is a collaboration that, through Performance Measurement and Incident Tracking, delivers the ITIL service management elements of T-TOC.

4.4. Analysis and Reporting

4.4.1. Asset Status

T-TOC will publish information about the status of each Operational Asset for use by other systems, including CHARM.
The status will take values indicating whether the Operational Asset is available for use. This will range from “Unavailable” through to “Available but with a low risk of degradation of service”.
The table below illustrates how the effect of some faults could be reported:

Table 1 - Illustration of Mapping Status to Availability

Status	Availability	Caveat
Power fail to a signal	Signal Unavailable	Affecting a significant number of Operational Assets
Unobtainable MIDAS Outstation	Traffic Counting site/loop pair Unavailable	Affecting a number of related Operational Assets
Ramp Metering signal failed	Ramp Metering site Unavailable	Affecting a single Operational Asset
Camera motor failure	Camera Available	Significantly degraded operation
LED character module fail	VMS Available	Some service degradation
Heater fault on signal	Signal Available	Risk of service degradation later
Suspect calibration	Traffic counting site/loop pair Available	Data and alerts being generated may not be reliable

The mapping between faults and status should be part of the information collected about Operational Assets during Procurement.

4.4.2. Data Analysis

This function is a capability for a more thorough analysis of the data collected by T-TOC that can be used to identify issues and propose resolutions.

The function aligns with a number of tools on the market which support the building of ad hoc queries and data visualisation.
It forms part of the Problem Analysis tool set.

4.4.3. Decision Support

This function will support Problem Analysis by guiding users through some standard processes, and presenting appropriate information as required. It may also be linked to the Knowledge Base to identify relevant knowledge base articles or notes.
It forms part of the Problem Analysis tool set.

4.4.4. Equipment Status

T-TOC will publish the status of each Equipment Item for use by other systems.
The following information will be published:

- Identifier of the Equipment Item
- If applicable, the identifier of the Parent Equipment Item
- Stores Location if the Equipment Item is in stores, the identifier of the store or warehouse
- Fixed Asset reference for installed Equipment Items
- GPS location, taken from the Fixed Asset reference
- Marker Post location, taken from the Fixed Asset reference
- Power supply identifier for installed Equipment Items
- Communications identifier for installed Equipment Items
- Status of the Equipment Item indicating whether it is available for use. The table below illustrates how status could be represented

Table 2 - Example Equipment Item Status

Status	Expansion	Description
Healthy		**No known faults**
Degraded	**Identifier of Child Equipment Items that have faults**	**Although the Equipment Item has no identified faults some Child Equipment Items have identified faults.**
Faulty	**Set of known fault reports affecting the performance of the Equipment Item, although it may still be functional**	**Where the Equipment Item has faults assigned to it but could still be used**
Failed	**Set of known fault reports affecting the performance of the Equipment Item**	**Where the Equipment Item is not usable**

4.4.5. Incident Status

T-TOC will publish information about the status of each Incident for use by other systems. The information will include:

- Identity of the affected Operational Assets
- Identity of the affected Equipment Items
- History of the Incident; when it was opened, list of actions, closure
- Identity of any Tasks planned to resolve the Incident

4.4.6. Knowledge Base

This function represents the collation of information about managing operational technology. It will contain a very wide range of information of which the list below illustrates with some examples:

- Notes regarding issues about specific Equipment Types
- Best practice for resolving common incidents
- Anecdotal evidence about causes of some common incidents that should be investigated
- Method statements that have been successful used in other areas

Some of this knowledge can be captured across T-TOC, for example method statements can be captured in task Templates.
The knowledge base will present and hold information in a variety of formats including Word documents, PDF files, imagery, training videos and spreadsheets.
The capturing of information within the knowledge base will be managed through using Governance workflows and may include Wiki capabilities to allow a range of stakeholders including maintainers and installers to contribute to the knowledge base.

4.4.7. Modelling

These are a suite of tools to support financial and lifecycle modelling for Operational Assets and Equipment.

4.4.8. Problem Analysis

This application provides a set of tools to analyse data held within the Operational data Store and Highways England Data Repository. The aim is to provide ad hoc reporting and visualisation to support the analysis of Problems that may be the root cause of critical or widespread Incidents.

4.4.9. Published Information

This is a collaboration bringing together a set of services that T-TOC can provide to Highways England systems, a snapshot of the current status of operational technology.

4.4.10. Reporting & Dashboards

This function represents a capability to build regular reports and “real-time” dashboards for use across Highways England, its supply chain and its partners.
There is an expectation that the dashboards will be incorporated into a number of corporate websites, presenting information to users across the organisation.

4.4.11. Task Status

This service provides other Highways England systems with the status of each of the Tasks being managed by T-TOC. This should include the associated Operational Assets, Equipment Items, Resolver Organisation any task Dependencies.

4.5. Workflow

4.5.1. Asset Change Control

This service represents a set of workflows to manage changes to Operational Assets and Equipment Items. These changes will include:

- Updates to attributes and other information associated with the Operational Asset
- Planning for the deployment of new Operational Assets
- Deployment of new Operational Assets
- Decommissioning of Operational Assets
- Deployment of Equipment Items into new Operational Assets
- Commissioning of Equipment Items into new Operational Assets
- Replacement of Equipment Items in Operational Assets
- Commissioning of Equipment Items in existing Operational Assets
- Decommissioning of Equipment Items in Operational Assets
- Updates to attributes and other information associated with Equipment Items
- Updates to Equipment Types
- Handover of Operational Assets and Equipment Items into maintenance (replacing the MCH1349 process)

The workflows will ensure that appropriate authorisations are maintained; that updates are provided to associated systems and that agreed business processes are followed. For example deployment of an Equipment Item that is linked to a service from NRTS will require a set of approved documentation, interaction with NRTS (perhaps through automatic discovery) and an agreed set of tests with associated certificates.

4.5.2. Governance

This service represents a set of workflows to enforce governance across the T-TOC solution. These will include:

- Authorisation and approvals for Tasking and Asset Change Control
- Managing updates to the Knowledge Base
- Controlling insertions and updates to the Operational data Store.

4.5.3. Task Authorisations and Permissions

This logical service is a set of workflows that implement business processes ensuring that Tasks have the necessary authorisations and permissions, that any road space has been booked and that any required documents/certificates are in place.
The sophistication and comprehensiveness of these workflows will be developed throughout the lifetime of T-TOC.
Initially the workflows must deliver the functionality currently provided by the PEW system.

4.5.4. Tasking

This logical service is a set of workflows that implement business processes managing the creation, scheduling and progressing of tasks. It will include the building of Task Dependencies, allocation to Resolver Organisations ensuring that Tasks are properly recorded.

4.5.5. Workflow

This is a general capability to build workflows to implement business processes within T-TOC. The focus of this capability will be the creation and management of Tasks within T-TOC

4.6. Document and Record Management

4.6.1. Data Extract

T-TOC will use the same approach to data retention as CHARM. That is all data will be immediately pushed to an enterprise wide data repository shared with other Highways England systems. Data will only be retained within T-TOC for a limited period, sufficient for day to day operation[3].
This function will ensure that data from the Operational Data Store is pushed to the Highways England Data Repository promptly and consistently.

4.6.2. Operational Data Service

This element provides the collation and presentation of all of the data used within T-TOC for day to day operation. It will include tools for managing documents and records as well as operational data in normalised relational databases.

4.7. Asset Management

This functional group brings together two views of the management of operational technology items; as Operational Assets (such as sign display or traffic counting site) and as Equipment Items (such as MIDAS Outstation or LED module). This is because both views have a management plan which drives a series of lifecycle events.
Operational Assets also need to be linked to systems managing fixed assets, such as gantries, while Equipment Items need to be linked to the stores systems. In both cases documents and events will have to be shared with the respective systems.

4.7.1. Asset Management

This function is a grouping of the Asset Management Plan and Asset Lifecycle Management functions aligned with the products on the market.

4.7.1.1. Asset Lifecycle Management

This function manages the technology elements of the life cycle of Operational and Fixed Assets. These include the scheduling of tasks for the deployment of the Asset, its commissioning, regular maintenance, managing obsolescence, renewals and eventual decommissioning.
Each life cycle task will use Task Templates from the Asset Management Plan, built during the procurement of the Asset, to schedule new Tasks at the required time. These will include initial deployment, regular inspections and maintenance.
For example when a new Operational Asset is required through Scheme Development this function could:

- Check that all of the required Documents and Records are available for that Operational Asset
- Use an Equipment Template to build a set of Equipment Types to be installed
- Check that all of the required Documents and Records are available for that Equipment Type
- Schedule a task to obtain the necessary authorisations and permissions
- Invoke the Asset Change Control service to ensure that the agreed business processes are followed
- Schedule the deployment task
- Schedule the commissioning task
- Update the Operational Data Service as required

[3] Due to the timing of putting in place enterprise wide storage there may be a requirement for the T-TOC project to provide adequate cloud storage as an interim arrangement

Wherever the Asset Management Plan identifies Tasks to be carried out during the life of the Asset this function will schedule those Tasks, ensuring that all the necessary Documents and Records are available. The Tasks may involve site visits or could be a desk top check of activities and records.
The Asset Management Plan will identify obsolescence checks, whether for up to date software versions or cabling to current standards. This function will schedule appropriate Tasks to perform these checks on a timetable included in the Asset Template.
Finally Asset Lifecycle Management will manage the decommissioning process. This will include a set of tasks for the removal of the Equipment Items safely as well as ensuring that all of the required records are collected.

4.7.1.2. Asset Management Plans

This function enables users to create, edit and update Asset Management Plans associated with Operational Asset types and Fixed Asset types. These plans include all of the technology related requirements for those Assets.
There will be a set of Documents, Records and Tasks expected at each stage of the lifecycle. The Asset Management Plan will identify the required Tasks, which will be managed by the Asset Lifecycle Management function.

4.7.1.3. Asset Management Systems

This interface represents all of the systems that manage Fixed Assets, such as cabinets, bridges and the road surface. Currently those systems include IAMIS, SMIS, HADDMS and HAPMS.
The interface needs to enable T-TOC to synchronise common information about the Fixed Assets that Equipment Items should be linked to, with the responsible systems. These include cabinets (SMIS), gantries (SMIS) and carriageway locations (HAPMS).
The interface also needs to enable T-TOC to access information held by the various Asset Management Systems based on an identifier held with the Equipment Item. This information could be asset attributes, documents, records or imagery. However the most important information is likely to be location, using both GPS and marker posts.

4.7.2. Equipment Management

This function is a grouping of the Equipment Management Plan and Equipment Lifecycle Management functions aligned with the products on the market. The requirements for Equipment Items are similar to those for Operational Assets and Fixed Assets and it may be feasible to use similar processes and products. However it should be noted that there are differences, not least because Operational Assets are fixed in location where as Equipment Items may move between different Operational Assets.[4]

4.7.2.1. Equipment Lifecycle management

This function manages the technology elements of the life cycle of Equipment Items. These include the scheduling of tasks for the deployment of the Equipment Item, its commissioning, regular maintenance, managing obsolescence and then decommissioning.
Each life cycle task will use Task Templates from the Equipment Management Plan, built during the procurement of the Equipment Type and then Equipment Item, to schedule new Tasks at the required time. These will include initial deployment, regular inspections and maintenance.
For example when a new Operational Asset is required through Scheme Development this function could:

- Check that all of the required Documents and Records are available for Equipment Type required for that Operational Asset
- Use an Equipment Template to build a set of Equipment Types to be installed

[4] See section 5.2.3 for an explanation of the differences between Operational Assets and Equipment Items

- Check that all of the required Documents and Records are available for that Equipment Type
- Schedule a task to obtain the necessary authorisations and permissions
- Invoke the Asset Change Control service to ensure that the agreed business processes are followed
- Schedule the deployment task
- Schedule the commissioning task
- Update the Operational Data Service as required

Wherever the Equipment Management Plan identifies Tasks to be carried out during the life of the Equipment Item this function will schedule those Tasks, ensuring that all the necessary Documents and Records are available. The Tasks may involve site visits or could be a desk top check of activities and records.
The Equipment Management Plan will identify obsolescence checks, whether for up to date software versions or cabling to current standards. This function will schedule appropriate Tasks to perform these checks on a timetable included in the Asset Template.
Finally Equipment Lifecycle Management will manage the decommissioning process. This will include a set of tasks for the removal of the Equipment Items safely as well as ensuring that all of the required records are collected.

4.7.2.2. Equipment Management Plan

This function enables users to create, edit and update Equipment Management Plans associated with Equipment Types.
There will be a set of Documents, Records and Tasks expected at each stage of the lifecycle. The Equipment Management Plan will identify the required Tasks, which will be managed by the Equipment Lifecycle Management function.

4.7.2.3. Equipment Tracking

This function enables a user at the roadside, and other locations, to update both the Stores Location of Equipment Items and to associate it with Fixed Assets.
The function will include the capability to scan bar codes, QR codes, RFID tags and manual entry of serial numbers to identify the Equipment Item. A similar capability is required to identify Fixed Assets at the roadside.
The function will update the location of the scanned Equipment Item together with all of its Child Equipment Items Similarly it will be able to associate a scanned Equipment Item together with all of its Child Equipment Items with a scanned Fixed Asset.
The Equipment Tracking will exchange information with the Stores system to associate Equipment Items with Stores Locations and, when installed, with a Fixed Asset.

4.8. Common Capabilities

4.8.1. Geographic Information Services (GIS)

T-TOC applications will need to be able to display maps, including schematics, and relate the position assets and Equipment Items to positions on those maps and schematics. This could be provided within one or more of the packages, or be linked to a wider Highways England GIS initiative.

