

## **APPENDIX A:**

### **ENGINEERING CONSULTANCY SERVICES**

#### **CAPABILITY STATEMENTS**

<b>A1: Multi- disciplinary Engineering Services</b>	<ul style="list-style-type: none"><li>• Civil Engineering and Structures</li><li>• Mechanical and Electrical Engineering</li><li>• Project and Programme Management</li><li>• Asset Management</li><li>• Architectural Services</li></ul>
<b>A2: Multi-isciplinary Rail Engineering Services</b>	<ul style="list-style-type: none"><li>• General Railway Infrastructure</li><li>• Rolling Stock and Assets Advice</li><li>• Railway Infrastructure, Rolling Stock and Asset Research</li><li>• Railway asset management</li><li>• Stations - including access, property, parking, mobility and security, Depots and stabling - strategy and advice</li><li>• Signalling and systems - strategy and advice</li><li>• Rolling stock - strategy and advice, management, acceptance, planning</li><li>• Technical due diligence</li><li>• Rail engineering, feasibility &amp; operating advice</li><li>• Power / electrification - strategy and advice</li><li>• Telecommunications / CIS - strategy and advice</li><li>• Railway infrastructure and assets commercial advice</li></ul>
<b>B: Specialist Engineering Services</b>	<ul style="list-style-type: none"><li>• B1: Electrical and Mechanical Services Engineering</li><li>• B2: Fire and Safety Engineering</li><li>• B3: Utilities Services</li><li>• B4: Pumps, Hydraulics &amp; Drainage and Sustainable Drainage (SuDS)</li><li>• B5: Earthwork Structures</li><li>• B6: Geotechnical Engineering &amp; Site Investigations</li><li>• B7: Ground Investigations</li><li>• B8: Topographical Surveys</li><li>• B9: Engineering Business Consultancy Support</li><li>• B10: Road Tunnels, M&amp;E and Systems</li><li>• B11: Building Information Modelling (BIM)</li><li>• B12: Building Surveying and Condition Monitoring</li><li>• B13: Buildings Control</li></ul>

<b>C: Engineering Architectural Services</b>	<ul style="list-style-type: none"> <li>• B14: Bridges and Structures</li> <li>• B15: Buildings and Structures</li> <li>• B16: Marine Engineering</li> <li>• B17: Obsolescence Management</li> <li>• B18: Tunnelling Engineering</li> </ul>
	<ul style="list-style-type: none"> <li>• C1: Transport Architecture</li> <li>• C2: Non Transport Architecture</li> <li>• C3: Commercial Architecture Support</li> <li>• C4: Urban Design</li> <li>• C5: Structural Engineering – Architectural Design</li> </ul>
<b>D: Highways Engineering</b>	<ul style="list-style-type: none"> <li>• D1: Traffic Engineering Projects</li> <li>• D2: Engineering Skills &amp; Support</li> <li>• D3: Ad Hoc Survey Procurement/Data Collection and Analysis</li> <li>• D4: Highways Engineering</li> <li>• D5: Traffic Control Engineering</li> <li>• D6: Traffic Signal Controller Configuration and Testing:</li> <li>• D7: Intelligent Transport Systems</li> <li>• D8: Road Safety Audit &amp; Collision Investigation</li> <li>• D9: Provision of arboricultural technical expertise</li> <li>• D10: Provision of horticultural technical expertise</li> <li>• D11: Provision of 'built green infrastructure' technical expertise</li> </ul>

	<ul style="list-style-type: none"> <li>• D12: Bus Design Engineering</li> <li>• D13: Bus Specialist Engineering Support</li> <li>• D14: Bus Specialist Investigation Support</li> </ul>
<b>E: Rail Engineering</b>	<ul style="list-style-type: none"> <li>• E1: Rolling Stock Design Engineering</li> <li>• E2: Rolling Stock System Specialist Engineering Support</li> <li>• E3: Rolling Stock Specialist Investigation/testing Support</li> <li>• E4: Depot Engineering, Plant and Equipment</li> <li>• E5: Transport System and Railway Development</li> <li>• E6: Incident Investigation</li> <li>• E7: Transportation Information, Security and Surveillance Systems</li> <li>• E8: Transport Control System Engineering</li> <li>• E9: Cyber Security Engineering</li> <li>• E10: Communications Engineering</li> <li>• E11: Systems Engineering</li> <li>• E12: Information Securities Engineering</li> <li>• E13: High Integrity Software Based Engineering</li> <li>• E14: Simulation and Modelling</li> <li>• E15: System Safety Engineering</li> <li>• E16: SCADA</li> <li>• E17: R&amp;R TCS Electronics</li> <li>• E18: Electromagnetic Compatibility (EMC)</li> <li>• E19: Human Factors (HF)</li> <li>• E20: RAM</li> <li>• E21: Railborne and non railborne plant</li> <li>• E22: Track Configuration</li> <li>• E23: Signalling, Installation, Testing and Maintenance</li> <li>• E24 – Signal Design Engineering</li> <li>• E25 – Power Engineering</li> </ul>

## **A1: Multi-disciplinary Engineering Services**

Multidisciplinary Services may include but will not be limited to a combination of the following sub categories:

### **Capabilities Details:**

#### **Civil Engineering and Structures**

Civil Engineering is about creating, improving and protecting the environment in which we live. Civil Engineers design and build bridges, roads, railways and tunnels.

Structural Engineers are involved in the design and supervision of structures which will include calculating loads and stresses, investigating the strength of foundations and analysing the behaviour of beams and columns in steel, concrete or other materials to ensure the structure has the strength required to perform its function safely, economically and with a shape and appearance that is visually satisfying.

The Bidder will need to demonstrate knowledge and understanding of Civil and Structural processes and procedures that allow TfL's legal accountabilities to be fulfilled and its required interfaces with regulatory and other agencies, to cover but not necessarily be limited to the following areas:

- Earthwork Structures
- Geotechnical Engineering
- Topographical Surveys
- Tunnelling Engineering
- Hydraulics and Drainage
- Bridges – Design and Assessment Engineering
- Buildings and Structures
- Road/Rail Interface
- Utilities Engineering
- Highway Design
- Site Investigations
- Site Supervision

## **Mechanical and Electrical Engineering**

The Bidder will need to demonstrate knowledge and understanding of Mechanical and Electrical processes and procedures that allow TfL's legal accountabilities to be fulfilled and its required interfaces with regulatory and other agencies.

The Bidder will be expected to provide a wide range of advice, studies, surveys, reports, design and supervision services which will in turn rely and depend on skill, competence and capabilities including but not limited to the following:

- Lift and Escalator Engineering
- Building Services Engineering
- Fire & Security Engineering
- Heating & Ventilation / Air Condition Engineering
- Information Systems Engineering
- Building Management Systems (BMS)

## **Project and Programme Management**

Project Management is the business process of creating a unique product, service or result. A project is a visible set of activities having specific start and completion dates undertaken to create a quantifiable deliverable, through well managed milestones and resources - identifying stakeholders and interdependencies, and keeping all parties clear about their goals and individual responsibilities.

Programme Management is the process of managing multiple ongoing inter-dependent projects. This will require the individual projects to be separately project managed.

In an organisation, Programme Management also reflects the emphasis on coordinating and prioritizing resources across projects, departments, and entities to ensure that resource contention is managed from a global focus.

Programme Management provides a layer above Project Management focusing on selecting the best group of programmes, defining them in terms of their constituent projects and providing an infrastructure where projects can be run successfully but leaving Project Management to the Project Management community.

A strategy is a long term plan of action designed to achieve a particular Programme Management goal. Strategy is differentiated from tactics or immediate actions with resources at hand by its nature of being extensively premeditated, and often practically rehearsed. Strategies are used to make the problem easier to understand and solve. Strategy is about choice which affects outcomes and is adaptable by nature rather than a rigid set of instructions.

The Bidder will need to demonstrate a practical knowledge and understanding of Project and Programme Management and strategy formation processes and procedures that allow TfL's legal accountabilities to be fulfilled and its required interfaces with regulatory and other agencies.

The Bidder will be expected to provide a wide range of advice, studies, surveys, reports, design and supervision services which will in turn rely and depend on skill, competence and capabilities.

## **Asset Management**

Asset Management is deemed to be the management of physical assets (their selection, maintenance, inspection and renewal). It is the art and science of making the right decisions and optimising these processes.

The Bidder will need to demonstrate knowledge and understanding of the concepts and practical application of asset management, whole life management and costing techniques. Knowledge of processes or systems for tracking and evaluating service performance will also be required along with the ability to analyse performance trends and their overall impact on the capacity and capability of the railway. The supplier will have the knowledge and ability to implement, communicate and influence good practice and to ensure that it is consistent with Publicly Available Specification (PAS) document PAS 55 and other related management systems.

The Bidder will be expected to supply a wide range of advice, studies, surveys, reports, design and supervision services which will in turn rely and depend on skill, competence and capabilities including but not limited to the following capability details:

- Providing asset management maturity assessment and certification services
- Developing and delivering asset management training
- Supporting the development of asset management strategies
- Supporting the development of asset information strategies and delivering activities that improve the management of asset information
- Supporting the development and implementation of whole life cost and investment planning practices, including asset modelling and prioritisation
- Supporting the management and delivery of an asset management improvement plan

## **Architectural Services**

Architectural Services are the delivery of sophisticated, sensitive, environmentally sustainable and commercially-grounded architectural projects across a range of scales. Projects might include civic buildings; community uses, cafes, libraries, health centres, utility

buildings, bridges and infrastructure; residential, commercial, industrial and mixed uses and other types as required.

Services may be procured across one or all of the RIBA stages (or equivalent), including concept design, feasibility, detailed design, construction information and monitoring. Works may be new build or refurbishment.

The services also capture the provision of design guidance and parameters relating to architecture and the built environment and advice on the architecture and urban design of major schemes and proposals, with the aim of improving and achieving the highest possible design quality across these projects.