4.9. External Services

4.9.1. Authentication Service

The expectation is that Highways England will provide an enterprise wide authentication service, expected to be provided through Microsoft Azure Active Directory Connect and Okta products.
All T-TOC components will use this authentication service to ensure that users and applications have the correct access rights.

4.9.2. CHARM reporting

This is an interface presented by CHARM that reports the status of CHARM interfaces. This is the interface to the CHARM Interfaces Status (see 4.2.5)

4.9.3. Highways England Incident Tracking

This interface is required to exchange Incident information with other systems within Highways England. The interface will be used to re-assign incidents raised on one system to another Incident Tracking function.
The description of incidents will have to be agreed between the various incident/service management products in use. Currently there are no such systems or products defined.
The reporting of Incidents across Highways England should be recorded in the Highways England Data Repository.

4.9.4. Highways England Data Repository

This is an enterprise wide data repository which, while out of scope for the T-TOC procurement[5], is important in providing a facility for producing management reports on performance of Operational Assets and Equipment Items.
T-TOC will ensure that all changes and additions to the Operational Data Store are reflected into the Highways England Data Repository.
The repository will have a collection of technology and tools for use by a wide range of users to generate analysis and reporting. These tools could include:

- Business Intelligence Tools – building information from the data with supporting visualisations
- Data Warehouse – specially designed database describing entities against commonly used report dimensions
- Enterprise Search – tools to search structured and unstructured data
- Information Analysis – data analysis tools to identify relations and correlations in data
- Relational Databases – standard database technologies
- Unstructured Data – tools designed to build links and analysis of unstructured data

4.9.5. MIDAS Status

This is an interface presented by CHARM that reports the status of MIDAS devices.

4.9.6. NMCS2 Device Status

This is an interface presented by CHARM that reports the status of NMCS2 devices.

4.9.7. NRTS Configuration

This is a service presented by NRTS that enable T-TOC and NRTS to synchronise their configuration data, especially the association between NRTS Services Delivery Points (SDP) and Equipment Items or Operational Assets that use those NRTS SDPs.
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4.9.8. NRTS Incidents

This is an interface provided by NRTS that provides information about relevant incidents. Specifically it will report on the health of a NRTS service, and the associated SDPs. This will be used to associate failure of devise to respond to a command/poll from CHARM or SNMP manager with a root cause (i.e. failure of the telecommunication service).
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[5] Depending on the timescales of various other planned projects the T-TOC provider maybe required to put in place interim arrangements for bulk storage of T-TOC generated data

4.9.9. Operational Configuration

This is a service presented by CHARM that enables T-TOC and CHARM to synchronise their configuration data, especially the association between CHARM Operational Assets, Fixed Assets and Equipment Items.
The key information is an accurate and complete list of the Operational Assets used by CHARM and monitored by T-TOC.

4.9.10. RMAS Remote Maintenance

The Remote Maintenance Access Service (RMAS) can be invoked by Technology Operators to perform specific tasks, including the retrieval of diagnostic information.
T-TOC will be able to provide configuration information for RMAS, built from data in the Operational Data Service.

4.9.11. road space Booking

This interface will be provided by the Network Occupancy Management System (NOMS). Ideally T-TOC would be able to invoke NOMS and include the road space booking within Tasks. As a minimum T-TOC will invoke NOMS and enable the user to record whether road space has been booked and provide a reference.

4.9.12. Scheme Development

This function provides a means to access information created by schemes that can be included in the Operational Data Store. These could include:

- Describing proposed new Operational Assets
- Records and Documents that should be linked with T-TOC entities such as As-Built drawings, site information (through Fixed Assets) and Asbestos register entries for cabinets
- BIM entities on a 3D model that represent Operational Assets or maybe Equipment items
- Demand for Equipment Items, which will need to be provisioned

4.9.13. Stores

This interface is provided to exchange information between T-TOC and the stores & logistics systems. In particular the location of Equipment Items, in terms of installed or in a store, should be shared between the systems. There are also other opportunities (such as the number of currently faulty Equipment Items and the expected provisioning of Equipment Items) that stores & logistics can use to ensure a sufficient supply of equipment.

4.9.14. TCMS

The Tunnel Control and Management System will manage all of the equipment deployed in the associated tunnel. It has a number of safety related requirements which require some measure of isolation from CHARM. However it is expected to provide Incident and service related information to T-TOC.
TCMS should report as a Performance Management System through the PMS Collection interface.

4.9.15. UTMC

There are a number of Urban Traffic Management Centre (UTMC) systems, usually controlling traffic signals on motorway junctions. It is expected to provide Incident and service related information to T-TOC as a Performance Management System through the PMS Collection interface.

4.9.16. Work Force Management

There is an expectation that some resolver Organisations will have Work Force Management systems. T-TOC may have to interface to those systems to provide information about Tasks. However the assignment of individuals is not considered to be in the scope of T-TOC.
It is important that T-TOC is able to require forms and checklists associated with Tasks to be completed by the engineer or other individual carrying out the Task.

5. Data Architecture

5.1. Conceptual Data Model

The conceptual data model presented below provides a description of the data entities referenced elsewhere in this document. The entities may not map directly on to the physical data within the solution, sometimes being included within larger entities or divided between blocks of physical data. Their purpose is to facilitate the description of the logical functions required and the information to be processed.
Each entity is described below together with the key concepts for understanding its use.

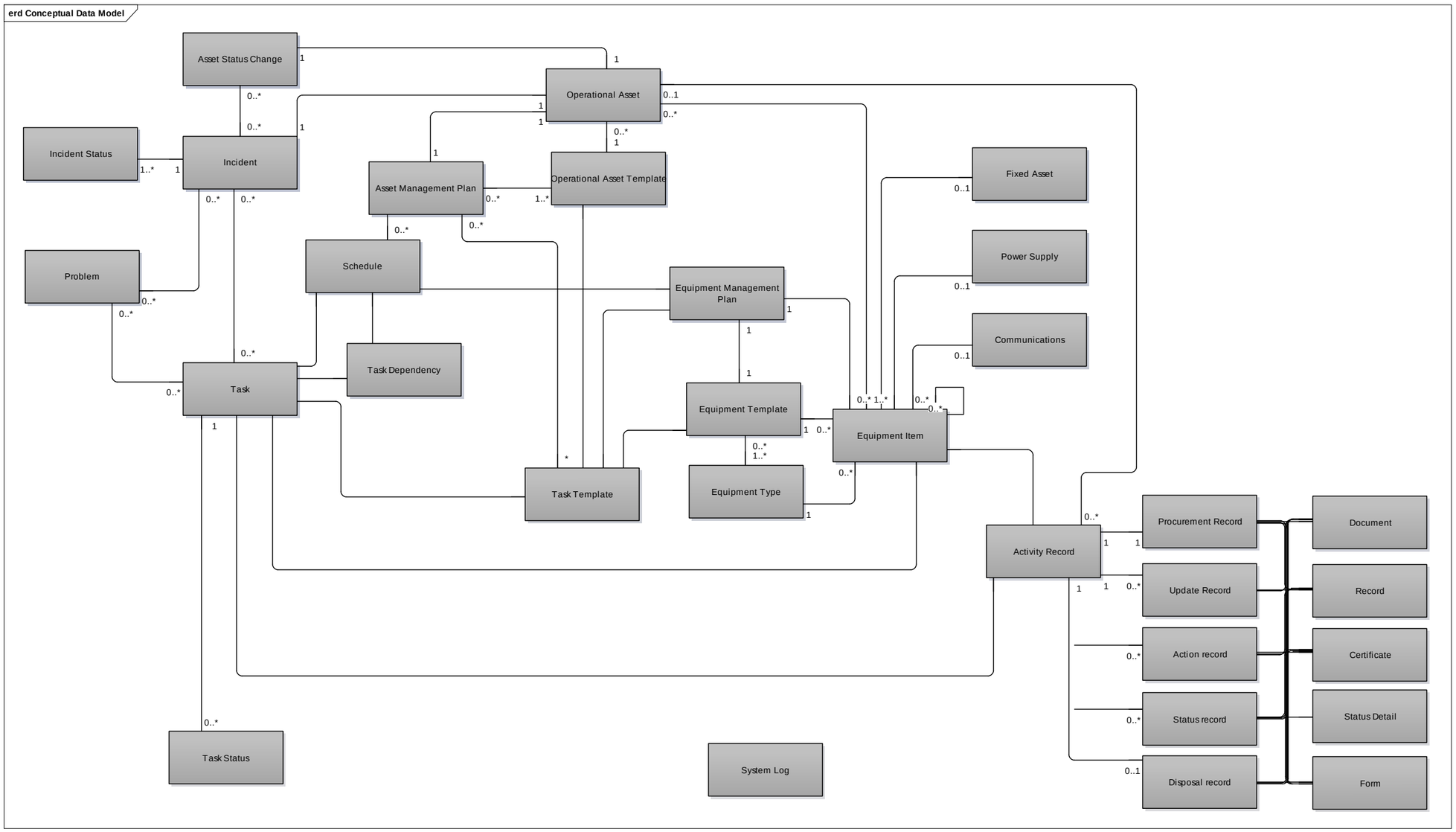

Figure 4 - Conceptual Data Model

5.2. Concepts

5.2.1. Data Domains

The Conceptual data Model has been divided into a series of data domains, based on how the data is used. Figure 5 illustrates these domains. The descriptions of the data entities below have been organised by the data domains.

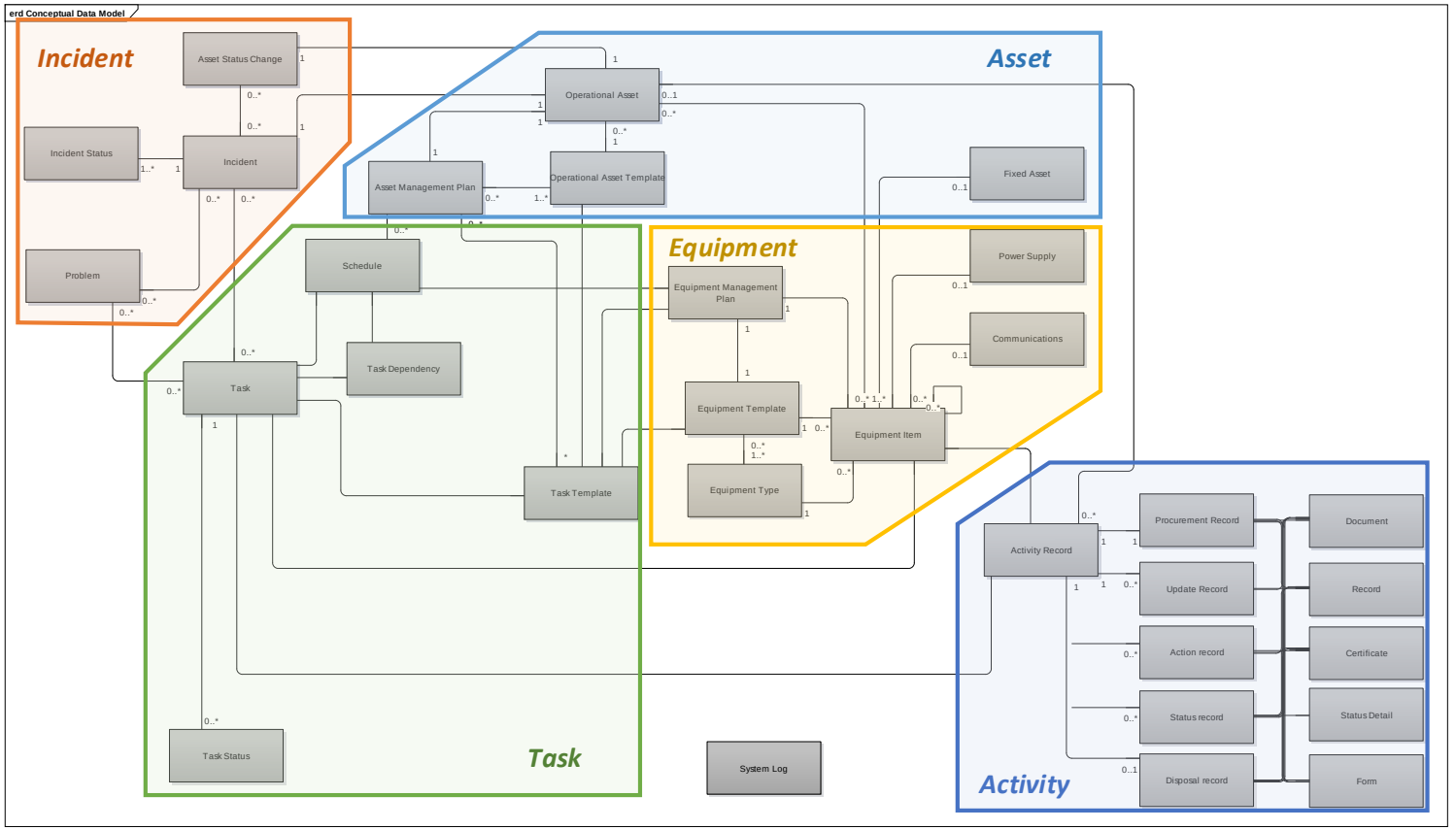

Figure 5 - Data Domains

5.2.2. Operational Assets as Services

Within ITIL incidents are always service affecting. Within T-TOC the services being provided are the assets used by operational systems, such as CHARM. Therefore the services monitored and reported on by T-TOC are largely synonymous with Operational Assets.
This approach matches the reporting from existing systems where faults, alarms and events are reported against an entity such as a message sign or a ramp metering site, rather than specific items of hardware.

5.2.3. Operational Assets, Fixed Assets and Equipment Items

The architecture makes a clear distinction between **Operational Assets**, **Fixed Assets** and **Equipment Items.**
Operational Assets correspond to the devices used by the operational systems to manage the road. These include signals, message signs, MIDAS loop pairs, Fog Detectors.
Fixed Assets are the physical structures, such as the gantries upon which Operational Assets are fixed or the cabinets in which the Equipment Items are physically located. They are not always at the same physical location as the **Operational Asset**. For example a number of MIDAS sites may be managed from a single cabinet several hundred metres away.
Equipment Items are the technology hardware, racks, boards, character modules etc. that implement the Operational Assets.
A typical MIDAS installation illustrates the differences between these entities. A MIDAS Outstation is an **Equipment Item** comprising a collection of other **Equipment Items** in a hierarchical (parent-child) relationship, including a number of line replaceable modules, each of which controls a number of loop pairs. These loop pairs are installed in each lane at a number of different geographic addresses. The outstation itself is installed in a cabinet, which is a **Fixed Asset**. There are also a number of smaller cabinets used to connect loop pairs in the road surface back to the equipment cabinet. The **Operational Assets** are the loop pairs which are where the traffic counts take place. The boards are **Equipment Items**, each of which is linked to a number of **Operational Assets** (the loop pairs).
The parent **Equipment Item** is the outstation which is located in a **Fixed Asset,** which is an equipment cabinet**.**
The table below further illustrates the differences between the Entities:

Table 3 - Operational Assets, Fixed Assets and Equipment Items

Attribute	Operational Asset	Fixed Asset	Equipment Item
Examples	Signal, Message Sign, MIDAS site by lane, Camera	Gantry, Post, cabinet	MIDAS Outstation, Signal Controller, Signal Head
Identification	Geographic address in CHARM or HATMS data	Marker post on the network or GPS	Serial number, barcode or RFID
Performance Management	Availability	Condition	MTTR, MTBF

The table below further illustrates the relationship between a range of common equipment and assets.

Table 4 - Relationship between Equipment and Assets

Equipment Item	Fixed Asset	Operational Asset	Description
Signal display	Post for signal or Gantry with mounting point	Carriageway signal or Lane signal	Signal displays are mounted on posts or gantries. Their mounting, and CHARM configuration, determines whether they are carriageway or lane signals
Signal controller (Cabinet)	Cabinet	A set of Lane Signals	A signal controller is usually installed in a nearby cabinet, controlling multiple signals on nearby gantries and posts
Post mounted signal	Post for signal	Carriageway signal	Some, usually older post signals, have integrated, signal controllers and displays.
Gantry mounted signal	Gantry with mounting point	Lane signal	Some, usually older gantry signals, have integrated signal controllers and displays
Message Sign Display	Post for VMS Or Gantry with mounting point	Message sign	Message signs can be configured in a similar way to signals, with co-located controllers or a controller for multiple message displays. Typically the display is mounted on a post or gantry while the controller is installed in a nearby cabinet.
Message Sign controller	Cabinet	One or more message signs	See for Message Sign display
Rotating plank VMS	Fixed sign location	Message sign	Simple VMS, used to provide variable text to otherwise fixed signage, are usually mounted directly onto the fixed sign and consist of an integrated controller and display mechanism.
Camera	Pole for camera or Gantry with mounting point or Post for VMS	Camera	Cameras are mounted on a range of locations, often on poles, gantries or on top of message signs

Equipment Item	Fixed Asset	Operational Asset	Description
TV Outstations	Cabinet or base of Pole for camera	One or more cameras	TV outstations are used to control a camera, usually from a cabinet but sometimes from an enclosure at the base of a pole.
Inductive Loop pair	Lane and longitudinal position on a pavement section	Traffic counting site by lane	An inductive loop pair counts traffic through loops installed in the road surface.
Traffic counting radar	Pole for radar or gantry with mounting point	A set of traffic counts by lane across a carriageway	Radar measures traffic flows on each lane across a carriageway
MIDAS Outstation	Cabinet	A set of Traffic counting sites, both by lane and carriageway	A MIDAS Outstation manages a number of traffic counting radars and inductive loop pairs
ANPR Camera	Pole for camera or gantry with mounting point	ANPR data point on a carriageway and direction	The ANPR camera provides a stream of identifiers for a carriageway in one direction
ANPR Outstation	Cabinet	A set of ANPR data points	The outstation manages a number of ANPR cameras in a locality
Fog Detector	Post for fog detector	Fog detection at a point on a carriageway	Fog detectors are normally standalone installations on the verge of a carriageway
ALM	Post for signal or Post for VMS or gantry with mounting point	Luminance level at a location	ALMs measure the lighting level at a geographic location

Equipment Item	Fixed Asset	Operational Asset	Description
ESS	Weather Station	A set of sensor readings related to a geographic position	ESS have tens of sensors, many of which relate to the geographic position of the weather station, but some relate to lanes on carriageways. The relationship between sensors and road position is only known to SWIS
Ramp Metering traffic signal	Post for traffic signal	Red/green cycle for traffic release for an identified slip road	The traffic signal is usually installed on a slip road
Ramp Metering traffic measurement	Lane and longitudinal position on a pavement section	Traffic measurement site by lane	The measurement relates to a main carriageway location
Ramp Metering outstation	Cabinet	A number of sets of “Red/green cycle for traffic release for an identified slip road” and “Traffic measurement site by lane”	A ramp metering outstation manages a number of pairs of traffic signals controlling the ramp and traffic measurement sites.
HADECS detector	Post for signal or Gantry with mounting point	An enforcement site on a lane of a carriageway	The HADECS detector is normally mounted close to but separate from the camera
HADECS Signal face	Post for signal or Gantry with mounting point	An enforcement site on a lane of a carriageway and a Carriageway signal or Lane signal	HADECS uses special variants of signals to ensure that the system knows the currently display aspect. So the HADECS signal must be associated with both the HADECS enforcement asset and the signal asset.
HADECS Outstation	Cabinet	A set of enforcement sites	The HADECS outstation records evidence, transmits to a central service and monitors the HADECS specific equipment

Equipment Item	Fixed Asset	Operational Asset	Description
Street lighting	Light standard	Lighting at a site on the road, applying to one or both carriageways	Lighting is controlled in blocks
Lighting controller	Cabinet	Set of lighting sites	Controls a number of street lighting sets, grouped in switchable blocks.
I2V	Cabinet	A communications channel at a location related to the road	Provides a communication path to passing vehicles at a location.
Drainage sensor	Place within drainage system	Measurement site within drainage system	Provides a measure of flow or level at a known point within the drains an ducts
Drainage outstation	Cabinet	Set of “Measurement site within drainage system”	The outstation collates the information from sensors and relays it to a central monitoring system
TMU	Cabinet	A set of Traffic counting sites, both by lane and carriageway	A TMU manages a number of traffic counting radars and inductive loop pairs

These concepts are further illustrated in the following diagram

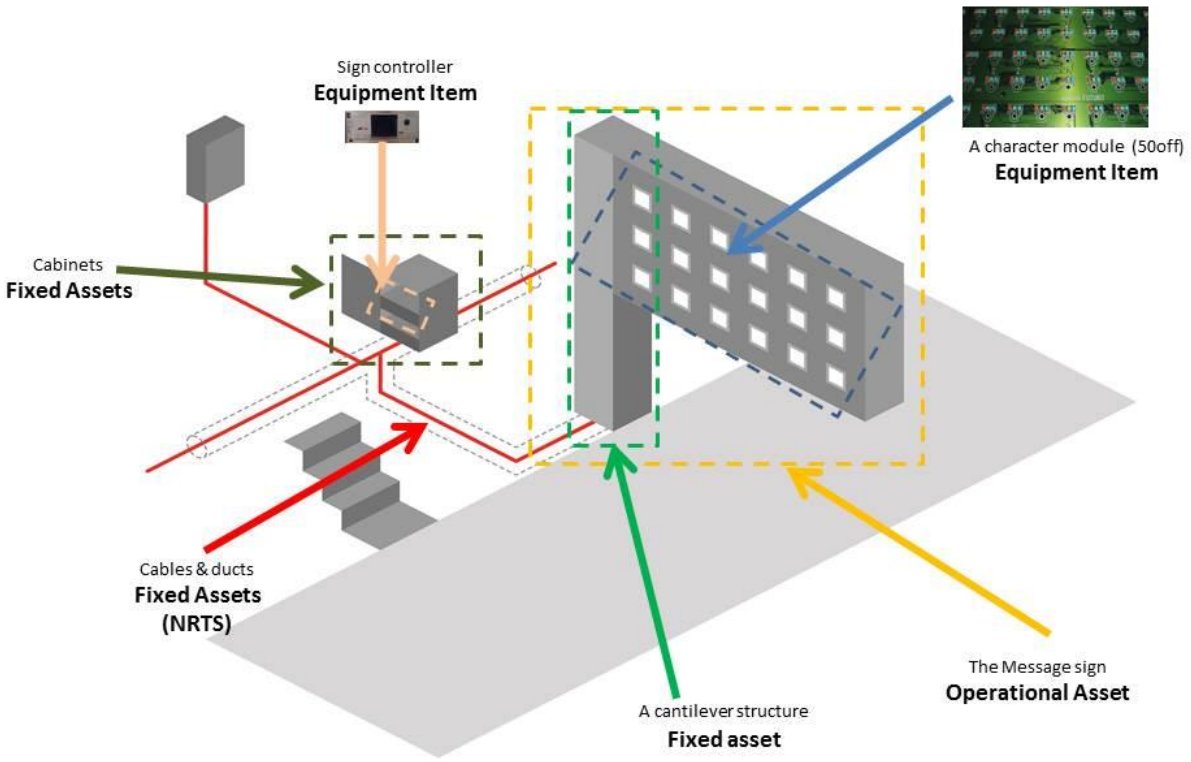

Figure 6 - Illustration of Fixed Asset, Operational Asset and Equipment Item Terminology

5.2.4. T-TOC Provides Incident Management

T-TOC's purpose is to manage the performance of the technology services used to operate the Strategic Road Network. Those technology services are not the racks of equipment or individual devices, such as character modules, but the ability to display a message at a location or count traffic at a point in the carriageway.

The equipment used to deliver those services may develop faults which may result in a loss of service. That loss of service is an **Incident** affecting an **Operational Asset**. In some cases the fault will not immediately affect the service, for example the failure of a heater on a signal, but it still represents a reduction in the quality of the service.

Equipment Items will have status information that will include reported faults.

This approach is reflected in the actual work carried out to resolve issues currently. When **Equipment Items** are swapped out TPMS marks the "fault" as cleared and service resumes. However it would be more accurate to say that the service affecting **Incident** has been cleared, the **Equipment Item** remains faulty.

T-TOC will track the status of **Equipment Items** but the repair process, which will change the fault status, maybe separately managed.

5.2.5. Asset Delivery Management Manual

The Asset Delivery Management Manual (ADMM) is being developed to provide a standard taxonomy. The intention is to liaise with the BIM team to align the technology view expressed in

this document with the ADMM, with the intention of populating the Technology section of that document.

5.2.6. Planning, Provisioning and Commissioning

There is a need to manage changes to **Operational Assets** and the **Equipment Items** comprising them in such a way that entities can be created without all of the supporting information. There will then be a process that manages the accumulation of information, leading up to the full provisioning of the **Operational Asset** and then commissioning of the **Operational Asset**.
It is proposed that T-TOC will have to support at least two states for **Operational Assets**:

- Not In Use – when the **Operational Asset** is not yet ready for use, or has been placed out of use. This is for new **Assets**, where **Assets** are within schemes or as part of a decommissioning process. It is not for **Assets** affected by faulty **Equipment Items**.
- In Use – when an **Operational Asset** is available for use, or is expected to be available for use.

The status of the **Operational Asset** is driven by the operational system that uses it. For signals and messages signs this will be CHARM, for ESS it will be SWIS.
It is proposed that T-TOC will have to support at least three states for **Equipment Items** associated with an Operational Asset

- Planned – when the **Equipment Items** are not installed within an **Operational Asset**, or have not been certified as ready for service. Thus a new **Operational Asset** will be created as part of a scheme with a template set of **Equipment Items**, but without serial numbers to link them to physical devices. Over time **Equipment Items** will be installed and serial numbers collected until there is a complete set.
- Provisioned – Once testing has established that the installation is fully complete, then the status can be changed to Provisioned. The **Operational Asset** is ready for service but not available to the operational system. This state is necessary to enable testing to be carried out.
- In Use – The **Operational Asset** will be commissioned by the operational system and then the **Equipment Items** will become In Use. Whenever an **Operational Asset** is In Use, all of the **Equipment Items** that comprise that **Operational Asset** are also In Use. If the **Operational Asset** becomes Not in Use, then the **Equipment Items** will revert to the Provisioned state.

The selected application may have a richer set of statuses, but it must be able to reflect the states described above.