The Bidder will be expected to supply a wide range of advice, studies, surveys, reports, design and supervision services which will in turn rely and depend on skill, competence and capabilities including but not limited to the following areas:

- Urban Strategies and Area Plans
- Architecture
- Site Masterplanning and Development Feasibility
- Public Realm and Landscape
- Transport Architecture and Interchange Design
- Design Advice and Design Management
- Environmental Design and Sustainability Advice
- Community Engagement and Local Regeneration
- Heritage and Conservation Advice
- Graphic Design and Place-based Marketing
- Interior Design and Space Planning (commercial and retail)
- Modelling and Visualisation

## **A2: Multi-disciplinary Rail Engineering Services**

Multidisciplinary Services may include but will not be limited to a combination of the following sub categories on Rail:

- General Railway Infrastructure
- Rolling Stock and Assets Advice
- Railway Infrastructure, Rolling Stock and Asset Research
- Railway asset management
- Stations - including access, property, parking, mobility and security, Depots and stabling - strategy and advice
- Signalling and systems - strategy and advice
- Rolling stock - strategy and advice, management, acceptance, planning
- Technical due diligence
- Rail engineering, feasibility & operating advice
- Power / electrification - strategy and advice
- Telecommunications / CIS - strategy and advice
- Railway infrastructure and assets commercial advice



## **B: Specialist Engineering Services**

### **B1: Electrical and Mechanical Services Engineering**

Electrical and Mechanical (E&M) Services Engineering, also known as Building Services Engineering, is the discipline responsible for the building services within stations, depots, train crew accommodation, rail tunnels, road tunnels and other operational buildings.

E&M Services Engineering covers all stages of the asset life cycle commencing with inception, through design, construction, commissioning, handover and maintenance. It is concerned with the creation and maintenance of building services assets to help maximise reliability, availability, maintainability and serviceability at an affordable whole life cost.

E&M Services enable human habitation and operation of buildings in accordance with the relevant Regulations and Standards.

The Bidder shall demonstrate:

- knowledge and understanding of E&M Services Engineering processes and procedures;
- their ability to co-ordinate the E&M Services design with other disciplines;
- their ability to manage interdisciplinary design interfaces;
- practical knowledge of installation, operation and maintenance methodologies;
- practical knowledge of the constraints on installing, operating and maintaining E&M Services in an operational railway environment;
- practical knowledge of the constraints on installing, operating and maintaining E&M Services in an operational road tunnel environment;
- compliance with TfL and/or LUL standards and procedures including the ability to meet safety requirements associated with gaining access to operational areas;
- a full working knowledge of relevant legislation, British Standards, building regulations and appropriate industry standards and ability to communicate with and influence their client using that knowledge;
- knowledge of TfL's legal accountabilities and how they shall be fulfilled;
- how they propose to manage TfL's required interfaces with regulatory and other agencies.

The Bidder will be expected to provide a wide range of advice, studies, surveys, computer modelling, reports, design, computer aided design (CAD) and supervision services which will

in turn rely and depend on skill, competence and capabilities. The Bidder shall demonstrate their knowledge and ability to communicate with and influence their Client in the design of the services, including but not limited to:

- Heating systems (gas, electrical, solar, ground source heat pump and other renewable sources);
- Ventilation systems (fresh air supply, exhaust, smoke control, machine room .);
- Tunnel ventilation systems (smoke control ventilation, exhaust, supply in rail or road environments.);
- Air conditioning services (chilled water systems, direct expansion and centralised refrigerant cooling systems, borehole cooling systems);
- Trigenation (combined cooling, heat and electrical power generation (CCHP));
- Domestic water services (hot and cold water services);
- Low voltage electricity distribution and circuitry;
- Natural and artificial lighting including emergency lighting;
- Lighting Control systems;
- Acoustics;
- Platform Edge Doors;
- Uninterruptible Power Supplies;
- Lightning Protection and transient surge suppression systems;
- Utility supplies: gas, electricity, water and renewable sources;
- Associated control systems to serve the above systems, and
- Building Management Systems.

## **B2: Fire and Safety Engineering**

Fire Engineering involves specification, design, installation, inspection and audit necessary to support the delivery of Fire Engineering requirements. These services specifically enable the safe human habitation of buildings and aim to minimise the disruption to operations and maximise building use.

The supplier shall demonstrate their knowledge and ability to communicate with and influence their client in the following areas:

- Fire engineering:

- Understanding of TfL and LUL standards
- Formulation of fire safety strategies for buildings and railway stations in accordance with BS 7974
- Modelling for fire strategies
- Specification and design of fire detection, suppression and alarm systems
- Specification and design of fixed fire-fighting water supplies, portable fire extinguishers and sprinkler systems
- Specification and design of passive, gaseous and aqueous fire protection systems
- Specification and design of access and other facilities for fire fighters
- Specification and design of fire compartmentalisation and fire resisting elements of construction
- Smoke Control and management systems
- Fire and smoke modelling and simulation
- Reaction to fire properties of materials, including flammability, smoke production and toxicity
- Undertaking Fire risk assessments

### **B3: Utilities Services**

TfL require the collection of underground utilities to ensure asset owners are aware of their assets and locations and to also reduce the number of deaths and injuries due to underground asset strikes. Knowing utility locations can also determine the outcome of proposed highway works and to reduce unforeseen costs of future work.

The accurate detection, identification, verification and location of utility assets is crucial in preventing:

- Risks to the safety of workers and to the public;
- Abortive and unnecessary work;
- Damage to third party assets;
- Inefficient design solutions;
- New construction often conflicts with existing underground infrastructure;
- Existing underground utilities and their related structures constitute inefficiencies and risks on projects.

Suppliers must be compliant with the 2014 Publicly Available Specification (PAS) 128 standards. This comprises the following:

- PAS 128 Survey Category Type D
  - Underground utility plotted from utility record data only (not detected by geophysical methods).
- PAS 128 Survey Category Type C
  - Underground utility plotted from utility record data only, but with site reconnaissance to match utility record with physical utility street furniture as a best fit.
- PAS 128 Survey Category Type B
  - Utility detected by multiple geophysical methods to obtain a horizontal and vertical position.
- PAS 128 Survey Category Type A
  - Utility verified and positioned by physical identification. This may be by strategically positioned vacuum excavation, hand dug trial pitting or by visual inspection within a utility chamber.

A full range of services is required, the following are examples:

- Collate existing utility company service record drawings
- Below ground utility location and mapping undertaken

All work to be provided in AutoCAD DWG format to the OSGB36 grid and all surveys shall be carried out in accordance with relevant TfL / LU and other applicable industry standards, particularly TfL's SQA587.

#### **B4: Pumps, Hydraulics & Drainage and Sustainable Drainage (SuDS)**

Pumps, Hydraulics and Drainage is the provision of drainage and systems design (foul, surface and combined .), assessment and modelling (e.g. InfoWorks (ICM) / Microdrainage or similar), flood risk assessments, developing sustainable drainage strategies, advice on sustainability (SuDS) issues, hydrological analysis.

The Supplier shall demonstrate:

- The ability to write and produce reports on flood risk assessments for all flood sources (natural and manmade).
- The ability to develop drainage strategies, designs and drainage/pump asset assessments.

- The usage of specialist tools and techniques to undertake assessment and design in the specialist areas of track and off track drainage systems, earth structures, highways, paved areas, station and gravity drainage systems and pumping systems.
- The ability to undertake pumping systems design.
- The ability to undertake, check or verify InfoWorks ICM analysis of drainage catchments.
- The provision of advice, design and assessment of SuDS.
- The ability to advise on the Mayoral Transport Strategy, London Environmental Strategy, National SuDS Development and London Sustainable Drainage Action Plan .
- The ability to assist, check or verify TfL Standards development and assessment for Pumping systems, Drainage, SuDS and Flood Risk.
- The provision of advice, design, check or verification of hydrological analysis (e.g. groundwater draw down assessment ).
- The ability to undertake drainage rehabilitation designs for both the railway and highway environments.
- Experience in liaison and successful scheme approval with Local Authorities, Utility Companies, Third Party asset owners.
- GIS and large data set development and delivery in 2D and 3D datasets within a suitable BIM format.
- Assessment and design of suitable Type C (BS 8102) structural waterproofing systems and advice of Type A & B (BS 8102).
- The ability to advise on, develop and review drainage and pumping design process and quality assurance documentation.

## **B5: Earth Structures**

Earth Structures are generally defined as cuttings and embankments and other natural slopes which have been constructed to provide a corridor and support for roads and rail transport infrastructure.

The supplier shall provide the following specialist engineering support with regards to Earth Structures to ensure a safe and efficient railway.

- Condition appraisal
- Inspection
- Monitoring
- Ground Investigation
- Assessment

- Maintenance
- Upgrade/renewal

The supplier shall provide specialist engineering support to carry out high quality geotechnical designs and construction drawings and specifications for stabilisation/renewal of Earth Structures, including usage of specialist geotechnical softwares such as Slope/W, WALLAP, G/Wall and other relevant softwares and database such as GINT and HoleBase.

## **B6: Geotechnical Engineering and Site Investigation**

Geotechnical Engineering is the provision of expert advice and support in assessing the stability and strength of soil and rock materials, as well as groundwater conditions.

The supplier shall demonstrate usage of specialist tools and techniques to undertake assessments and/or design of the following:

- Geotechnical investigations
- Foundations and retaining walls
- Deep basements and excavations.
- Grouting and underpinning
- Soil and rock slope stability
- Reinforced earth
- Soil nails and ground anchors
- Roads and pavement
- Temporary works
- Numerical analysis

A site investigation is the process of the collection of information on ground and groundwater conditions, the appraisal of data, assessment and reporting without which the hazards of the ground beneath the site cannot be known.

The supplier shall demonstrate their ability to provide technical and professional support with regards to site investigations which includes the following:

- Ground investigations for road and rail infrastructure projects
- Soil stiffness and ground movement
- Geotechnical interpretation and assessment for design and construction of civil engineering structures

- Assessment of failed structures and slopes
- Earthworks and drainage
- Site survey for potential contamination risks

## **B7: Ground Investigations**

Ground Investigation services are required to meet TfL Project requirements. A full range of services are required, including but not limited to:

1. Cable Percussive Boring (Standard and Modular)
2. Rotary Drilling (All Methods)
3. Cone Penetration Testing (All Types)
4. Dynamic Sampling (Hand Held, Modular, Tracked)
5. Dynamic Probing (All Types)
6. Hand Dug and Machine Dug Trial Pitting and Trenching
7. Foundation Inspection Pitting
8. Concrete Coring
9. Geophysical Surveys
10. Utility Surveys to PAS 128
11. In-situ (Field) Testing (CBR, Plate Load Bearing, Self-Boring Pressuremeter)
12. Soil and Rock Logging
13. Site Supervision
14. Instrumentation and Monitoring (Groundwater, Gas, Ground Movement)
15. Materials Testing
16. UXO Surveys and Supervision
17. UKAS/MCERTS Accredited Geotechnical/Environmental Soil, Rock and Aggregate Testing
18. Topographical Surveys
19. Ground Investigation Report (Factual)
20. Provision of AGS Data

The ground investigation is to be undertaken in accordance with the relevant British Standards or equivalent European Standards, in particular BS EN 1997-2, BS EN ISO 22475-1, BS EN ISO 22475-2, BS EN ISO 22475-3, BS 1377, BS 5930:2015 and BS10175, or other recognised standards or Codes of Practice current on the date of the works.