5.2.7. Activity Records

Every **Operational Asset** and **Equipment Item** will have an associated set of **Activity Records** that will define and describe the lifecycle of the entity. An **Activity Record** can be linked to a **Task** or **Tasks**. The Activity Records can be grouped into the following subsets:

- **Procurement Records** are the documents and other records collected when the entity is first brought into T-TOC, either as part of the initial procurement or planning stage. It will include sufficient information to allow the entity to be brought into use. For example site installation certificates for Operational Assets and manufacturer's warranties for Equipment Items. The required set will be refined and improved as Highways England's processes mature.
- **Update Records** are updates to the **Procurement Records**, for example revised warranties or new site access advice
- **Action records** are used to record work, as described by **Tasks,** that affect the entity
- **Status Records** are used to log changes to the health status of **Operational Assets** and **Equipment Items**
- **Disposal Records** are used to record the end of life activities, for example disposal of an **Equipment Item** under the WEEE legislation or the permanent decommissioning of a MIDAS traffic counting site.

5.3. Incident

5.3.1. Asset Status Change

Status changes reported by other systems relate to **Operational Asset**. Thus an NMCS2 signal reports that there is an LED failure for a HATMS device. T-TOC will record this as an **Asset Status Change** and then submit it to Automatic Analysis to determine what the incident is. At that point it is not clear what the fault is. For example it could be due to a drop in voltage affecting a number of **Equipment Items**.

5.3.2. Incident

An **Incident** is degradation in a service, where a service is a directly connected with an **Operational Asset**.
The service degradation may not directly affect performance, but must have the potential to affect the service. The following are examples of **Incidents**:

- Power failure to a sign will be an **Incident** that directly affects performance
- Failure of a character module will be an **Incident** that degrades the performance of the sign
- Heater failure will be an **Incident** that does not directly affect performance but has the potential to degrade the performance in future
- Cosmetic marks on the exterior of the sign will not be an **Incident** because performance isn't affected, and is not likely to be in the future

The objective of technology management is to deliver the technology services, not keep equipment healthy. Therefore the management of **Incidents** is the core activity.
Faults recorded against **Equipment Items** may be a symptom, and may cause an Incident. However the recorded fault may not be a defect in the **Equipment Item**, but could be the result of a deeper problem.
Where a fault, as reported in, **Asset Status Change,** does not directly affect service an Incident will still be raised but handled as less critical.
Table 1 above provides some examples of incidents.

5.3.3. Incident Status

The raising, update and closing of an Incident will be recorded as an Incident Status. The information recorded will include:

- Identity of the affected **Operational Assets**
- Identity of the affected **Equipment Items**
- Raising of the **Incident**
- Creation of any **Tasks** planned to resolve the **Incident**
- Updated to the information held in the **Incident**, such as completion of an associated **Task**.
- Closing of the **Incident**

5.3.4. Problem

A **Problem** is an identified issue that is being investigated. It is likely to be associated with a number of **Incidents.**
Technology Operators will collate sets of information and generate reports during Problem Analysis that may need to be tagged as of relevance.
Once a plan has been agreed that aims to resolve the **Problem** then it may be referenced by a number of **Tasks**.

5.4. Asset

5.4.1. Asset Management Plan

For every **Operational Asset** this entity describes how that **Operational Asset** will be managed through its life. The plan should be built from the **Procurement Records**, and updated as described in any **Update Records**. This will include:

- An assessment of its criticality
- The life cycle tasks, such as inspections and maintenance actions, which should be carried out.
- How obsolescence should be managed

It will be built for each **Operational Asset** using the **Operational Asset Template**.

5.4.2. Fixed Asset

Fixed Asset is a link to the civil assets. It references the physical structure in, or on, which the **Equipment Item** is located. This may be different to the location of the **Operational Asset**. For example a traffic counting device may be remotely measuring a location on another carriageway.
In many cases the **Fixed Asset** will be a cabinet but in some cases it may be a location within a lane of a carriageway (MIDAS Loop pair), attached to a post (camera) or bolted to a position on a gantry.
Ideally the link should be a reference with a system managing those assets, which may encompass more than one system.

5.4.3. Operational Asset

An **Operational Asset** directly corresponds to a technology service, such as the display of a speed limit, ramp metering on a slip road or an ERT.
It is located at its “point of action”. This could be a point in the carriageway for a traffic counting loop or up above a junction for a camera.
As well as any technical attributes T-TOC will hold ownership and responsibility information. This will include the organisation that legally owns the asset, any maintenance contractor responsible for the asset, maintenance responsibilities, calibration/tuning responsibilities and warranty arrangements.

5.4.4. Operational Asset Template

The **Operational Asset Template** relates to a type of **Operational Asset**. It contains the default information required when creating a new **Operational Asset**, including a default **Asset Management Plan**.

5.5. Equipment

5.5.1. Communications

This entity describes the communication Service Delivery Point (SDP) usually provided by NRTS, that is associated with an **Equipment Item**. For HATMS devices, that description may include an IP address allocated by NRTS. It should be associated with an identifier linking to a specific service provided by NRTS. This should enable T-TOC to link service issues reported by NRTS to a **Communication** entity and thus to a set of affected **Equipment Items** and then to affected **Operational Assets.**

5.5.2. Equipment Item

This is a core entity that describes line replaceable or referenceable elements of technology. This can be physical item, such as a rack or system, or a software application with an associated version.
More complex assemblies of equipment are built using parent child relationships. Thus a rack of equipment will be an **Equipment Item** that is the parent of an **Equipment Item** that is a shelf of equipment. If the boards in that shelf can be replaced individually then the shelf **Equipment Item** will be the parent of each board level **Equipment Item**. NRTS use a 5 level Parent Child description of their equipment, although the software they use will support up to 7 levels.
Equipment Items are linked to the relevant **Fixed Asset**, **Power Supply** or **Communications** entity at the highest level that applies. Thus a rack level **Equipment Item** will be linked to the cabinet **Fixed Asset** and all of its child items will be linked by inference. Similarly if the shelf level **Equipment Item** has its own power connection it will be linked to a **Power Supply** entity. Finally Equipment Items with discrete communications will be linked to the associated **Communications** entity.
In our proposed model Equipment Items are linked at the highest applicable level, not at every level. The example of cabinet contents below illustrates those relationships.

Equipment Type				References		
Parent	Child 1	Child 2	CHARM/HATMS	Fixed	Power	NRTS
Message Sign Controller			M6/1234A	CAB:600/001	001	23.24.0.1
	SSL VMS Controller	SSL VMS V2.67				
MIDAS Outstation				CAB:600/001	001	23.24.0.2
	Siemens MIDAS OS	STCL MID V12.6				
	Loop Controller shelf					
		Loop controller 1	M6/1237A1 M6/123472			
		Loop Controller 2	M6/123473			
MIDAS Outstation				CAB:600/001	002	23.24.0.3
	Imtech MIDAS OS	Peek MID V3.2				
	Loop Controller shelf	Loop controller 1	M6/1232B1 M6/1232B2			

Each **Equipment Item** will be linked to an **Equipment Type** that will be used to describe its generic attributes.
In order to simplify the construction of assemblies of **Equipment Items** they may be linked to an **Equipment Template** that provides a proforma set of related **Equipment Types**. These will be used to support the description of delivered equipment, which will often already be assembled into sets of related **Equipment Items**. Similarly templates will be used by **Equipment Management Plans** to link together similar **Equipment Items**.
For every Equipment Item there will be an **Equipment Management Plan**, built from the **Equipment template**, to manage the equipment lifecycle.

5.5.3. Equipment Management Plan

For every **Equipment Item** this entity describes how that **Equipment Item** will be managed through its life. The plan should be built from the **Procurement Records**, and updated as described in any **Update Records**. This will include:

- The life cycle tasks, such as inspections and maintenance actions, which should be carried out.
- How obsolescence should be managed

It will be built for each **Equipment Item** using the **Equipment Template**.
Importantly the Equipment Management Plan will define the performance levels required of that Equipment.

5.5.4. Equipment Template

The equipment template will be used to describe an assembly of **Equipment Types** commonly deployed together. An example could be an ERT which consists of 4 components. The Equipment template provides a link to documents and records associated with common assemblies, such as installation guides.
The **Equipment Template** will include a default **Equipment Management Plan**. It can also be used to support processes that require replacement equipment for forward planning.

5.5.5. Equipment Type

Equipment Type is the description of a line replaceable module.
It is also the link to all of the documents that provide information about that module including maintenance manuals, notes in the Knowledge Base and performance criteria.

5.5.6. Power Supply

The **Power Supply** entity is used to link an **Equipment Item** to the applicable power supply point. Ideally this would be a link to a system managing that resource but our current understanding is that this does not yet exist.
Often a **Fixed Asset** will have an associated **Power Supply** which can be used as a default **Power Supply** for new **Equipment Items**.

5.6. Task

5.6.1. Resolver Organisation

A **Resolver Organisation** is any grouping that can be assigned to a **Task** to resolve an **Incident** or **Problem**, or to carry out a lifecycle **Task**.
Resolver Organisations can include any of the User Roles defined in this architecture, including Director level roles.

5.6.2. Schedule

The Schedule is a list of **Tasks** ordered in sequence and by criticality. The intention is to support the assignment of **Tasks** and for reporting Task Status, particularly for predicting when a **Task** might be started or completed.
It includes **Task Dependency** information in its ordering.

5.6.3. Task

A **Task** is a description of a set of actions to carry out. It will be assigned to an organisation to carry out.
Tasks may be created from **Task Templates**, or manually crafted.
They may be initiated as part of Asset Lifecycle Management and Equipment Lifecycle Management, or manually.

Technology Operators may group one or more **Incidents** as to be resolved by a **Task**. Alternatively a set of **Tasks** may be designed to resolve a **Problem**.
An individual **Task** should only be assigned to a single **Resolver Organisation**. **Tasks** should then be linked with **Task Dependencies** within the **Schedule**.

5.6.4. Task Dependency

Task Dependencies are records of links between **Tasks** to describe a required order. For example if a **Task** is to repair or replace a MIDAS Outstation it might have to be successfully completed before a **Task** to re-calibrate the associated loop pairs is started.
Task Dependencies should also record any external resources, such as road space bookings, that prevent the **Task** being carried out.

5.6.5. Task Status

This entity is a record of any changes to the status of a **Task**. For example a **Task** could be scheduled, waiting on a dependency, in-progress or complete.

5.6.6. Task Template

Task Templates are used to define proformas for standard **Tasks**. They will be included as part of **Asset Management Plans** and **Equipment Management Plans** to define lifecycle **Tasks**. They should enable Technology Operators to support best practice, as well as reducing the effort required to initiate **Tasks**.

5.7. Activity

5.7.1. Action record

An **Action record** is linked to an **Activity Record**. It provides a record of an action taken by the systems or organisations. In particular each task undertaken should be recorded as an **Action record** associated with an **Operational Asset** and/or **Equipment Items**.
An **Action Record** may reference:

- **Document** – perhaps a standard used to carry out the action
- **Record** – for example a written report of the action taken
- **Certificate** – a formal record of the results of a test or inspection
- **Form** – a completed form generated for a task, for example a checklist for an inspection collected on a mobile app

5.7.2. Activity Record

A linking entity between **Tasks**, **Operational Assets** and **Equipment Items** and the document, records and other information held.
One or more **Activity Records** will be generated for each **Task** undertaken. These will then be linked to the **Operational Assets** and **Equipment Items** affected.
The records associated with an **Activity record** can be one of the following:

- **Procurement Record** – This is the collection of documents and certificates provided when the **Operational Asset** is first deployed or the **Equipment Item** is procured or deployed. Examples would be: warranty; installation instructions; equipment specifications etc.
- **Update Record** – This is the collection of up-issues of documents collected as part of the procurement or deployment. Examples might be updated installation instructions or new specifications with a software update
- **Action Record** – recording of a task undertaken through documents, certificates etc. An example might be the annual electrical testing with its associated Pass certificate.

- **Status Record** – logging changes to status, basically fault recording.
- **Disposal Record**- All of the documents associated with the decommissioning of an **Operational Asset** or **Equipment Item**.

5.7.3. Certificate

A **Certificate** is a formal record of the results of a test or inspection, usually something that it is required by regulation of policy. Examples are electrical testing certificates and asbestos declarations.
For T-TOC the certificate could be a signed electronic document, a scanned image or any other officially accepted record.

5.7.4. Disposal record

This entity links all of the documents and records associated with the decommissioning of an **Operational Asset** or **Equipment Item**. For equipment this might be expected to be something for the Stores and Logistics team to produce.
Disposal Records should include any records or certificates required by the WEEE directives or asbestos regulations.

5.7.5. Document

Documents contain specifications or definitions. They are provided by other parties, rather than generated within the organisation. Examples would be specifications, user manuals, warranty arrangements and installation instructions.

5.7.6. Form

A **Form** is a record that includes input from a user. An example would be calibration check to be carried out on a MIDAS site (**Operational Asset**).
It would usually be associated with an **Action Record**.
Blank forms would be part of **Task Templates**.

5.7.7. Procurement Record

For every **Equipment Item** there is an expectation that a set of information will be collated when it is procured, and before it is accepted into the logistics systems. This will include supplier details, warranty information, test certificates and detailed specifications. These are the **Procurement Records**.
Similarly for each **Operational Asset** there should be a set of information, to be collated before accepting it into service. This may also include warranty information and should include as-built drawings. Much of this information is already specified in the existing procedures for handover into maintenance.

5.7.8. Record

A **Record** is a catchall for any items used to record activities that do not fall into the **Document, Certificate, Status Detail** or **Form** types. They could, for example, be a set of notes from the installing engineer or a photograph of the earthing arrangements.

5.7.9. Status Detail

This entity is used to record changes to the status of **Equipment Items, Operational Assets and Tasks** as part of a **Status Record**. It can also be used to record specific information about the change, such as completed repair resetting the health of an **Equipment Item** or work on a site that should reset the **Operational Asset** service status.
For **Equipment Items** the **Status Detail** reflects the health of the equipment Item.
For **Operational Assets** the **Status Detail** reflects the service status, as depicted in any **Incidents**.