## **B8: Topographical Surveys**

Land and Measured Survey services are required to meet TfL Project requirements. A full range of measured survey services is required, including but not limited to:

- Track, tunnel and platform surveys
- Tunnel gauging
- Embankment and cuttings – earthworks
- General topographical surveys

- Control networks
- High Definition Scanning (HDS) surveys for 3D modelling of stations, tunnels, bridges and buildings
- Track and structure monitoring
- Tunnel to surface correlation surveys
- Highway surveys
- Measured building surveys
- Setting-out of new works

All surveys for LU, DLR and Tramlink shall be carried out to London Survey Grid (LSG) and height datum, created and plotted using MicroStation V8 (to avoid corruption during conversion from other formats), supplied in Microstation V8 DGN in 2D or 3D as required. The LU Survey Data Manager will check the delivered data prior to formal acceptance.

Survey undertaken for Surface shall be undertaken to OS datum and presented using AutoCAD.

The surveys shall be carried out in accordance with relevant TfL / LU and other applicable industry standards.

## **B9: Engineering Business Management Consultancy Support**

Engineering Business Management Consultancy Support may include but will not be limited to a combination of the following:

### **Capabilities Details:**

- Provision of business management consultancy for TfL Engineering.
- Provision of expertise to support the TfL Engineering's matrix management.
- Provision of expertise to support engineering business performance measurement and improvement (i.e. business process and business change management in an engineering environment)
- Provision of expertise to support the development of a culture of innovation and technology led change.
- Provision of expertise in the application of new technologies.
- Provision of strategic and technical advisory services



## **B10: Road Tunnels, M&E and Systems**

Road Tunnels comprise of a number of specialist M&E assets along with General building service requirements which span across a range of asset types found in the other areas of this section.

The supplier shall demonstrate their ability to provide technical and professional support with regards to Road Tunnels and their Tunnel Service / plant room buildings

To have working Knowledge / familiarity with:-

- Road Tunnel design and Maintenance standards and best practice both in the UK and European / International.
- Current Electrical, Mechanical, Communication and Systems Standards and best practice.
- Road Tunnel Safety Regulations 2009, Road Tunnel EU Legislation and TfL Tunnel Policy regarding their implementation.
- Fire Safety Regulations (RRO Fire Safety 2006).
- Have an understanding of Road Tunnel Operations (Preferably TfL Tunnels).
- Tunnel SCADA systems including PLC's (predominantly Vijeo Citect), Software and Hardware Security processes.
- IP Communications networks and protocols.

To provide suitably qualified and competent staff to carry out the following services:-

- Feasibility and conceptual /preliminary design for Tunnel Systems, such as but not limited to:
  - Tunnel Fire life safety systems (Inc. Fire mains, in Tunnel fire suppression technology, way guidance and low level evacuation .)
  - Tunnel Ventilation (surveys and CFD modelling)
  - Tunnel Lighting to BS 5489 pt2
  - In Tunnel Communications (Radio / PA/ Mobile LTE, )
  - In Tunnel CCTV, VAID and cutting edge incident detection systems
  - Pumping Systems (Inc. Gas detection and level monitoring, Aquaview monitoring)
  - Building services systems (Fire / intruder / small power / Heating / air cooling )
  - Electrical Design Inc. HV, LV and ELV

- Electrical Standby systems generation and UPS.
- Carry out Inspections and Surveys to meet TfL requirements including but not limited to :
  - DSEAR reviews on Tunnels & Pumping Stations
  - Tunnel M&E Principal and Specialist Inspections in accordance with TfL guidelines
  - Cat 3 Check on Tunnel M&E systems
- Review, Condition Survey and Update:
  - M&E Asset registers
  - M&E Drawings
  - Tunnel Operations and Maintenance documentation and manuals

### **B11: Building Information Modelling (BIM)**

BIM is a process involving the collaborative production, use and management of digital representations of the physical and functional characteristics of a facility / asset.

Standards, Methods & Procedures (SMPs) and Digital Engineering are key components of BIM:

- Standards, Methods & Procedures: provide a consistent collaborative approach to the production, use and management of data and information
- Digital Engineering: the use, manipulation, simulation and analysis of digital data to inform decisions. Examples may include the use or application of virtual design (3D), virtual construction (4D), virtual estimating (5D), virtual energy / carbon management (6D), digital fabrication and the use of mobile technology

TfL believes that BIM enablers of improved efficiency are:

1. Information Standards
  - File naming and classification
  - Modelling standards
  - Industry standards
2. Information Requirements
  - OIR, EIR & AIR
  - Requirements management
3. Process
  - Process and workflows
  - Roles and responsibilities
4. Technology
  - Common Data Environment (CDE)

- Data use and modelling
- Digital Engineering
- 5. Contract Implications
  - BIM protocol
  - Works and services information
- 6. Business change
  - Training and capability development
  - Communications
  - Performance management
  - Continual Improvement
- 7. Security PAS1192-5:2015
  - Strategy development
  - Role definition
  - Compliance auditing and advice
- 8. Health and Safety PAS 1192-6:2018

## **B12: Building Surveying and Condition Monitoring**

Building surveyors advise on the maintenance and repair, redevelopment and/or alterations to existing buildings. They advise on the continued fitness for purpose of buildings, within client requirements and applicable Legislation, Regulation and LU Standards. They also provide advice on the design and construction of new and altered buildings on the TfL estate. These buildings include, but are not limited to:

- London Underground Stations
  - National Rail Stations (London Overground)
  - Light Railway Stations (DLR)
  - Tram Stops
  - Bus Stations
  - Coach Stations
  - Pier Buildings
- 
- Office and Staff Support buildings – eg train crew accommodation
  - Staffed Operations buildings – eg control centres
  - Un-staffed Operations buildings – signal equipment rooms
  - Maintenance buildings – eg depot train sheds
  - Storage buildings

The supplier shall demonstrate their ability to provide technical and professional support to these buildings, including but not limited to:

- The provision of advice about building/property issues including technical, financial, legal, environmental, building regulation, CDM and occupiers welfare and restoration matters.

- Undertaking property and land surveys and valuations.
- Undertaking measured surveys, condition surveys and dilapidation surveys.
- Work bank development and management.
- Preparing plans, contracts, budgets and other documentation.
- Recording finding in the survey collection database and writing technical reports.
- Planning and overseeing building / building project works, monitoring progress and ensuring work is completed in time.
- Acting for TfL as the Building Owners Surveyor or Adjoining Owners Surveyor under the Party Wall Etc Act 1996.
- Providing expert advice and gaining consents for Town Planning and Listed or heritage Buildings.

A Condition Survey of a building or building element is carried out to advise a client on the current condition of a building or elements of its construction. This informs short, medium & long term proposals for future maintenance and/or development. A condition survey involves the examination and photographic recording of an object, surface or building prior to treatment.

The supplier shall demonstrate their ability to provide technical and professional support including but not limited to:

- Recording the present condition of a Building or Building Element, highlighting areas of failure or concern
- Provide a better understanding of the nature, history, technology and significance of the Building or Building Element
- Investigating previous interventions
- Identifying causes of historic and ongoing deterioration
- Presenting conservation recommendations based on the results of the survey
- Providing an estimate for works, if required

### **B13: Buildings Control**

Some parts of TfL are “Statutory Undertakers” with some exemption of procedural obligations under the Building Act 1984 but still require all new work and alterations to existing buildings to comply with the Building Regulations contained within Schedule 1. Other TfL modes do not act as “Statutory Undertakers” & so are required to engage independent Building Control Bodies (BCB) to ensure full compliance with procedural & substantive requirements of the Building Act 1984 & associated legislation.

Timely TfL & Building Control advice is required to be given on new and altered TfL premises within the framework of relevant legislation relating to building works within TfL operational boundaries. Such works include demolitions, alterations, installations, maintenance, change of use, additions, removals and temporary works.

All building work carried out shall meet applicable TfL CAT 1 Standards, current building codes and legislative requirements to ensure that buildings are designed and constructed to relevant legislation including that based in the Planning, Heritage, Health & Safety, Security, Energy, Materials, Highways, Workplace, Equality, Environment, Marine & Port fields.

The CIC registered or Local Authority supplier shall demonstrate their current ability to provide independent competent technical and professional support, in accordance with current MHCLG Performance Standards including but not limited to:

- Demonstration of Independence
- Building plans assessment and reporting
- Site inspection and reporting
- Issues log management
- Adequate competent resources
- Change control
- Completion certification

In accord with the project programme.

## **B14: Bridges and Structures**

Bridges – Design and Assessment Engineering involves the design and assessment of rail and road bridges. It includes a wide range of bridge structures including overbridges, underbridges, footbridges, arches & viaducts, tenanted arches, pipe bridges, culverts, subways, retaining structures and gantries.

The supplier shall demonstrate:

- The knowledge and ability with regard to Structural Eurocodes, DMRB and TfL Standards.
- The knowledge and ability with regard to design, checking and assessment of bridges or elements of bridges in the UK and overseas.
- The knowledge and ability with various types of structure including highway bridges, rail bridges, temporary bridges and footbridges.
- The knowledge and ability to provide advice to the client on Underground structures, earth retaining walls, including gabions, ancillary structures and components and culverts and cable bridges.

- An understanding of the behaviour of bridge structures and materials under a variety of environmental conditions, loadings and accidental actions.

### **B15: Buildings and Structures**

Buildings and Structures services include initial advice for business cases and feasibility studies, through concept and detailed design stages to full construction and handover. It requires the utilisation of computer software packages to undertake analysis, design and specialist assessment, such as vibration, dynamic response and fire resistance.

The supplier shall demonstrate their ability to provide technical and professional support with regards to buildings and structures. This includes the following:

- Office and Accommodation buildings
- Storage buildings
- Workshops
- Depot Buildings and Structures
- Train washing facilities
- Sub stations

The supplier shall demonstrate their ability to provide technical and professional support with regards to station structures, which includes the following:

- Station buildings,
- Ticket halls,
- Platforms,
- Lift and Escalator shafts,
- Pump rooms,
- Equipment rooms,
- Control rooms and
- Staff mess and locker rooms.

The supplier shall demonstrate their ability to provide technical and professional support with regards to building and station ancillary structures which includes the following:

- Roof structures
- Canopies
- Stairs
- Ramps
- Ladders
- Handrails
- Barriers
- Vehicle Impact protection
- Escalator support structures
- Lift support structures

## **B16: Marine Engineering**

The supplier shall be able to demonstrate their knowledge and ability to communicate with and advise their client in the following areas in the marine environment:

- a) Marine Structures Engineering
- b) Architecture
- c) Marine Vessel Engineering
- d) Marine Asset Incident Investigation

### **(A) Marine Structures Engineering**

Marine Engineering involves the design, checking and assessment of marine structures such as river piers, pontoons, ferry infrastructure and river walls. It also includes elements of structures such as bridges and Ship Impact Protection barriers located in the marine environment.

The supplier shall demonstrate:

- The knowledge and ability with regard to marine engineering standards, Structural Eurocodes, DMRB, and TfL Standards
- The knowledge and ability with regard to design, checking, inspection, assessment, maintenance, refurbishment and operation of marine structures or elements of marine structures in the UK and overseas.
- The knowledge of consents and licenses processes required to undertake works in the London marine environment , throughout the UK and overseas

- The knowledge and ability to provide advice to the client on structures in the marine environment including river piers, river walls, and elements of structures such as bridges and Ship Impact Protection barriers located in the marine environment
- An understanding of the behaviour of marine structures and materials under a variety of environmental conditions, loadings and accidental actions.
- The knowledge and ability to conduct root cause failure investigation of marine structures & vessels

## **(B) Architecture**

Architectural marine structures support includes initial advice for business cases and feasibility studies, through concept and detailed design stages to full construction and handover.

The framework applies to all stages of the project lifecycle from Outcome Definition to Handover and suppliers should demonstrate their capabilities within each stage.

The supplier shall demonstrate their ability provide technical and professional support for marine architectural projects across a range of scales.

Services may be procured across one or all of the RIBA stages (or equivalent), including concept design, feasibility, detailed design, construction information and monitoring. Works may be new build or refurbishment.

The services also capture the provision of design guidance and parameters relating to marine architecture and the built environment.

The Bidder will be expected to supply a wide range of advice, studies, surveys, reports, design and supervision services which will in turn rely and depend on skill, competence and capabilities including but not limited to the following areas:

- Urban Strategies and Area Plans
- Architecture
- Site Master planning and Development Feasibility
- Design Advice and Design Management
- Interior Design and Space Planning including core sizing
- Modelling and Visualisation

The supplier shall demonstrate knowledge and understanding of the requirements of designing a variety of different structures with varying constraints.

Bidders should provide evidence of the above in their response. Recent, relevant projects of appropriate scale are preferred, ideally across a variety of RIBA workstages. Bidders are



encouraged to use their response to demonstrate their flexibility, design flare, as well as ability to design to a variety of levels of scale and budget in different contexts.

Many TfL buildings have heritage features or are statutorily listed. If suppliers have relevant expertise in this area they are encouraged to provide evidence in their response.

Suppliers must demonstrate in their response how they comply with Section 20 of the Architects Act 1997, and how their design review process enable compliance with Section 20 (3).

Suppliers should demonstrate an understanding of the relevant CDM and Health & Safety legislation associated with the design of buildings. Where suppliers have experience of designing marine structures near transport infrastructure they are encouraged to include evidence or examples of this in their response.

Where a supplier has evidence of innovative, national or international experience in the design of marine structures the supplier is encouraged to explain in their response how the knowledge and experience gained would add value to TfL.

### **(C )Marine Vessel Engineering**

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

- Root cause failure investigation of marine structures & vessels
- Marine propulsion systems
- Marine Electrical & Control systems
- Marine diesel generators & thruster units
- Operational ship management
- Docking systems

### **(D) Marine Asset Incident Investigation**

Marine Incident Investigation involves investigation following a marine structure or asset failure which could include piers, pontoons, docking systems, linkspans or boarding ramps and vessels.

The supplier shall demonstrate:

- Usage of specialist tools and techniques required by TfL during accident investigations
- Their experience in leading an investigation, engaging with TfL specialists as required
- Their ability to communicate and advise on technical aspects of most marine systems and investigation analysis of simulated or actual accident scenarios that involve marine systems

- Their knowledge and experience in the understanding of accident mechanisms, their immediate causes, causal factors and root causes
- Their competence in applying investigative techniques including root cause analysis
- Their ability to preserve and manage evidence captured in a controlled manner
- Their knowledge and experience in assessment of damage to assets
- Their knowledge and experience in assessment of remedial works necessary to recover damaged assets and bring them back to full service operation
- Usage of specialist tools and techniques to be able to be an expert witness
- The ability to present their findings and conclusions, in terms of immediate causes, causal factors and root causes, in clear, logical structured report with recommendations that appropriately address the root causes identified.

## **B17: Obsolescence Management**

IEC 62402 defines obsolescence as the, “Transition from being obtainable from the original manufacturer to becoming unobtainable”. The objective of Obsolescence Management in TfL is to ensure that the risks of obsolescence are effectively and economically managed to meet TfL's commitment to provide a world class, safe and reliable transport system for London.

The supplier shall demonstrate competence and capability in the following areas to achieve these objectives;

- Standards, TfL Pathway, NR Grip, legislation and changes
- Lifecycle processes, project controls and procurement
- Managing obsolescence, monitoring, surveys, management and resolution strategies and plans
- Hardware, software and people obsolescence
- Managing and supporting the supply chain
- Obsolescence management processes, tools and documentation appropriate for a large organisation.
- Access to domain specific, technical and market knowledge.

## **B18: Tunnelling Engineering**

Tunnelling Engineering describes the provision of a conduit or space under or through an obstacle, e.g. a road or rail system under a busy city centre or a road link underneath a river. Critical to the construction of the tunnel is the length, size and the ground & groundwater conditions.

The supplier shall demonstrate their ability to provide technical and professional support with regards to tunnelling and underground excavation. This includes the following:

- Geological/ geotechnical investigation,
- Excavation and materials handling,
- Ground support,
- Environmental control,
- Cross passages between running tunnels,
- Step plate junctions,
- Overrun, sliding, platform, concourse, crossover, depot approach and station passageway tunnels,
- Tunnel headwalls, ring walls, opening and junctions,
- Inclined shafts (e.g. escalator shafts),
- Vertical shafts (e.g. ventilation, access, service, lift and substation shafts),
- Cable and pump shafts,
- Disused tunnels and shafts and
- Other tunnels and shafts constructed by mining methods.

The supplier shall demonstrate their ability to provide technical and professional advice with regards to modern soft-ground tunnelling which includes the following:

- Settlement damage and lost ground
- Hand-mined and shield/TBM tunnels
- Sprayed concrete lined tunnels
- Water control
- Soft-ground moles
- Pipe jacking

The supplier shall demonstrate their ability to provide technical and professional advice with regards to modern rock tunnelling which includes the following:

- Nature of the rock mass

- Conventional blasting
- Rock support

## **C: ENGINEERING ARCHITECTURAL SERVICES**

With every technological breakthrough and every game-changing solution, TfL Engineering has kept our city moving and evolving for over 150 years. And now it's time to take our expertise further. We're working to meet the needs of the 21st century and beyond.

Our ambition is to create a city for all Londoners. As we are modernizing vital infrastructure across London, we're looking for Architectural practices to support or undertake architectural design work for projects of small and medium scale across different transport modes. This is a unique opportunity to work on TfL's iconic network, and we have divided the Architecture lots into three different sections to enable a variety of architectural practices, each with different skills and experience, to share and collaborate with TfL and support us in delivering the replacement, renewal, refurbishment and repurposing of our Built Environment Assets.

### **C1: Transport Architecture**

The scope of this lot includes the design of new buildings, extensions to existing buildings and remodelling or refurbishment of existing buildings.

This applies to all stages of the project lifecycle from Outcome Definition to Handover and suppliers should demonstrate their capabilities within each stage.

Transport Building types include:

- London Underground Stations
- National Rail Stations (London Overground)
- Light Railway Stations (DLR)
- Tram Stops
- Bus Stations
- Coach Stations
- Pier Buildings
- Transport Interchanges

*Work let under this lot is not likely to be whole stations or major line upgrades, which would fall under the Major Projects route. Instead works would include medium scale projects, such as remodelling or refurbishment works, step free access..*

### **C2: Non Transport Architecture**

This applies to all stages of the project lifecycle from Outcome Definition to Handover and suppliers should demonstrate their capabilities within each stage.

Buildings under the section 'non-station architecture' include:

Office and Staff Support buildings – eg train crew accommodation, bus driver facilities

Staffed Operations buildings – eg control centres, surface transport ticket kiosks  
Un-staffed Operations buildings – signal equipment rooms  
Maintenance buildings – eg depot train sheds  
Storage buildings

### **C3: Commercial Architecture Support**

Architectural Commercial Support includes initial advice for business cases and feasibility studies, through concept and detailed design stages to full construction and handover.

This applies to all stages of the project lifecycle from Outcome Definition to Handover and suppliers should demonstrate their capabilities within each stage.

The supplier shall demonstrate their ability provide technical and professional support for architectural projects across a range of scales. Projects are most likely to include retail, office, residential and mixed use schemes but may include other typologies.

Services may be procured across one or all of the RIBA stages (or equivalent), including concept design, feasibility, detailed design, construction information and monitoring. Works may be new build or refurbishment.

The services also capture the provision of design guidance and parameters relating to architecture and the built environment and advice on Over Station Developments (OSD).

The Bidder will be expected to supply a wide range of advice, studies, surveys, reports, design and supervision services which will in turn rely and depend on skill, competence and capabilities including but not limited to the following areas:

- *Urban Strategies and Area Plans*
- *Architecture*
- *Site Masterplanning and Development Feasibility*
- *Design Advice and Design Management*
- *Interior Design and Space Planning including core sizing*
- *Modelling and Visualisation*

### **C4: Urban Design**

Urban design involves the design, and advice on the design of new public realm, streetscape, public space and landscape architecture. Many of TfL's projects involve or include changes to or new the creation of new areas of public realm, which in turn provide the setting for new, renewed or upgraded transport infrastructure.

This applies to all stages of the project lifecycle from Outcome Definition to Handover and suppliers should demonstrate their capabilities within each stage.