For **Tasks** the **Status Detail** reflects whether the **Task** is pending, delayed, in-progress or complete.

5.7.10. Status record

This entity is a container for sets of **Status Details**.

5.7.11. Update Record

Update Records are updated versions of the **Procurement Records**. This could be a change of ownership, expiry of the warranty or an updated specification.

5.8. Logging

5.8.1. System Log

The **System Log** is a rolling record of system actions and exceptions used for analysis of T-TOC system operation.

6. Technology Architecture

6.1. Context Diagram

The figure below illustrates the main input and output data flows for T-TOC, each corresponding to a service either exposed on the public internet or on Highways England's proposed ESB.

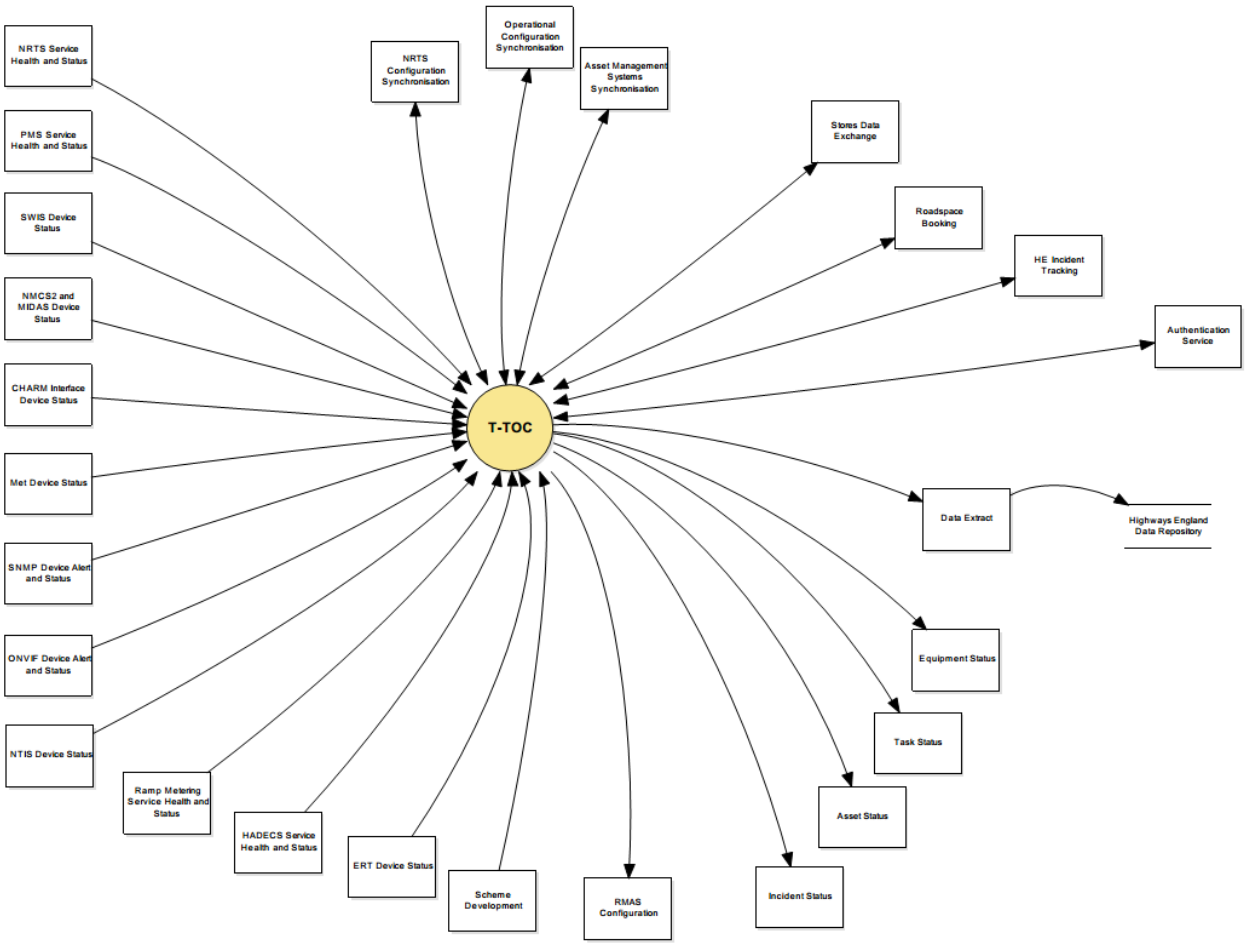

Figure 7 - Context Diagram for Data Flows

6.2. Physical Architecture

The detailed physical technology architecture for T-TOC will be determined by the successful bidder, especially whether they include any SaaS elements in their solution.
However the Highways England Service Design team have stated that if the solution is not using SaaS then it may be hosted in the same infrastructure as the CHARM application. The details of that infrastructure are not yet available but are expected to include dual redundant data centres using widely available virtualised environments.
CHARM will be deploying Red Hat Fuse to provide a service bus for web services within CHARM and for collaborating systems, including T-TOC. CHARM will use Red Hat's containerisation technologies, including Red Hat OpenShift and Kubernetes to provide a number of instances within the virtualised infrastructure. These are all very widely used technologies and support an even wider range of COTS adaptors and tools for integration with other applications and web services. T-TOC will be expected to deliver an ESB to integrate the various systems that exchange data with the core T-TOC applications, the solution will be determined by the successful bidder but this could be achieved by building on the ESB solution being implemented by CHARM..
CHARM itself will support a number of groupings within the overall service bus configured for particular bandwidth, latency and volume requirements. In particular the CHARM project has identified low latency high volume messaging to the roadside devices (termed the Roadside Service Bus within this document) and a logically distinct requirement for messages to other Highways England applications (termed the Application Service Bus in this document). The allocation of services to groupings will be a management function within the Fuse configuration that does not need to be visible to applications providing web services.
The Enterprise Architecture Technology Policies (ref. [2]) propose a federated Enterprise Service Bus, with each project considering how best to deliver the required messaging and connection to other service buses. The Highways England Service Design Group, who are responsible for enterprise architecture have agreed that the CHARM proposal provides the technical architecture for that federated enterprise service bus.
The diagram below (Figure 8) illustrates how a solution installed within the recommended hosting architecture and service bus usage could look. In particular it considers where services could be hosted and accessed.
Further sections discuss the hosting and service arrangements in more detail.

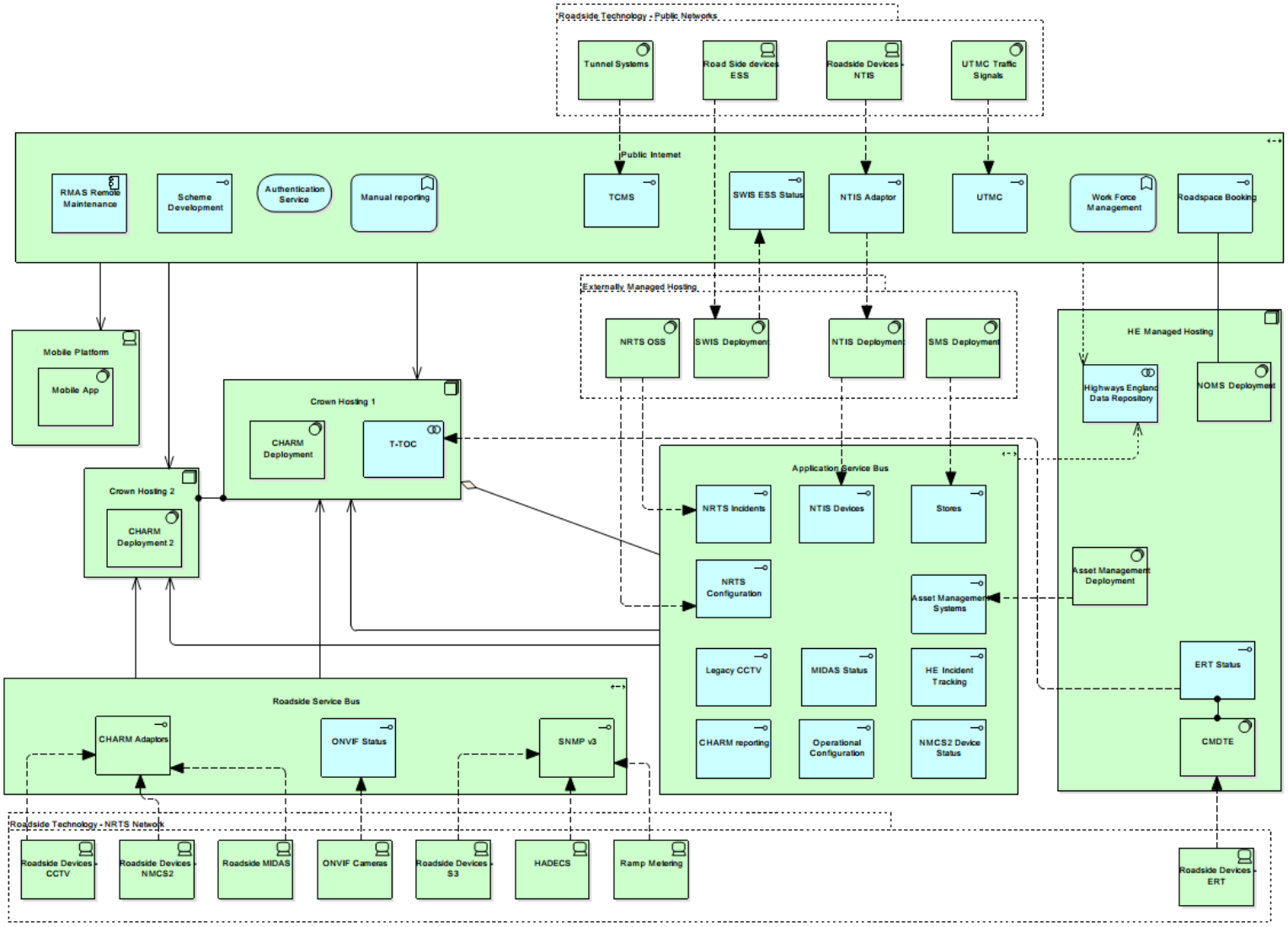

Figure 8 - Physical Architecture

6.3. Hosting Architecture

Figure 8 above has grouped hosting according to its management. The hosting is important for T-TOC in considering how to access the data from that source, and any security implications.

6.3.1. Charm Hosting

Unless the T-TOC uses a SaaS solution the Highways England Service Design team would allow using the same hosting as CHARM. This would certainly provide a more than capable hosting infrastructure as CHARM's requirements are for lower latencies and more resilient hosting.
If T-TOC is deployed onto the CHARM hosting then it will be able to share the services that CHARM will be deploying, including services buses and any Service Management product. CHARM will be deployed as a resilient application across two data centres. T-TOC does not need that level of resilience and so it is suggested that, to save costs and simplify the design, T-TOC is run only within a single data centre. In the event of irrecoverable failure to the data centre it could be re-deployed on to the second data centre hosting.

6.3.2. Highways England Managed Hosting

Some applications, such as many of the Asset Management systems and CMDTE, are deployed within Highways England data centres or into public cloud that is actively managed by Highways England. The business has already procured a hosting facility from Microsoft Azure and is looking to migrate applications from some of its dedicated data centres into public cloud. Applications on Highways England managed hosting should already be within the business's security arrangements and by default should be able to directly access the Application Service bus. Although for some applications, such as NOMS, have to present their interfaces on to the public internet to be accessed by third party systems.
For T-TOC the following applications in Highways England Managed Hosting are significant:

- NOMS Deployment and Asset Management systems, such as IAMIS – It is understood that most of the asset management systems are hosted within Highways England's data centres, and NOMS is a module of one of those applications. Ideally these will use the Application Service Bus to communicate with T-TOC but it may be necessary to federate the Application Service Bus to one or more service buses provided under the contracts that provide the asset management systems.
- CMDTE is a standalone system installed in its own servers within a Highways England data centre. There has been consideration of how best to support this facility going forward.

There is an assumption that only CMDTE will have to be directly accessed by T-TOC within its data centre hosting.

6.3.3. Externally Managed Hosting

Many existing applications are hosted by their suppliers. Some of these are fully developed SaaS arrangements such as the Oracle Fusion (which will be used for the Stores Management System). Others are more ad-hoc arrangements, such as SWIS and NTIS, with hosting provided and managed by the application suppliers.
The characteristics of the external hosting varies significantly with some, such as the NRTS and NTIS, systems already having, or have planned, connections to the service buses being provided under CHARM. For example NRTS will be connected to the Roadside Service Bus in order to provide access to the roadside devices.
For T-TOC the following externally hosted applications are significant:

- NRTS Operations Support System[6] – hosted within NRTS but providing information about NRTS incidents and its configuration through the Application Service Bus.
- SWIS – providing the status of ESS to T-TOC, but through a service on the public internet.
- NTIS – providing the status of TMUs and ANPR. The assumption is that, as NTIS will have direct connection to the Application Service Bus, to collect MIDAS Gold and the HATMS Gateway Service, this information will be provided on the Application Service Bus.

[6] Referred to as the NRTS Service Management System (SMS) in NRTS2

- SMS – providing information about Equipment Items as part of the stores and logistics function. It is currently proposed that this service will be built on the Oracle Fusion SaaS platform. The diagram shows a connection directly to the Application Service Bus but this interface may have to use the Public Internet.