Work under this lot would include;

- New public squares and plazas of small scale
- Refurbishment or renewal of Station forecourts or similar
- Landscape Architecture design associated with new station or ancillary buildings
- Streetscape improvements associated with renewal, refurbishment, replacement or construction of new Built Environment assets
- Detail design based on concept stage of urban design / landscape proposals to include 3D topographic / levels design, ensure compliance with legislation and national standards.

### **C5: Structural Engineering – Architectural Design**

To support the design of Architectural projects this lot seeks specialist structural engineering and design expertise associated with the following;

- Station Canopies
- Bridges, cantilevered walkways and cycleways
- Visual Concrete
- Architecturally designed retaining structures
- Complex internal structural adjustments
- Complex, lightweight or specialist building structural design

The Lot applies to all stages of the project lifecycle from Outcome Definition to Handover and suppliers should demonstrate their capabilities within each stage.

## D: Highways and Traffic

### Traffic Engineering

Traffic Engineering involves the provision of specialist traffic engineering services for the planning, design, construction, operation and maintenance of the road network. This service is provided to TFL Surface Transport directorates to enable delivery of the Mayors Transport Strategy (MTS), the London plan and other Mayoral objectives.

The key supplier requirement is to demonstrate the relevant skills, knowledge, and experience for the following areas:

**D1:** The ability to deliver traffic engineering projects across a broad range of TfL business portfolios.

**D2:** The ability to deliver specialised engineering design, advice and support for specific engineering disciplines/workstreams.

**D3:** The procurement/delivery, and if required analysis, of ad hoc engineering surveys and data collection.

For D1 and D2, the supplier is required to outline their capability to deliver work packages externally and/or ability to provide resources to directly support the internal Traffic Engineering business needs. Additionally, the delivery requirements for D1 and D2 can be applied to any stage of a TfL project or for the full project lifecycle. Therefore the supplier shall demonstrate their ability to deliver the appropriate Lot technical requirements for each individual project stage. TfL's project stages are outlined below with a brief description of the knowledge, skills and deliverables expected from the supplier:

- **Outcome Definition:** Demonstrate the ability to scope a range of potential design options to address TfL business requirements with the competence to illustrate and report the considered design options/impacts and associated costs.
- **Option Selection/Feasibility Design:** Demonstrate the ability to produce engineering drawings, a construction cost estimate, appropriate traffic modelling and relevant CDM documentation for a single option solution.
- **Concept Design:** Demonstrate the ability to produce engineering drawings, a construction cost estimate, identify the location of all or new amended assets in three dimensions for the further detail development of the single option solution.
- **Detailed Design:** The development of the single preferred option from concept design to a sufficient level of engineering detail to enable construction. Drawings are produced reflecting the series specified in Manual of Contract Documents for Highway Works and cost estimates are updated.
- **Delivery and Project Close Out:** The supplier is required to support the building of the physical outputs of the project through site supervision and the demonstrate the ability to produce necessary documentation for project close out and handover for operational/business use and maintenance



## **D1: Traffic Engineering Projects**

The supplier shall demonstrate their knowledge and ability to communicate, advise and for the following business portfolios:

- 20mph Speed Limits/Signing and Line marking design
- Bus Priority and Bus Stop Accessibility schemes
- Road Safety studies and collision analysis
- Small Multi-Modal Schemes inclusive of junction and link design, parking, enforcement, loading and freight studies
- Transformational Schemes (Interchanges, gyratory removal, grade separation, pedestrianisation)
- Cycling schemes (Inclusive of significant infrastructure interventions)
- Designer and Principal Designer responsibilities as per CDM Regulations 2015

## **D2: Engineering Skills and Support**

The supplier shall demonstrate their knowledge and ability to provide, support and deliver for the following engineering workstreams/skillsets:

- Production of public consultation information including visualisations and use of Adobe Illustrator
- Urban/Streetscape Design
- Street Lighting Design
- Hostile Vehicle Mitigation and Vehicle Restraint System Design
- Local Area Traffic Modelling (using packages as LINSIG2, TRANSYT, PICADY)
- Highway Drainage/SUDS design
- AutoCAD Civil 3D
- Environmental Impact Assessments
- Sustainability Audits
- Risk Management
- Assurance/Quality Management/Design Auditing
- Engineering support for assessment of planning applications and development control
- Whole life project cost estimating
- Healthy Streets Designer Checks
- Scheme Monitoring/Benefits realisation

## **D3: Ad Hoc Survey Procurement/Data Collection and Analysis.**

The supplier shall demonstrate their knowledge and ability to deliver and analyse if required the following surveys:

- PAS 128 Survey (Cat A-D)/Statutory undertaker surveys
- Traffic Counts (OD/Classified/Pedestrian/Speed)
- Topographic/Sign Surveys
- Kerbside Activity Surveys
- Drainage CCTV Surveys
- Street Lighting Surveys
- Noise and Vibration Surveys
- Ground Conditions/Site Investigations/Trial Holes
- Air Quality Surveys
- Archaeological Surveys

- Environmental Surveys

#### **D4: Highway Engineering**

Highway Engineering services are required to enable the safe and cost efficient operation and maintenance of the TfL road network. This involves investigation, specification, design at all stages, inspection, and assurance as necessary for the delivery of engineering activities throughout all stages of asset life cycle.

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client on the following assets:

- Vehicle and pedestrian restraint systems
- Drainage
- Earthworks
- Pavement materials
- Kerbs and footways
- Traffic signs and road markings
- Lamp columns, masts
- Electrical work
- Street furniture

The supplier is expected to be competent in the following areas and be able to provide:

- Highways design and assurance to technical standards, specification and best practice appropriate to the environment
- Legislation, regulations and requirements relating to Highways
- Product design and selection in line with guidance set out in the TfL Streets Toolkit including Streetscape Design Guidance and London Cycle Design Standards.
- Provision of professional services and subject matter experts on a secondment basis as and when required.

#### **D5: Traffic Control Engineering**

Traffic Control Engineering (TCE) forms part of the TfL Engineering Highways and Traffic Profession. TCE is accountable for discharging engineering technical authority for all TfL owned traffic control Infrastructure including Traffic Signals, Over-height Vehicle Detection (OVD) and Variable Message Signs (VMS).

TCE covers all stages of the asset life cycle commencing with inception, through design, construction, commissioning, handover and maintenance. It is concerned with the creation and maintenance of assets to help maximise reliability, availability, maintainability and serviceability at an affordable whole life cost.

The supplier shall demonstrate a full working knowledge of the relevant legislation, national standards and TfL requirements for the delivery and operation of traffic control assets.

The supplier shall demonstrate their ability to co-ordinate traffic control engineering advice and design services with other disciplines.

The supplier shall be able to demonstrate experience in:

- Feasibility reviews of layouts including comments on safety, legality, buildability and maintainability and the preparation of traffic signal safety critical timings such as inter greens and phase delays for modelling
- Production of detailed designs including the proposed infrastructure arrangement, method of control, supporting sub-surface civil infrastructure and the writing of traffic controller specifications and statements of requirements.
- Providing engineering support through traffic control builds including expert advice on how existing infrastructure can be modified through multiple construction phases to minimised disruptions to all road users.
- Commissioning of traffic control installations including local accepting testing and stage 3 safety and quality checks to handover into maintenance.

#### **D6: Traffic Signal Controller Configuration and Testing**

The supplier shall demonstrate their ability to meet the delivery requirements for the writing and/or testing of Traffic Signal Controller Configurations. Ensuring what is specified in the detailed signal design (signal layout and controller specification) is reflected in the configuration.

The supplier shall be able to demonstrate experience in the writing and assuring of Traffic Signal Controller Configurations consistent with specification TOPAS 2500 and MCH1827

#### **D7: Intelligent Transport Systems**

Intelligent Transport Systems Engineering discipline encompasses the specification, design, assessment, implementation, support and assurance of Intelligent Transport Systems technology, including but not exclusive to Urban Traffic Control (UTC) systems, , digital communications and detectors for traffic control featuring advanced functionalities such as vehicle counting and classification.

A key requirement is to demonstrate knowledge with an understanding of the design processes within an urban road and traffic environment, regulatory standards and procedures that allow TfL's legal accountabilities to be fulfilled.

The following list outlines the skills and knowledge required for ITS Engineering:

- Broad and current knowledge of ITS systems and knowledge of implementation in an urban highways and traffic environment.
- Urban Traffic Control (UTC) systems.

- Detector analysis, running trials and assessment on new and emerging technology, including assessing compliance against TOPAS and TSRGD 2016 standards.
- Variable Message Sign (VMS) systems and standards.
- Knowledge of Connected and Autonomous (CAV) vehicle standards, Mobility as a Service and Smart Cities.
- Knowledge of video compression, digital video transmission, video analytics systems its implementation in ITS.
- Knowledge of telecommunication systems Development of prototype systems, including electronics and software development.
- Engineering assurance of safety critical systems.
- Road Tunnel Control Systems.
- Accreditation, for working safely in an urban highways and traffic environment.
- Third party liaison on technical issues and producing reports, for example liaison with London Boroughs, Metropolitan Police, and Highways England.
- ITS product assessment, running equipment trials in live environments, undertaking site surveys and delivering Traffic related products onto the TfL road network.
- Knowledge and experience of traffic control or information systems relating to Public transport such as Buses, Trams, Taxis and Surface Rail.
- Awareness of cyber security and implementation for ITS systems.

#### **D8: Road Safety Audit & Collision Investigation**

Road Safety Auditing is a defined process that considers operational road safety of a change to the highway. The requirements and procedure for the completion and delivery of Road Safety Audits, within Greater London, is defined in TfL's Road Safety Audit Procedure (SQA-0170), the current edition is dated May 2014.

The supplier shall demonstrate their ability to adhere to the delivery requirements of TfL's Road Safety Audit Procedure SQA-0170 (Current edition dated May 2014).

The supplier shall also demonstrate experience in the following areas:

- Pre-construction Road Safety Audits (Stages 1&2) in a major urban UK context on a range of schemes of varying size and scope.
- Post construction Road Safety Audits (Stage 3) in a major urban UK context on a range of schemes of varying size and scope.
- Post-implementation monitoring Road Safety Audits (Stage 4) on a range of schemes of varying size and scope.
- Collision data analysis and/or collision investigation studies of varying size and scope.

TfL's Road Safety Audit Procedure SQA-0170, dated May 2014 will shortly be revised, and the current edition superseded. The supplier shall also demonstrate a resilience to adopt any procedural alterations to the completion of RSAs brought about by any update to TfL's Road Safety Audit Procedure.

## **Green Infrastructure**

Technical specialism in Green Infrastructure (GI) involves the specification, design, installation, inspection and audits of GI elements. This includes assets such as street trees, woodland, shrub beds, grass verges as well as built GI such as green walls, green roofs and some sustainable drainage features. These services help ensure the safety and effective running of road networks and contribute towards meeting highway policy objectives including those contained within the Mayor's Transport Strategy and London Environment Strategy.

### **D9: Provision of arboricultural technical expertise**

The technical specialism Arboriculture covers all matters relating to the disciplines of arboriculture and urban forestry including the management of street trees and woodlands.

The suppliers shall demonstrate their knowledge, qualifications, competence and ability to deliver the appropriate technical requirements in the following areas:

- National and regional policy and best practice relating to arboriculture.
- Relevant legislation and British Standards.
- Tree safety inspections.
- Tree surveys (including BS5837 and tree valuation surveys).
- Environmental and ecological surveys (including birds and bats).
- Specification and design of planting schemes.
- Relevant pests and diseases.
- Monitoring and auditing of works.

### **D10: Provision of horticultural technical expertise**

The technical specialism of Horticulture covers all matters relating to the disciplines of landscape and horticulture, including shrub beds, bedding and grass verges.

## **Skills and Knowledge**

The suppliers shall demonstrate their knowledge, qualifications, competence and ability to deliver the appropriate technical requirements in the following areas:

- National and regional policy and best practice relating to landscaping and horticulture..
- Relevant legislation and British Standards.
- Shrub bed surveys (plant identification, health, condition ).
- Specification and design of landscape planting schemes.
- Relevant pests and diseases.
- Injurious weed management.
- Monitoring and auditing of works.

### **D11: Provision of 'built green infrastructure' technical expertise**

The technical specialism of 'Built green infrastructure' covers all matters relating to built green infrastructure including green walls and green roofs.

#### **Skills and Knowledge**

The suppliers shall demonstrate their knowledge, qualifications, competence and ability to deliver the appropriate technical requirements in the following areas:

- National and regional policy and best practice relating to green roofs and green walls..
- Relevant legislation and British Standards.
- Inspections (plant identification, health, condition ).
- Specification and design of built green infrastructure schemes.
- Relevant pests and diseases.
- Monitoring and auditing of works.

### **D12: Bus Design Engineering**

The delivery of successful bus designs or bus modifications depends on the following skill sets:

- Validation of project and stakeholder requirements
- Liaising closely with bus OEM, DVSA, VCA and other road vehicle authorised testing bodies
- Liaising closely with bus engineering specialist and maintenance staff during the design process
- Interfacing with other TfL engineering disciplines e.g. roads and building infrastructure, bus garage, bus stations, surface engineering power engineering and operations.
- Carrying out any necessary visits to depots to investigate failure modes, examine reports, analyse results and develop innovative, cost-effective solutions in collaboration with engineers
- Carrying-out any necessary site visits to depots to examine a range of bus designs/models types and conducting design correlation activities
- Provision of competent and M2/M3 category passenger vehicle experience and specialist resources to design, check and approve designs
- Knowledge of, or obtaining knowledge of and implement London bus design standards, operational performance and assurance arrangements
- Availability of the supporting tools e.g. CAD, Software Development tools, or other tools, to support the production of the designs and drawings
- Delivering all documentation to ensure the works can be built, installed, tested , commissioned and maintained over its design life
- Technical support and management of 1 to 8

### **D13: Bus Specialist Engineering Support**

The supplier will need to demonstrate specialist knowledge and understanding of all professional engineering matters relating to Bus Engineering and be able to apply them to the operation of different propulsion systems, pure electric, hydrogen, high powered inductive and conductive changing

The delivery of successful bus specialist designs or modifications depends on the following skills, knowledge and experience:

- Vehicle emissions
- Air Quality
- Exhaust gas after-treatment
- Hybrid systems technology
- Battery technology
- Battery safety
- Battery fires
- Fuel cell technology
- Hydrogen vehicle safety
- Hydrogen refuelling station safety
- Hydrogen workshop safety
- Vehicle Fire investigations
- Vehicle design for fire prevention
- Incident investigation and support
- Related EMC
- Investigation and designs for retro fit solutions

1. Validation of project and stakeholder requirements
2. Liaising closely with bus OEM, DVSA, VCA and other road vehicle authorised testing bodies
3. Liaising closely with Bus specialist engineers and maintenance staff during the design process
4. Interfacing with other TfL engineering disciplines e.g. roads, building infrastructure engineering, bus garage, bus stations, Surface engineering power engineering and operations.

5. Carrying out any necessary visits to depots to investigate failure modes, examine reports, analyse results and develop innovative, cost-effective solutions in collaboration with fleet engineers and specialist bus engineers
6. Carrying-out any necessary site visits to depots to examine buses and conducting design correlation activities
7. Provision of competent and M2/M3 category passenger vehicle experience and specialist resources to design, check and approve designs
8. Knowledge of, or obtaining knowledge of and implement London bus design standards, operational performance and assurance arrangements
9. Availability of the supporting tools e.g. CAD, Software Development tools, or other tools, to support the production of the designs and drawings
10. Delivering all documentation to ensure the works can be built, installed, tested , commissioned and maintained over its design life
11. Technical support and management of 1 to 8

#### **D14: Bus Specialist Investigation Support**

The supplier will need to demonstrate specialist knowledge and understanding of all professional engineering matters relating to road passenger transport technical investigations and be able to apply them to the operation of different propulsion system; pure electric, hydrogen, high powered inductive and conductive charging

The delivery of successful rolling stock specialist investigation support requires the skills, knowledge and experience of specific outsourced technical investigation services in, for example:

- a) Materials analysis
- b) Metallurgy
- c) Fire performance of materials
- d) Other scientific analyses
- e) Fracture analysis
- f) Specialist NDT testing
- g) RAM and Safety Analysis
- h) Maintenance optimisation

These activities include requirement for:-

1. Validation of project and stakeholder requirements
2. Liaising closely with bus OEM, DVSA, VCA and other road vehicle authorised testing bodies
3. Liaising closely with bus specialist engineers and maintenance staff during the investigation process
4. Interfacing with other TfL engineering disciplines e.g. road and building infrastructure engineering, bus garage, bus stations, surface engineering (garage design) power engineering and operations.
5. Carrying out any necessary visits to depots to investigate vehicle failure modes, examine reports, analyse results to fully understand functional / operational environment in collaboration with fleet engineers and specialist bus engineering.
6. Knowledge of, or obtaining knowledge of and implement London bus design standards, operational performance and assurance arrangements
7. Delivering all investigation documentation to enable TfL Engineering to make fully informed decisions regarding replacement, modifications and /or



mitigation measures necessary to maintain safe operations whilst longer term solutions are being implemented

Technical support and management of 1 to 7 above

## **E: RAIL ENGINEERING**

### **E1: Rolling Stock Design Engineering**

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

- Brake systems
- Door systems
- Car bodies
- Bogie
- Mechanical design
- Electrical design, installation and protection (high / low voltage)
- Auxiliary systems design
- Pneumatic system design
- Structural integrity
- Fire performance of materials
- Propulsion systems
- Train management system design and functionality
- Rolling stock maintenance
- Rolling stock testing and commissioning
- Depot equipment (and associated equipment/systems)
- Rolling stock audits and inspections

### **E2: Rolling Stock System Specialist Engineering Support**

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

- Brake systems
- Door systems
- Car bodies
- Bogies

- Crashworthiness
- Mechanical design
- Electrical design, installation and protection (high / low voltage)
- Auxiliary systems design
- Pneumatic system design
- Structural integrity
- Fire performance of materials
- Propulsion systems
- Train management system design and functionality
- On-train diagnostic systems – e.g. Rolling Stock CCTV, incident recorder systems
- Automatic Train Operation (ATO) systems
- Automatic Train Protection systems
- Train performance
- Wheelset design
- Wheel rail interface
- Optimisation of train performance in low adhesion conditions
- Noise, ride & vibration
- Vehicle Dynamics
- Rolling stock maintenance
- Rolling stock testing and commissioning
- Depot equipment (and associated equipment/systems)
- Rolling stock audits and inspections
- Human factors, cab design and driver ergonomics
- Incident investigation
- Feasibility studies with business cases
- ALARP justification and QRA

### **E3: Rolling Stock Specialist Investigation/testing Support**

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

- Brake systems
- Door systems
- Car bodies
- Bogies
- Crashworthiness
- Mechanical design
- Electrical design, installation and protection (high / low voltage)
- Auxiliary systems design
- Pneumatic system design
- Structural integrity
- Fire performance of materials
- Propulsion systems
- Train performance
- Wheel rail interface
- Noise, ride & vibration
- Vehicle Dynamics
- Rolling stock maintenance
- Rolling stock testing and commissioning
- ALARP justification and QRA

### **E4: Depot Engineering, Plant and Equipment:**

- Depots and non-rolling stock depots
- Fire compliance of materials for Depot equipment ( Non E&M)

- Fire engineering within a metro rail system and compartmentation
- Specific Skills, Knowledge and Experience of roiling stock related depot, plant and equipment:-
  - Train washes
  - Wheel Lathes and associated equipment
  - Jacking / Lifting systems
  - Bogie press, drop tables and jigs
  - Equipment lifting tables/equipment

## **E5: Transport System and Railway Development**

The objectives of a transport system project development assignment are to:

- Work with stakeholders and agree the requirements of the problem to be solved.
- Identify possible solution options, their feasibility, benefits, costs and risks.
- Prepare a business case to justify works to implement a solution.

The supplier shall demonstrate competence and capability in the following areas to achieve these objectives;

- Working with the client to identify the problems to be solved, option identification, solution and requirements development and recording.
- Report writing and presentation skills, the management of 'soft projects' that have diverse stakeholders.
- Transport system economics and value estimation – demand forecasting, whole life cost modelling and the development and use of business cases.
- Case specific domain, technical and market knowledge.

Project development assignments vary in terms of several characteristics.

These characteristics include:

1. The position of the project in the life cycle, eg: pre feasibility stage to delivery to test and commissioning.
2. Hierarchy within the structure of the delivery organisation eg: operator – specifier – lead contractor – sub contractor.
3. The transport system mode; TfL operates multi-modal services d including trams, metro, mainline, river crossing services, highways and other sponsored services (e.g. cycle hire, dial-a-ride).
4. Specialist asset domain knowledge employed: eg: ticketing - rolling stock - signalling, highways

## **E6: Incident Investigation**

Incident Investigation involves accident investigation including accident assessment, repair assessment and brake investigations on assignments such as depot derailments and collision damage.