6.3.4. Mobile Platform

There is an expectation that T-TOC will need to deploy, and interact with, applications installed on mobile telephones and tablets. This will require security over the public internet and mobile phone networks to be managed,

6.3.5. Others

There are a few systems installed by the road side or in specialist hosting. Examples could include Ramp Metering, UTMC or HADECS. Their requirements will have to be addressed individually when more information is available.

6.4. Service Buses and Channels

The CHARM project will be deploying two service groupings within its service bus. The first services grouping will be used for handling the low latency high bandwidth message to the roadside and the second for messaging within CHARM and with other applications. For the purposes of this document: the first will be referred to as the Roadside Service Bus and the second the Application Service Bus.
The vision for T-TOC involves both buses. Initially health and status information will come in messages from the managing functional application. For example CHARM will report on the health of NMCS2 devices through the Application Service Bus. In the medium to longer term new devices will deploy as SNMP capable devices. Access to the device status through SNMP should use the Roadside Service Bus, because the volume of data, number of connections and message frequency.
The Service Catalogue entries in section 6.6 will identify which bus this document proposes to use for the service.
Some services will be provided over the public internet, either because the information is from a third party or from a system without access to one of the services. CHARM has similar requirements and it is proposed to share the frameworks, including security being developed for CHARM.
It should be noted that T-TOC will use the authentication service being procured by Highways England which is based on a service provided over the public internet.
Finally there are a small number of interfaces where none of the above mechanisms will be appropriate. An example is the interface to CMDTE. These will have to be addressed as they are identified and investigated.

6.5. Service Bus Technical Implementation

The CHARM project buses will both align with the Enterprise Architecture technology policies in using lightweight APIs, preferably based on the RESTful style. They will be deployed within the CHARM hosting, under Highway England management and governance.
The Roadside Service Bus will use Red Hat Fuse to provide a low latency service bus. The Application Service Bus will also use Red Hat technologies, JBoss™ Fuse™, to provide a service bus that can be exposed to other Highways England applications. The details are still being agreed but it is expected that the Red Hat Openshift Container Platform™ technologies will be used to provide overall management of containerisation and deployment.
The CHARM project is in the process of developing the detailed deployment design, after which further technical details will be available.

6.6. Service Catalogue

This section identifies and describes a set of services which T-TOC will require to meet the requirements. The detailed technical specification of each service will have to be agreed between the T-TOC projects and the sources or consumers of each service.
A sketch estimate of likely message volumes and acceptable latencies are provided in Annex 2 – Web Service Sizing Calculations.

6.6.1. Inbound Service Requirements

Inbound services will be published by other systems and consumed by T-TOC.

Name	6.6.1.1. NRTS Service Health and Status		
Source	NRTS	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
NRTS Monitoring	Provides information on the health of each NRTS service and the end points it affects.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	Proprietary to NRTS	Unknown	The list of end points must correspond to the T-TOC Communications entity
Description	NRTS should provide information on the status of any outages or service degradations that could affect the Operational Assets. T-TOC needs to relate the end points referenced in the message to a Communications entity, in turn to Equipment Items and then to the Operational Assets. Ideally NRTS would report to the same interface as other PMS.		

Name	6.6.1.2. PMS Service Health and Status		
Source	Any Performance Management System (PMS)	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
PMS Collection TCMS UTMC	Provides information on the health and status from any systems, including TCMS for Tunnels and UTMC for traffic signals, that can provide information on each service they provide.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Each referenced service must correspond to an Operational Asset
Description	The systems must provide an understood health status for each service, for example: a traffic signal has failed. The list of relevant Operational Assets must be provided by each reporting system, and associated with any Equipment Items being tracked.		

Name	6.6.1.3. SWIS Device Status		
Source	SWIS	**Channel**	Public Internet
Logical Function(s)	**Purpose**		**Type**
SWIS Monitoring	Provides health and configuration information for Environmental Stations (ESS) on the network		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	DATEX II	Each referenced ESS must correspond to an

			Operational Asset
Description	The systems must provide an understood status for each ESS and all of its sensors as a publication. This should include statuses derived by SWIS, such as stuck sensors Datex II includes a full definition of the set of ESS and their configuration which must be interpreted by T-TOC. Data linking ESS to Fixed Assets, Communications and Power must be provided manually.		

Name	6.6.1.4. NMCS2 and MIDAS Device Status		
Source	CHARM	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Legacy Monitoring MIDAS Status NMCS2 Status	Provides device status relating to faults for every NMCS2 (principally signals and signs) and MIDAS device on the network.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	Binary data, with supporting information	Each referenced device must correspond to an Operational Asset
Description	The information provided is mainly contained within the CF=(23H) STATUS REPLY and CI=(45H) & (46H) DEVICE STATUS DATA messages initially received from the devices themselves. It must be supplemented by information derived by CHARM based on communication failures and results from the CI=(28H) & (29H) TEST RESULTS messages. T-TOC will have to interpret the binary data for each device type. It may be necessary for T-TOC to understand other relationships in the CHARM data model, such as between ambient light monitors and signals		

Name	6.6.1.5. CHARM Interface Device Status		
Source	CHARM	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
CHARM reporting CHARM Interface Status	Provides status relating to system level interfaces for CHARM, such as the 2nd Generation CCTV interface to NRTS. These interfaces affect the availability of roadside equipment being monitored by T-TOC.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Service impact needs to be included in business rules for Automatic Analysis
Description	The systems must provide an understood health status for each service, for example: 2nd Generation CCTV not available.		

Name	6.6.1.6. Met Device Status		
Source	Specialist device managers for standalone weather information such as anemometers	**Channel**	Roadside Service Bus
Logical Function(s)	**Purpose**		**Type**

Legacy Met Devices	Provides device status relating to faults for those Met devices not managed by CHARM, for example some standalone wind meters on bridges.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Each referenced device must be associated with an Operational Asset
Description	The list of relevant Operational Assets must be provided by any reporting system, and associated with any Equipment Items being tracked.		

Name	6.6.1.7. SNMP Device Alert and Status		
Source	SNMP Element Managers	**Channel**	Roadside Service Bus
Logical Function(s)	**Purpose**		**Type**
SNMP Monitoring	Handles alerts and status information for SNMP devices.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	SNMP MIB formations to be agreed	SNMP	Each referenced device must be associated with an Operational Asset
Description	The service will accept alerts generated from the MIBs, as Traps, and the information collected by polling the MIBs. It may be possible to procure this capability as a product, generally referred to as an SNMP element manager.		

Name	6.6.1.8. ONVIF Device Alert and Status		
Source	ONVIF instations	**Channel**	Roadside Service Bus
Logical Function(s)	**Purpose**		**Type**
ONVIF CCTV	Handles alerts and status information for ONVIF devices.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	ONVIF	Unknown	Each referenced device must be associated with an Operational Asset
Description	ONVIF is an open standard for managing cameras and other video devices. The protocols are focussed on operational control and video streaming. Monitoring health is usually done through the controlling system, which will be CHARM for Highways England. Some ONVIF compatible cameras are able to report status through SNMP MIBs, in addition to ONVIF, and this may offer an alternative route for T-TOC to monitor cameras.		

Name	6.6.1.9. NTIS Device Status		
Source	NTIS	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
NTIS Monitoring	Provides device status relating to faults for devices entirely managed within NTIS.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Each referenced device must be associated with an Operational Asset
Description	The list of relevant Operational Assets must be provided by NTIS, and associated with any Equipment Items being tracked.		

Name	6.6.1.10. Ramp Metering Service Health and Status		
Source	Ramp Metering outstations	**Channel**	Roadside Service Bus
Logical Function(s)	**Purpose**		**Type**
Ramp Metering Monitoring	Provides information on the health and status Ramp Metering Installations.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Each referenced site (slip road) must correspond to an Operational Asset
Description	The systems must provide an understood health status for each site. Ideally this would be as a PMS, using the same interface as TCMS and UTMC.		

Name	6.6.1.11. HADECS Service Health and Status		
Source	HADECS Outstations	**Channel**	Roadside Service Bus
Logical Function(s)	**Purpose**		**Type**
HADECS Monitoring	Provides information on the health and status of HADECS Installations.		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Each referenced site (gantry and lane) must refer to an Operational Asset
Description	The systems must provide an understood health status for each site. Ideally this would be as a PMS, using the same interface as TCMS and UTMC.		

Name	6.6.1.12. ERT Device Status		
Source	CMDTE system	**Channel**	Other to be determined
Logical Function(s)	**Purpose**		**Type**
ERT Monitoring	Provides device status relating to faults for Emergency Roadside Telephone (ERT).		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
To be agreed	To be agreed	To be agreed	Each referenced ERT must be associated with an Operational Asset
Description	The list of relevant Operational Assets must be provided by the reporting system, and associated with any Equipment Items being tracked. The current monitoring system is CMDTE, which T-TOC would have to poll to collect ERT status information.		

Name	6.6.1.13. Scheme Development		
Source	To be determined, possibly Asset Management systems		
Source	To be determined, possibly Asset Management systems	**Channel**	Public Internet
Logical Function(s)	**Purpose**		**Type**
Scheme Development	Provide information on planned schemes through changes to Operational Assets and Fixed Assets		Consumer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
To be agreed	To be agreed	To be agreed	Changes must be reflected in the T-TOC data
Description	This interface provides a means to update the set of Fixed and Operational Assets from new schemes. It may initially be manual, with an aspiration to develop workflows based on a system level input.		

6.6.2. Outbound Service Descriptions

These services will be published by T-TOC for consumption by other systems.

Name	6.6.2.1. RMAS Configuration		
Consumer	RMAS	**Channel**	Public Internet
Logical Function(s)	**Purpose**		**Type**
RMAS Remote Maintenance	Populates the configuration of the RMAS so that it can communicate with and interpret data held by remote devices.		Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
File	To be agreed	To be agreed	Information held by RMS should be compatible with T-TOC's view of Equipment Items and Operational Assets
Description	RMAS needs information held by T-TOC to provide the required information about Equipment Items it is communicating with, and their relationship to Operational Assets, which users are likely to understand.		

Name	6.6.2.2. Incident Status		
Consumer	Other systems within the Highways England estate that have an interest in technology incidents, such as NRTS	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Incident Status	Publishes information on the status of active and recently closed Incidents to other Highways England systems.		Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	N/A	JSON	All Incidents will reference an Operational Asset
Description	The Incident Status information will be published when it changes. Other systems will register via the ESB.		

Name	6.6.2.3. Asset Status		
Consumer	Other systems within the Highways England estate that have an interest in operational assets. CHARM could use this service to provide secondary information about the status of roadside devices	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Asset Status	Publishes information on the health status of Operational Assets to other Highways England systems.		Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	N/A	JSON	All statuses will reference an Operational Asset
Description	The Asset Status information will be published when it changes. Other systems will register via the ESB.		

Name	6.6.2.4. Task Status		
Consumer	Other systems within the Highways England estate that have an interest in the status of tasks, for example systems within organisations carrying out roadside maintenance	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Task Status	Publishes information on the status of active and recently closed Tasks to other Highways England systems.		Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	N/A	JSON	Each task may reference an Operational Asset, Resolver Organisation, Fixed Asset or Equipment Item
Description	The Task Status information will be published when it changes. Other systems will register via the ESB.		

Name	6.6.2.5. Equipment Status		
Consumer	Other systems within the Highways England estate that have an interest in equipment, such as suppliers monitoring their own equipment.	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Equipment Status	Publishes information on the status of Equipment Items to other Highways England systems.		Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	N/A	JSON	Each Equipment Item must reference an associated Fixed Asset, and a list of associated Operational Assets
Description	The Equipment Status information will be pulled by other systems on request. Other systems will register via the ESB.		

Name	6.6.2.6. Data Extract		
Consumer	Highways England Data Repository	**Channel**	Other
Logical Function(s)	**Purpose**		**Type**
Data Extract	Acts as the conduit between the Operational Data Service and the Highways England's Data repository.		Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
ETL based protocol	As required	Not applicable	Not applicable
Description	The Data Extract will regularly push information from the Operational data Service to the Highways England Data Repository to ensure that management reporting from the Data repository is sufficiently recent. The expectation is that the Data Extract function will be provided by an Extract, Transform and Load (ETL) tool, scheduled hourly or more.		

6.6.3. Exchange Service Descriptions

The services described in this section are used to exchange information about common data, for example configuration, with other systems

Name	6.6.3.1. NRTS Configuration Synchronisation		
Exchange Partner	NRTS	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
NRTS Configuration	Exchanges changes to information held about Equipment Items and Communications with NRTS to ensure that both the reference held in the Communications entity and any caches of NRTS information are synchronised.		Consumer/Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	NRTS end points should correspond to a Communication entity
Description	Whenever there are changes to the deployed Equipment that affect the relationship with NRTS, such as a new device, or a new NRTS end point, then NRTS and T-TOC need to exchange information that enables their data to remain synchronised. That information could include: equipment (routers, DSL modems etc.) held in the NRTS asset management systems that are located within cabinets also referenced by T-TOC(i.e. to support the planning of space and power supply usage). Note that cabinets are generally maintained by the RTMC but if NRTS is the sole occupier of the cabinet they are then also responsible for the cabinet and its upkeep		

Name	6.6.3.2. Operational Configuration Synchronisation		
Exchange Partner	CHARM	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Operational Configuration	Exchanges changes to information held about Equipment Items and Operational Assets with CHARM to ensure that both the reference held in the Operational Asset entity and any caches of CHARM information are synchronised.		Consumer/Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	CHARM devices should correspond to an Operational Asset entity
Description	Whenever there are changes to the deployed Equipment that affect the relationship with CHARM, such as a new device then CHARM and T-TOC need to exchange information that enables their data to remain synchronised.		