The supplier shall demonstrate:

- Usage of specialist tools and techniques required by TfL during accident investigations
- Their experience in leading an investigation, engaging with TfL specialists as required
- Their ability to communicate and advise on technical aspects of most railway systems and investigation analysis of simulated or actual accident scenarios that involve railway systems
- Their knowledge and experience in the understanding of accident mechanisms, their immediate causes, causal factors and root causes
- Their competence in applying investigative techniques including root cause analysis
- Their ability to preserve and manage evidence captured in a controlled manner
- Their knowledge and experience in assessment of damage to assets
- Their knowledge and experience in assessment of remedial works necessary to recover damaged assets and bring them back to full service operation
- Usage of specialist tools and techniques to be able to be an expert witness
- The ability to present their findings and conclusions, in terms of immediate causes, causal factors and root causes, in clear, logical structured report with recommendations that appropriately address the root causes identified

## **E7: Transportation Information, Security and Surveillance systems**

Transportation Information, Security and Surveillance systems are deployed throughout TfL's transport network to enable the safe and efficient operation of TfL's multi-modal capability and are commonly considered vital to the organisation's capability to offer services to its customers. These systems ordinarily interact with travelling customers, operational personnel, operational control systems and third party systems and therefore require complex systems engineering and systems integration to result in expected high levels of function, usability, performance and availability.

Operational control of Transportation Information, Security and Surveillance assets is provided locally and at defined centralised locations. These systems provide key capability for TfL's staff and third parties as well as delivering enhanced customer benefit. Transportation Information, Security and Surveillance systems facilitate normal, degraded and emergency modes of service operation, provide many safety related functions and interface with the emergency services during incidents.

The supplier, based upon their demonstration of required knowledge, skills and experience, will be expected to be capable of providing support to the TfL Engineering Telecommunications team in the following delivery roles:

- Technical research based advice;
- Standards, processes and technical strategies;
- Optioneering and feasibility studies;
- Intrusive and non-intrusive surveys;
- Technical reports;
- Technical design at concept, detailed or construction level;
- Preparing communication system documentation
- Project / programme supervision services which include design management;
- Construction co-ordination, audit and independent assurance;

Provision of these services will rely on experience within both the telecommunications transportation sector and specific technology applications within the TfL Telecommunications portfolio, including but not limited to the following.

Transportation Information, Security and Surveillance systems include:

- Integrated Transport hub management systems:
- Public Address systems, localised and distributed control;
- Public Address / Voice Alarm systems, localised and distributed control (safety related);
- CCTV surveillance and security systems, analogue and digital;
- CCTV train dispatch systems, platform based and vehicle based (safety related);
- Vehicle identification systems, ANPR, incident identification
- Passenger Help Point including emergency voice communications systems (safety related);
- Intruder and event detection systems;
- Customer information systems;
- Telephony systems incl. emergency response systems

## **E8: Transport Control Systems Engineering**

As demand for public transport rises TfL needs to augment passenger capacity to meet this ever increasing demand. This increase in capacity necessitates a greater degree of automation and communication facilities to monitor and control services, ensuring the public are able to feel secure in our stations and rolling stock while travelling efficiently. In order to do this engineered systems are required to be developed integrating railway assets, procedures and people.

The programmes of work may cover development of new or renewal, extensions and upgrades to existing Railway Control Systems, integrating signalling, track, infrastructure, depots, rolling stock and stations.

At the heart of these changes are communications and train scheduling systems and ultimately control room staff, as such care must be taken to ensure that all aspects, including technical, physical and cognitive issues are considered and managed. It is

essential that their capabilities and limitations are accounted for during system development to ensure safe and reliable system performance.

## **E9: Cyber Security Engineering**

Following the recent government spending review, TfL continues to increase passenger capacity to meet ever increasing demand, and improve customer service across all modes.

Our service is now more reliant on computer, communication, and software systems and the interconnectivity between electronic systems is increasing unabated. This includes the connectivity between systems within our organisation and interfaces to external networks (such as the internet and COTS-based wireless communication systems). To improve the delivery of transport services and enhance the customer experience there is a desire to obtain, communicate and utilise the information that is generated and used by our systems.

To protect against safety threats, deliver services reliability and consistently, reduce costs through unnecessary reactive controls, mitigations and recoveries, and to restrict the reputational damage to TfL from undesirable actions or threats, the electronic security of systems and information is critically important to us.

We also have a duty of care to protect sensitive customer data and other private information that may reside on our systems and to comply with existing and future legislation.

A whole-system approach is needed to ensure that people (including staff, suppliers, customers and attackers) are appropriately considered, including the dependency and vulnerabilities posed by them.

TfL is seeking specialist support to ensure that the systems and information on our estate is protected and remains secure from accidental or intentional unauthorised access or interference.

There is a need to develop appropriate system and information security strategies and policies that deliver quantifiable benefits in an efficient and effective way whilst minimising the impact on services, customers and staff.

Support is needed to assess the security risks and threats, based on an understanding of current trends, including how systems may develop and interact in the future.

There is a need to develop system security requirements from best practice and analyses of system functions.



There is a need to prescribe integrated security solutions that are consistent with the design intent of the system assets, procedures, and people interactions to which they apply.

Support is additionally required to review and audit the specification, design, development, migration and operational use of the security solutions across multiple systems and environments.

## **E10: Communications Engineering**

Communication networks are deployed throughout TfL's transport networks to enable and support operations, maintenance and support services in wide range of geographic locations. Support is provided locally and at line and network control centres. Communications networks provide key interfaces and functions to TfL's staff, customers and third parties. They facilitate normal, degraded and emergency mode of service operation but also interface with the emergency services during incidents.

The supplier, based upon their demonstration of required knowledge, skills and experience, will be expected to be capable of providing support to the TfL Engineering Telecommunications team as follows:

- Technical research based advice;
- Standards, processes and technical strategies;
- Optioneering and feasibility studies;
- Intrusive and non-intrusive surveys;
- Technical reports;
- Technical design at concept, detailed or construction level;
- Preparing communication system documentation
- Project / programme supervision services which include design management;
- Construction co-ordination, audit and independent assurance;

In support of the operation of TfL's services, fixed engineering networks (provisioned through structured copper and optical cabling) support the organisations requirement for robust and reliable operational and / or collection of condition and performance data between related or disparate systems. Fixed engineering networks will in some instances integrate with other business or operational network systems to provide distributed functions.

A variety of radio based systems are also in use on the TfL transport networks from LF (low frequency) for inductively coupled services to Microwave services in the GHz bands. Wireless devices and services may range from asset tags to complex digital trunk radio systems.

Communications networks include:

- Critical and vital fixed operational / engineering network infrastructures, TCP/IP, Ethernet, MPLS (potentially safety related / critical);
- Critical and vital wireless operational / engineering network infrastructures, TETRA, LTE, 5G, FRMCS, radio spectrum management (potentially safety related / critical);

Signalling data communications fixed and wireless networks (safety critical).

## **E11 : Systems Engineering**

Systems engineering is an interdisciplinary approach and a mean to enable the delivery of systems that will meet the customer/user needs. It focuses on defining customer/user needs and requirements early in the development cycle systematically, documenting them, and then proceeding with design synthesis, implementation and system verification and validation while considering the complete problem, including operations, cost and schedule, performance, training, test, manufacturing and disposal.

Systems engineering is a combination of various techniques that aims to manage engineering risk throughout the projects / programmes lifecycle by considering the problem as a whole rather than disparate parts.

The supplier will be expected to supply advice, studies, surveys, reports, design and supervision services which will in turn, rely and depend on skill, competence and capabilities including but not limited to the following capability details:"

The supplier should describe their methodology for systems integration and strategy for risk mitigation, which demonstrates their understanding of applying systems engineering concepts and techniques to the delivery of new systems to be integrated with existing systems in the TfL transport environment. The supplier shall demonstrate competence in:

- Systems engineering standards and reference bodies of knowledge
- Systems engineering documentation
- Lifecycle processes and project controls
- Requirements elicitation, documentation and management,
- Work / Functional Break Down Structure planning and management
- Design: formulating concepts
- Design: architecture and architecture description
- Interfaces management
- Management of integrated design review
- Validation and verification
- Configuration and change management
- Migration planning and management
- TfL transport including surface, river crossing and railway environment domain knowledge
- Knowledge and understanding of the application of systems engineering in transport environments and the TfL surface, river crossing and railway environments in particular

## **E12: Information Securities Engineering**

Information security engineering is a set of risk-based technical and procedural controls to minimise vulnerabilities of engineering systems to electronic (or cyber) threats throughout the asset lifecycle. In the TfL environments, particular systems are critical to the safe and reliable operation of the railway, such as road and rail signalling systems, SCADA, customer information systems and CCTV systems.

The supplier, based upon their demonstration of required knowledge, skills and experience, will be expected to be capable of providing support to a wide range of disciplines within TfL Engineering in the following delivery roles:

- Objective Information Security input into procurement tenders;
- Definition of Information Security project / programme requirements & management;
- Scoping for Cyber Penetration Testing;
- Information Security threat analysis review;
- Defining Security Operations Centre (SOC) Support requirements;
- Development of Information Security Standards, Policies and Procedures including on-wards auditing;
- Assistance with NIS Compliance review;
- Defining Cyber Security Strategy;
- Prescribing Cyber Security Asset Management needs;
- The application of existing information security competence frameworks;
- The application of Information Security legislation and standards;
- Production and / or review of Information security documentation;
- Managing cryptographic systems to provide governance and control of electronic security;
- Advising on management of security and information risk consistent with HMG IA policy, standards and guidance.

Provision of these services will rely on experience within both the transportation sector and specific technology applications within the TfL asset portfolio, including but not limited to the following:

- Telecommunication systems;
- Data networks, fixed and wireless;
- Control and Information systems;
- Power and power control systems;
- Signalling and signalling control systems;
- Centralised operational management systems.

## **E13: High Integrity Software Based Systems**

Software systems are increasingly at the core of modern transport networks. TfL undertakes the following roles within the transport network: operator, specifier, intelligent client and overall integrator. In general, TfL prefers not to specify and procure bespoke software, due to the impacts of risk, time and cost. This strategy results in the need to leverage supplier's products where necessary, with adaptation and modification for the particular transport application's environment and needs. Managing the specification, development, test, migration and performance of (supplier)

software is often critical to the successful delivery of transport projects and transport systems.