Name	6.6.3.3. Asset Management Systems Synchronisation		
Exchange Partner	Asset management systems	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Asset Management Systems	Exchanges changes to information held about Equipment Items and Fixed Assets with Asset Management Systems to ensure that both the reference held in the Fixed Asset entity and any caches of Asset Management System information are synchronised.		Consumer/Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Referenced Asset Management System assets should correspond to a Fixed Asset entity
Description	Whenever there are changes to the deployed Equipment that affect the relationship with Fixed Assets, such as a new gantry or cabinet then the relevant Asset Management System and T-TOC need to exchange information that enables their data to remain synchronised. There are likely to be more than one Asset Management System as Fixed Assets will include gantries, cabinets, pavement segments (with lane identifier) and bridges.		

Name	6.6.3.4. Stores Data Exchange		
Exchange Partner	Stores and Logistics	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Stores Equipment Tracking	This interface has multiple functions: • To share information about the location of Equipment Items, primarily whether they are installed and if not which stores they are in • To share information about Equipment Item status, for example whether they are faulty, and to identify Equipment Items required but not yet provisioned • To share Documents and other Records associated with an Equipment Item		Consumer/Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
HTTPS	To be agreed	To be agreed	Equipment Item unique identifiers should be in both inventories Equipment Types must be in a shared catalogue
Description	Both T-TOC and Stores & Logistics systems need to know where Equipment Items are. Stores in order to locate them if they are needed, T-TOC to trace issues and as part of Task planning. Sharing information about Equipment Item status supports supply forecasting, whether it is understanding how many faulty items may need to be repaired or the number of new Equipment Items that will need to be provisioned. There should be a set of Procurement Records collected for each new Equipment Item. Stores & Logistics are likely to be responsible for this initial		

	collection. However updated documents, for example a modified installation procedure, could be collected by T-TOC or Stores. In either case both systems need access to the revised information.

Name	6.6.3.5. Authentication Service		
Exchange Partner	Authentication service, probably Azure Active Directory	**Channel**	Public Internet
Logical Function(s)	**Purpose**		**Type**
Authentication Service	Provides a single authority for authentication of users across Highways England.		Consumer/Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
As specified by Highways England	OAuth 2.0, OpenID Connect, WS-Federation, or SAML 2.0, as specified by Highways England	As specified by Highways England	Not applicable
Description	Highways England are providing an enterprise wide authentication service, using Azure Active Directory that T-TOC must use for authentication of users and systems.		

Name	6.6.3.6. road space Booking		
Exchange Partner	NOMS	**Channel**	Public Internet
Logical Function(s)	**Purpose**		**Type**
road space Booking Workflow	To exchange information linking a Task with proposed traffic management on the NOMS system.		Consumer/Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
To be agreed	To be agreed	To be agreed	A unique reference that can be held with Task information and used to reference the traffic management booking on NOMS
Description	Tasks for roadside work often require traffic management to be provided, which will delay the start of the work. Being able to link to the traffic management booking enables users to assess when the work will be done. When invoking the NOMS systems T-TOC will also be able to provide an assessment of the criticality of the work required, assisting any manual scheduling of traffic management.		

Name	6.6.3.7. Highways England Incident Tracking		
Exchange Partner	Other service management systems, for example Business IT or CHARM service desk	**Channel**	Application Service Bus
Logical Function(s)	**Purpose**		**Type**
Highways England Incident Tracking Service Management	Exchanges information on the health and status of services with other incident tracking/service management functions within Highways England.		Consumer/Producer
Expected Protocol	**Standards and formats**	**Message format**	**Canonical data**
To be agreed	To be agreed	To be agreed	A unique reference for each service Reported by Operational Asset for T-TOC Business rules within Incident Tracking will have to understand identifiers and information from other systems. Health status will need to have agreed meaning across systems
Description	For T-TOC a service will correspond to an Operational Asset. Thus T-TOC will report on the availability and health status (Okay, faulty, degraded etc.) for each Operational Asset. Other systems will report against other service. If these have an effect on T-TOC then the service description must be part of business rules within the T-TOC Service Management collaboration. It should be possible to standardise this interface with the PMS Service Health and Status interface (6.6.1.2).		

Annex 1 – Terminology, Acronyms and Architecture Diagram Key

Table 5 - Acronyms

Acronym	Term	Definition	Further Information
	2nd Generation Cameras	The current generation of cameras and their control mechanisms.	
	Agile	A set of principles for software development in which requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development, early delivery, and continuous improvement, and it encourages rapid and flexible response to change	Wikipedia
ALM	Ambient Light Monitor	A device that measures the current lighting level to enable nearby signals and signs to adjust their luminance levels appropriately.	
API	Application Programme Interface	An API is a set of routines, protocols, and tools for building software applications. It specifies how software components should interact	
ADMM	Asset Delivery Management Manual	A taxonomy being developed by Highways England for use, primarily within asset management, but more generally applicable	
AD	Asset Delivery model	The new operational model for managing the SRN assets, including pavements, which will replace the current ASC arrangements. It was piloted in Area 7 and is now being rolled out to a number of other Highways England areas as ASC contracts are renewed. This operating model was previously referred to as the Asset Led Delivery Model (ALDM)	
ALDM	Asset Led Delivery Model	Now superseded by the Asset Delivery model	
APM	Asset Performance Management	Class of application that uses analytics to model and predict the performance and optimise the life of assets	
ASC	Asset Support Contract	Refers to the contracts within each Highways England area that provide road maintenance	
AVIS	Asset VIsualisation Service	Highways England initiative and set of systems, including LIDAR, for high quality imagery.	

Acronym	Term	Definition	Further Information
ANPR	Automatic Number Plate recognition	A system, including cameras and other equipment, used to record number plates and thereby by to identify journeys made using vehicle across the network. These units are used by NTIS for journey time measurement.	
BIM	Better Information Management	A initiative within Highways England to improve the quality of data held about assets,	
BI	Business Intelligence	A set of techniques and tools for the acquisition and transformation of raw data into meaningful and useful information for business analysis purposes, often involving visualisations	
BPM	Business Process Management	A set of tools to describe, support and automate the workflows required by business processes	
CMDTE	Centralised Maintenance Depot TErminal	A system that is able to check the health of ERTs by dialling them and then reporting their status	
CCTV	Closed Circuit TeleVision	Used to refer to systems of cameras, recorders and displays used to provide video imagery of the road network	
CHARM	Combined Highways Agency and Rijkswaterstat Model	A project between Highways England and their Dutch equivalent for a new set of systems and applications to provide operational management of the SRN	
	Command & Control	A system, called ControlWorks, used by Traffic Operators to log road traffic incidents and actions taken in response to these incidents	
COTS	Commercial Off-The-Shelf	Used to refer to applications and systems that can be deployed without bespoke development	
CBM	Condition Based Maintenance	Function of EAM applications that provides detection of imminent asset failures through embedded sensors and/or external portable equipment	
CI	Configuration Item	An element in the ITIL CMDB	
CMDB	Configuration Management DataBase	The structure and contents of the inventory used by ITIL processes	
COBS	Control Office Base System	The central subsystem of the HATMS systems, used to provide a user interface to control and monitor roadside technology and interface to, amongst other systems, Halogen.	

Acronym	Term	Definition	Further Information
	Datex II	European standard for the interchange of traffic information, generally for information between traffic management centres but also utilised for devices.	Website
	Docker	A technology used to encapsulate software to support scaling and multiple deployments. Containers and Kubernetes are related terms and technologies	Wikipedia
DDS	Dynamic Display System	Refers to the large video walls deployed in RCCs and elsewhere for monitoring traffic and to provide situational awareness	
ERT	Emergency Roadside Telephones	Special purpose telephones for emergency use installed at 1 mile intervals on the motorway network, and on stretches of all-purpose roads	
EA	Enterprise Architecture	A framework for the design and implementation of systems, service and processes within an organisation	
EAN	Enterprise Asset Management	Class of business application covering the whole life cycle of assets, often including service management, workflows and document/record management	
ECM	Enterprise Content Management	Tools for managing, curating and searching data items including documents, imagery, records and databases. They are a development of Electronic Document and Record Management products.	
ERP	Enterprise Resource Planning	Category of applications spanning a wide range of business activities including development, manufacturing, sales and marketing	
ESB	Enterprise Service Bus	A technology set used to manage the exchange of messages, data and functions between applications across an enterprise. The services offered vary widely but will include a message routing service and a published catalogue of available services	
ESS	Environment Sensor Station	A roadside device consisting of a central communications module and set of connected sensors measuring, for example, road surface temperature and wind speed	
XML	eXtended Mark-up Language	A widely used format for describing and containing data.	

Acronym	Term	Definition	Further Information
ETL	Extract, Transform and Load	Category of application used to move data between data stores, performing any required mapping or other processing along the way.	
	Fabric	A technology used to manage deployment and the integration of components, for example within an ESB	
	Fuse	A standardised stack of applications that implement a Java based ESB	
GIS	Geographical Information Systems	Systems for present information as part of, or with reference, geographic information such as maps.	
GPS	Global Positioning System	Used to refer to any generic satellite based positioning system	
HADECS	Highways Agency Digital Enforcement Camera System	System including cameras and recording used to enforce speed limits	
HADDMS	Highways Agency Drainage Data Management System	System that holds information about all of the drainage arrangements for the SRN	
HALOGEN	Highways Agency LOgging ENvironment	A system collecting logging information from HATMS and other systems managed by Highways England. It provides the feed to TPMS as well as number of reporting outputs	
HAPMS	Highways Agency Pavement Management System	System that hold information about the construction of the roads within the SRN	
HATMS	Highways Agency Traffic Management System	Use to refer to the collection of systems installed within each RCC to manage traffic using MIDAS, message sign and signals. These systems are being replaced by the CHARM project.	
HE	Highways England	The organisation responsible for managing the SRN	Website
HTTPS	HyperText Transport Protocol Secure	A protocol for secure communication over a computer network which is widely used on the Internet.	
ISU	Incident Support Unit	Formerly a team working to respond to traffic management and repairs caused by incidents	
ITD	Information Technology Directorate	A Highways England Directorate within which there are groups who are responsible for the specification, procurement and ongoing support of operational technology	

Acronym	Term	Definition	Further Information
ITIL	Information Technology Information Library	A widely used set of processes for service management in IT environments. The latest version is referred to as ITIL v2011	Website
IaaS	Infrastructure as a Service	An arrangement where a supplier provides and manages hosting used by the customer for customer applications and data	Wikipedia
I2V	Infrastructure to Vehicle	Describes a communication channel between a fixed device on the road and a vehicle system. In the future these channels could be used to provide information on road conditions and warnings directly to vehicle systems	
	Instation	A term used, to differentiate from outstation, for systems and applications deployed in data centres	
IAMIS	Integrated Asset Management Information Service	Highways England project to bring information on fixed assets into a single database or set of linked databases	
iBPMS	Intelligent BPM Systems	Marketing term for very capable BPM tools	
IoT	Internet of Things	An emerging set of technologies for managing intelligent devices	Wikipedia
IP	Internet Protocol	Widely used protocol over which messages can be exchanged	
ITT	Invitation To Tender	The process for procuring by requesting suppliers to bid against description of the desired system or service	
	ISO 55000	International standard for asset management.	Website
ITOM	IT Operations Management	Applications used to monitor data centre activity and equipment health	
ITSCM	IT Service Continuity Management	An ITIL process for ensuring that the service is resilient to failure, particularly widespread failures such as power or data centres	
ITSM	IT Service Management	An application that provides the frameworks and tooling to help organisations deliver, manage, and improve IT services and infrastructure	
ITSSM	IT Service Support Management	Similar to ITSM products but with additional capabilities for managing workflows and user engagement	
JSON	JavaScript Object Notation	A widely used format for describing and coding information, analogous to XML	

Acronym	Term	Definition	Further Information
	JBoss	A collection of Java based technology applications originally produced by the JBoss company	
KPI	Key Performance Indicator	A measure of service, often associated with SLAs	
KM	Knowledge Management	Processes for managing the collation and sharing of knowledge gained through collection and management of the information	
	Kubernetes	See “Docker”	
LED	Light Emitting Diode	A modern lighting technology in extensive use due to its low power requirements and high reliability	
LRU	Line Replaceable Unit	The lowest level of component that can be replaced separately	
MRO	Maintenance, Repair and Operations	Term sometimes used for technology operations	
MIB	Management Information Base	Within SNMP; the definition of an information set held in a device. There can be a number of these associated with an SNMP device	
MTBF	Mean Time Before Failure	The average (arithmetic mean) before an Equipment Item fails after being declared healthy. This requires careful definition of “failure”.	
MTTR	Mean Time To Repair	The average time an Equipment Item between an Equipment Item being declared faulty and its return to service. This requires careful definition of both faulty and return to service.	
MAC	Media Access Control	An international standard that provides unique MAC addresses to equipment network connections	
MIDAS	Motorway Incident Detection and Automatic Signalling	Used to refer to the HATMS subsystem and the associated roadside equipment for measuring traffic flows and then automatically implementing signal and message sign plans.	
NDC	National Distribution centre	A centre used to store roadside technology and spares managed by the Highways England Stores and Logistics team who distribute spares and new equipment to maintainers and schemes as required.	
NFDB	National Faults DataBase	An application enabling technology faults to be reported by users, and the tracking of fault resolution	

Acronym	Term	Definition	Further Information
NMCS2	National Motorways Communications System 2	A set of protocols and specifications used to manage roadside technologies including signs and signs.	
NRTS	National Roads Telecommunications Service	An outsourced contract to provide roadside telecommunications to roadside technology for Highways England	Supplier website
NTIS	National Traffic Information Service	An outsourced contract to publish Highways England information to drivers, transport organisations and the wider public. This includes the www.trafficengland.com website Historically it also manages its own set of roadside technology to supplement that provided through HATMS however all such technology is now maintained by RTMCs and so falls under the scope of the T-TOC project	
NDD	Network Development and Delivery	Directorate of Highways England that, until the re-organisation of 2016, was responsible for providing the network, its technology and maintenance. Now replaced by the Operations Directorate.	
NOMS	Network Occupancy Management System	A system for booking road space on the network. For example requesting a lane closure for carriageway repairs	
	OAuth	An open standard for authorization, commonly used as a way for Internet users to log in to third party websites using their Microsoft, Google, Facebook, Twitter, One Network etc. accounts without exposing their password	
OID	Object IDentifier	An identifier used to name and point to an object in the MIB hierarchy as part of SNMP	
ONVIF	Open Network Video Interface Forum	A set of open standard for managing devices, primarily for cameras and other video equipment	Website
OSGi	Open Service Gateway initiative	One of a standardised ways of describing services and applications	
	OpenID	Allows users to be authenticated by co-operating sites using a third party service, eliminating the need for webmasters to provide their own ad hoc login systems, and allowing users to log in to multiple unrelated websites without having to have a separate identity and password for each	
OTS	Operational technology Strategy	Overarching policy informing T-TOC. See reference [3]	

Acronym	Term	Definition	Further Information
	Outstation	A term used to refer to systems deployed on the roadside or away from data centres	
PMS	Performance Management System	Used to refer to any system that measures or assess the status of technology	
PC	Personal Computer	Used to refer to computers assigned to an individual and normally used on a desk or office environment	
PEW	Planned Engineering Work	An application supporting the business process for approval of work affecting technology at the roadside and within the RCCs	
PaaS	Platform as a Service	A category of cloud computing services that provides a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure typically associated with developing and launching an app. PaaS provides more functionality than IaaS but less than SaaS	Wikipedia
QR	Quick Response code	New two dimensional form of barcode for codifying more information	
RFID	Radio Frequency IDentification	A technology allowing components to be uniquely identified and interrogated using radio,	
	Ramp Metering	A systems that measures traffic flows near junctions and then uses traffic signals to control the flow of traffic on the associated slip roads	
RCC	Regional Control Centre	The seven regional centres, staffed by Highways England Traffic Officers, used to provide operational management of the SRN	
RTMC	Regional Traffic Management Contractor	The contracts, organised within regions that provide on-road resources for maintaining roadside technology	
RCM	Reliability Centred Maintenance	Function of EAM applications that provides detection of imminent asset failures through embedded sensors and/or external portable equipment	
RMAS	Remote Maintenance Access Service	System for directly connecting to roadside technology for remote software upgrade, configuration and maintenance	

Acronym	Term	Definition	Further Information
RESTful	Representational State Transfer ful	Style of API, often using HTTPS, that web browsers and other web services can use to retrieve web pages and send data. The messages are usually “Stateless”, that is the services don’t have to store the “state” of a multi-message transaction, making them more resilient to communications failure.	
RACI	Responsible Accountable Consulted Informed	A method for classifying the level of involvement that users or roles have in business processes. Responsible – actively carries out the process Accountable – is ultimately responsible for ensuring that the process is carried out correctly Consulted – contributes to the process with consent or information Informed – is only informed of the status of the process	
SAML	Security Assertion Mark-up Language	An XML-based, open-standard data format for exchanging authentication and authorization data between parties	
SCM	Service Catalogue Management	The process of managing the list of services and their descriptions	
SDP	Service Delivery Point	A NRTS term denoting the address and location of a network endpoint. For example each MIDAS outstation will be connected at an SDP with an IP address, which will be polled by the subsystem.	
SIAM	Service Integration And Management	Term used to describe an overarching contract awarded to manage the overall service provided by IT within a business, usually including support and management of other suppliers	
SLA	Service Level Agreement	A, usually contractual, agreed quality of service provision with an agreed set of measures and thresholds	
SOA	Service Oriented Architecture	An architecture for computer software design in which application components provide services to other components via a communications protocol, typically over a network. The principles of service-orientation are independent of any vendor, product or technology	
SWIS	Severe Weather Information Service	A system that collects weather information from a network of roadside sensors (ESS) and forecasters and presents it through a website and web services within the Highways England community	

Acronym	Term	Definition	Further Information
	SHARE	A Highways England office IT system used to hold documents and records. It is based on the OpenText Content Server product	
SNMP	Simple Network Management Protocol	A widely used protocol for managing devices on a network.	Wikipedia
SSO	Single Sign-On	Facility to enable users, and systems, to authenticate once in order to use all of the facilities and interfaces across a system rather than providing individual authentication.	
SaaS	Software as a Service	An arrangement where a supplier hosts the application and data on hosting they manage and control	Wikipedia
SRN	Strategic Road Network	The set of roads managed by Highways England	Extent
SDS	Streamlined Data Services	Formerly used to refer to the systems now referred to as T-TOC	
SMIS	Structures Management Information System	System that holds information about structures on the SRN	
TIU	Technology Intelligence Unit	Team envisaged by the Operational technology Strategy (ref. [3]) as providing analysis and research on operational technology issues	
TOC	Technology Operations Centre	A common location for managing technology, as described by the Operational Technology Strategy (ref. [3])	
TPMS	Technology Performance Management System	An application currently used to manage technology assets, It includes automatic analysis, service management, workflows, asset management and reporting	
TIC	Test and Innovation Centre	A facility that will allow for integration testing of end to end technology solutions used on the SRN. The facility will also provide training facilities and capabilities to try new innovations. It's currently planned to be co-located with the NDC (ref.[3])	
TOGAF	The Open Group Architecture Framework	A framework for developing and documenting business and IT architectures	Website
T-TOC	Tools for Technology Operations Centre	This is used to refer to the set of systems, applications and processes used to manage the operational technology in the future.	
TMU	Traffic Monitoring Units	Technology, usually inductive loop based, for measuring traffic flows. These units were deployed by NTIS as part of the original contract provision	

Acronym	Term	Definition	Further Information
TCMS	Tunnel Control Management System	System being developed by Highways England for managing tunnels on the SRN	
UTMC	Urban Traffic Management Centre	An architecture, protocols and taxonomy widely used for managing traffic technology in urban environments in the UK.	Website
VMS	Variable Message Sign	A roadside message sign capable of display different message to road users	
	WAR	A file format used for holding files before deployment as an OSGI bundle	
	WS-Federation	WS-Federation defines mechanisms for allowing disparate security realms to broker information on identities, identity attributes and authentication	

Annex 2 – Web Service Sizing Calculations

Name	In/Out	Message size	Volumetric method	Volume	Frequency method	Peak Frequency (Hour)	Average Bandwidth (kb/s)	Latency approach	Acceptable Latency (s)	Peak Bandwidth (kb/s)
NRTS Service Health and Status	In	Medium (10Kb)	Based on the number of services being 5 times the number of NMCS2 devices (50000)	250000	1% of services change status each day, with a constant frequency across the 24 hour day	104.17	3	Processed by system. No response reqd by user	1.00	10000
PMS Service Health and Status	In	Medium (10Kb)	An estimate of the number of sites being about 1000. This based on: - a dozen tunnels with 100 services each - 100 UTMCs with 10 services each - 100 Ramp metering sites with 2 services each - 500 HADECS sites with 1 service each	3000	5% of services change status each day, with a constant frequency across the 24 hour day. On the grounds that HADECS etc are less reliable than NRTS services	6.25	0	Processed by system. User response after analysis	1.00	10000
SWIS Device Status	In	Large (100kb)	there are 300 ESS. Although there about 50 sensors on each ESS, which constitute separate services the messages are per ESS	300	An ESS will report between 2 to 20 sensor faults per day. Using an average of 5. However the messages are sent every 10 minutes	1800	500	Processed by system. User response after analysis Process within 1% of next message time	10.00	10000
NMCS2 and MIDAS Device Status	In	Compact (100b)	Per NMCS2 device	50000	Assumes that health status is only reported when it changes and every 5 minutes	600000	167	Processed by system. User response after analysis Process within before Status affects other users Process before next message	0.01	10000
CHARM Interface Device Status	In	Small (1kb)	There are only a very small number of interfaces to report on, probably less than 5	5	Interfaces should be very reliable. One failure a week would be high but reporting should be minute	300	1	Processed by system. User response after analysis Process within 1% of next message time	0.10	10000
Met Device Status	In	Small (1kb)	There are up to 20 devices per RCC	150	Only changes health status is reported, and a 5 minute refresh	1800	5	Processed by system. User response after analysis Process within 1% of next message time	0.10	10000

SNMP Device Alert and Status	In	Small (1kb)	Initially only a small number but eventually every device	100000	The SNMP element managers can be located to reduce the load, with only changes being reported. Assumes that 1% of devices change health status every day	42	0	Processed by system. User response after analysis	0.10	10000
SNMP Device Alert and Status	In	Small (1kb)	Initially only a small number but eventually every device	100000	Assume a 5 minute refresh	1200000	3333	Processed by system. User response after analysis Process within 1% of next message time	0.10	10000
ONVIF Device Alert and Status	In	Small (1kb)	Up to the number of cameras - approximately 2000	2000	The SNMP element managers can be located to reduce the load, with only changes being reported. Assumes that 1% of devices change health status every day	0.83	0	Processed by system. User response after analysis	0.10	10000
ONVIF Device Alert and Status	In	Small (1kb)	Up to the number of cameras - approximately 2000	2000	Assume a 5 minute refresh	24000	67	Processed by system. User response after analysis Process within 1% of next message time	0.10	10000
NTIS Device Status	In	Medium (10Kb)	2400 TMU sites, corresponding to 4800 measurement points, 1500 ANPR cameras Asumes Datex II	6500	Assume a 5 minute refresh	78000	2167	Processed by system. User response after analysis Process within 1% of next message time	1.00	10000
Ramp Metering Service Health and Status	In	Medium (10Kb)	100 ramp metering sites each with 2 services	200	Assume a 5 minute refresh	2400	67	Processed by system. User response after analysis Process within 1% of next message time	1.00	10000
HADECS Service Health and Status	In	Medium (10Kb)	500 HADECS sites with 1 service each	500	Assume a 5 minute refresh	6000	167	Processed by system. User response after analysis Process within 1% of next message time	1.00	10000
ERT Device Status	In	Small (1kb)	7000 telephones on the network	7000	ERTs are only checked daily	292	1	Processed by system. User response after analysis	1.00	1000
Scheme Development	In	Enormous (1Mb)	A new scheme every day and more	500	Assumes scheme development is per year but they are loaded at the same time each day	2	6	User waiting but expecting a delay Overall process months	100.00	10000

RMAS Configuration	Out	Enormous (1Mb)	Assume RMAS equipment for each RCC area, and centrally.	20	Assumes a new download every week per RMS instance during the working day	0.83	2	User waiting but expecting a delay Infrequent task	100.00	10000
Incident Status	Out	Small (1kb)	Assume 10000 incident updates per day	10000	Incidents are evenly distributed	417	1	Publication to other systems	0.10	10000
Asset Status	Out	Small (1kb)	Assume 10000 incident updates per day	10000	Incidents are evenly distributed	417	1	Publication to other systems	0.10	10000
Task Status	Out	Small (1kb)	Assume each on-road resource (say 50) handles 20 incidents per day	1000	Task updates are evenly distributed through the working day	125	0	Publication to other systems	0.10	10000
Equipment Status	Out	Small (1kb)	Assume 10000 Equipment updates per day	10000	Equipment updates are evenly distributed through the working day	1250	3	Publication to other systems	0.10	10000
Data Extract	Out	Vast (100Mb)	Extracts all day	5	Evenly distributed during the day	0.21	58	Overnight batch	10000.00	10000
NRTS Configuration Synchronisation	Exchange	Medium (10Kb)	Based on the number of services being 5 times the number of NMCS2 devices (50000)	250000	1% of services change each day, with a constant frequency across the 24 hour day	104.2	3	Processed by system Other activities take hours	10.00	1000
Operational Configuration Synchronisation	Exchange	Medium (10Kb)	Based on number of devices being managed	50000	1% of devices change each, spread over working day	62.5	2	Processed by system Other activities take hours	10.00	1000
Asset Management Systems Synchronisation	Exchange	Medium (10Kb)	Based on a similar number of assets to CHARM	50000	1% of devices change each, spread over working day	62.5	2	Processed by system Other activities take hours	10.00	1000
Stores Data Exchange	Exchange	Medium (10Kb)	Based on a 5 pieces of equipment for each asset in CHARM	250000	1% of equipment items change each, spread over working day	312.5	9	Processed by system User may have to wait for response	1.00	10000
Authentication Service	Exchange	Compact (100b)	Assumes authentication for a session, rather than per transaction. Assumes 1000 users and systems restarting sessions per hour	1000	New sessions each hour	1000	0	High performance, time critical transaction	0.01	10000
road space booking	Exchange	Medium (10Kb)	Based on 1000 tasks per day	1000	25% of tasks require NOMS information/permissions on a daily basis	31.25	1	User interaction, but complex	1.00	10000

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