The supplier will be expected to supply advice, studies, reports, analytical, modelling, testing and supervision services which will in turn, rely and depend on skill, competence and capabilities including but not limited to the following capability details:

The supplier shall demonstrate competence in:

- Software system requirements
- Software systems documentation
- Software development and testing
- Software quality and delivery
- Software capability assessments
- TfL Railway Environment domain Knowledge
- Knowledge and understanding of the use of high integrity software in transport environments and the TfL railway environments in particular.

#### **E14: Simulation and Modelling**

System Performance Engineering aims to understand the behaviour of railway performance as a whole and how constituent parts interact. Modelling tool-sets are used to improve and optimise network capacity through the identification and mitigation of system constraints. In delivering this capability, TfL develops in-house software based engineering tools to allow for detailed understanding of the railway as a whole. TfL applies this engineering capability at different stages of the programme lifecycle to ensure the railway performs as intended, efficiently and effectively.

The supplier shall demonstrate competency in one or both of the following areas:

- Systems Performance Engineering Delivery, analysis, modelling & simulation techniques, including, but not limited to the application of the following:
  - Analysis of Run Times, Run Out, Run In times (RORI) and Confliction times
  - Complex Junction modelling
  - Termini modelling
  - Depot capacity modelling
  - RES (Railway Engineering Simulator) or an equivalent multi-train signalling simulator
  - Timetable and journey time analysis
- Systems Performance Engineering Tools Development
  - Development of engineering modelling & simulation tools within Windows and Linux/Unix environments
  - Experience in design, test, develop, document and maintain software
  - Knowledge of Intel and/or Sun computers, their operating systems and commonly used development systems
  - Object-oriented coding techniques using C++, produce and implement structured, and well-documented code, and software testing plans
  - High-level programming languages including Python

- Linux/Unix (or other OS) administration, hardware builds and imaging
- Development of data pre-processing and post-processing programs and scripts
- Development of visualisation tools

## **E15: System Safety Engineering**

System safety engineering is the identification, understanding, management and control of safety hazards that originate from incorrect operation or use and that could harm the customers or staff of a transport system.

The objective of System Safety Engineering is to demonstrate that the transport system is free from harm and that safety risks are managed to acceptable levels.

The supplier will be expected to supply advice, studies, surveys, reports, safety cases, design and supervision services which will in turn, rely and depend on skill, competence and capabilities including but not limited to the following capability details:"

The supplier shall demonstrate competence in:

- Safety requirements including legislation and standards
- Safety documentation
- Safety modelling and tools
- Engineering safety management processes
- Safety risk assessment
- Risk control
- Specifying safety targets and related requirements.
- TfL Railway Environment domain safety knowledge
- The understanding and application of system safety engineering in transport environments and the TfL railway environments in particular.

## **E16: SCADA**

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control plant or equipment in many applications such as telecommunications, electrical power control and railway transportation.

The supplier will be expected to supply advice, studies, test procedures, analysis, reports, design and supervision services which will, in turn, rely and depend on skill, competence and capabilities including but not limited to the following capability details:

The supplier shall demonstrate competence in:

- SCADA requirements including legislation and standards, operational and maintenance requirements
- Design, development and implementation of SCADA architectures; distributed, networked, cloud-based

- Telecoms networks – LAN's / WAN's, fibre-based transmission, wireless
  - PLC's/ RTU's design applications in SCADA type plant/ environments
  - PLC/ RTU programming / ladder logic/ IEC 61131-3
  - SCADA protocols – Modbus-TCP, Ethernet, TCP/IP, DNP3, IEEE 60870-5
  - SCADA standards - IEEE 60870, IEEE C37.1-2007
  - SCADA testing and commissioning
  - Preparing SCADA documentation
  - TfL Transport Networks including TfL Railway Environment domain Knowledge
- Knowledge and understanding of the SCADA systems, other assets, processes and roles that are used in the railway environments of London Underground, the Docklands Light Railway, London Overground and Croydon Tramlink.

## **E17: R&R TCS Electronics**

Electronics is equipment that contains circuit boards, circuitry and components that are used for transmitting or processing analogue and/or digital data. On the TfL estate this ranges from hand-drawn and built circuitry from the 1950s to modern microprocessor based systems with surface mount construction. TfL are seeking specialist support to undertake electronics design to support delivery and maintenance projects, primarily for signalling and fleet. The scale of this scope could be from a single design for one-off use through to design changes and upgrades that have network-wide implications.

There is a need for support for state-of-the-art new equipment and designs but also for older systems using uncommon and often, obsolete technology.

The design support shall also include provision for supporting assurance documentation for the proposed design, demonstrating adherence to relevant standards and safety assurance processes. The supporting assurance documentation could also include on-site testing and surveys through to lab development, design and testing.

The supplier will be expected to supply advice, studies, reports, and design services which will in turn, depend on skill, competence and capabilities including but not limited to the following:

- Electronics design & documentation.
- Electronics CAD and simulation tools.
- Testing, reverse engineering and investigation.
- Standards for electronics design, manufacture, test, rework and repair.
- Safety assurance of electronics in safety and non-safety applications.
- Embedded software / firmware / hardware configuration for electronics.

It is desirable that the supplier has knowledge of electronics used in TfL network control systems, but knowledge of electronics in transport systems more generally will be sufficient when combined with a high level of general electronics skills and knowledge.

## **E18: Electromagnetic compatibility (EMC)**

Electromagnetic compatibility is the understanding, management and control of electromagnetic interference arising from the emission of electromagnetic energy from systems and the impact of that phenomenon on other systems that are susceptible to it. The objective of EMC is to control emissions and susceptibility, so that adverse effects are avoided.

The supplier will be expected to supply advice, studies, surveys, reports, design and supervision services which will in turn, rely and depend on skill, competence and capabilities including but not limited to the following capability details:"

The supplier shall demonstrate competence in:

- EMC requirements
- EMC documentation
- EMC modelling and tools
- Signalling and rolling stock compatibility
- EMC Testing
- Risk based approach to EMC, a risk based and economic approach to the management and control of EMC.
- TfL Railway Environment domain EMC Knowledge

Knowledge and understanding of the EMC characteristics of the assets that are used in the railway environments of London Underground, the Docklands Light Railway, London Overground and Croydon Tramlink and those areas of these railways that interface with, adjoin or are in close proximity to Network Rail.

## **E19: Human Factors**

Human Factors (HF) is the understanding of interactions between humans and other elements of a transport system, and the application of theory, principles, data and methods to the analysis and design of the transport system in order to optimise overall system performance through optimised human performance and well-being.

The supplier will be expected to supply advice, studies, surveys, reports, design and supervision services which will in turn, rely and depend on skill, competence and capabilities including but not limited to the following capability details:

The supplier shall demonstrate competence in:

- HF Lifecycles
- HF Documentation
- HF Analysis
- HF Design
- HF Testing and Commissioning

- The application of HF in transport environments, and in particular across all TfL modes

## **E20: Reliability Availability Maintainability (RAM)**

TfL's customers and stakeholders expect Transport Systems within London to be reliable and affordable.

- Reliability is the probability that a system will continue to perform correctly to a particular time.
- Availability is the ability of a system to be in a state to perform correctly at any time.
- Maintainability is the probability that a maintenance action can be carried out within a stated time interval. Maintainability also includes the cost of planned maintenance activities required to support safe and reliable operation in service.

The objective of RAM within TfL is to manage the reliability, availability and cost of transport networks so that the performance of these three parameters improves continuously and the adverse effects of any changes are avoided.

The supplier will be expected to supply advice, studies, reports, analytical, modelling, testing and supervision services which will in turn, rely and depend on skill, competence and capabilities including but not limited to the following capability details:

The supplier shall demonstrate competence in:

- RAM requirements
- RAM evidence
- RAM application over the life cycle
- RAM application to software based systems
- Reliability Growth Prediction:
- TfL Railway Environment domain RAM Knowledge

The understanding and application of RAM in transport system environments in general and within TfL railway environments in particular.



## **TRACK**

Permanent Way is an asset which varies widely in both age and environment from the deep tube environment through to the sub surface tunnels to open areas. The supplier is required to provide technical and professional advice on the Permanent Way asset and provide pragmatic solutions. The supplier shall also demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

### **E21: Railborne and non railborne equipment**

- Assessment of track railborne and non railborne equipment for track renewals
- Assessment of track railborne and non railborne equipment for track maintenance
- Approval of track railborne and non railborne equipment
- Standards including specifications

### **E22: Track Configuration and Layout**

- Strategy
- Feasibility Design
- Track Component design
- Noise and Vibration
- Wheel Rail Interface
- Standards including specifications

### **E23: Signalling Installation, Testing and Maintenance Engineering**

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in one or more of the following areas:

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in one or more of the following areas:

- Signalling installation, testing and commissioning
- Signalling maintenance & repair
- Signalling audit and inspection
- Incident investigation
- Signalling asset management / asset performance
- Point operating equipment
- Remote condition monitoring
- Risk based maintenance
- Assurance activities for product and system acceptance
- General technical support

## **E24: Signal Design Engineering**

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

- Signalling design process
- Interfaces with a variety of equipment including, but not limited to, Point operating equipment, Passenger information systems, Remote condition monitoring .
- Fixed block legacy signalling systems
- Automatic Train Control (ATC) systems, including coded track and Communications Based Train Control (CBTC) systems that provide Automatic Train Operation (ATO) and Automatic Train Protection (ATP)
- Automatic Train Supervision (ATS) systems
- Assurance activities for product and system acceptance
- General technical support

## **E25: Power Engineering**

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

The supplier shall demonstrate their knowledge and ability to communicate with and advise their client in the following areas:

- Power SCADA specialism
- AC Power Modelling and Studies (including DNO and National Grid infrastructure assessments)
- DC Power Modelling
- Train Simulation and Multi Train Simulation for Power System Modelling
- Power Quality Studies (including DNO and National Grid infrastructure assessments)
- Power System Reliability Modelling
- Harmonic Profile Modelling (including DNO and National Grid infrastructure assessments)
- AC Protection Studies
- Asset Management deep technical support e.g. review of age profiles and specialist asset condition assessments

- High Voltage specialist technical support e.g. Specialist advice and support on partial discharge monitoring and testing
- Development of HV Power electrical design, including concept and detailed design
- Earthing systems specialist advice and technical support
- All aspects of DC Electrical Track Equipment (ETE) including conductor rail design
- Overhead Line Equipment (OLE) design and maintenance