Schedule 6.2 – Testing and Assurance

CHANGE HISTORY

Version	Description	Author	Document Number
5.0	Execution version	TfL	75251755.12

Contents

1 General Requirements

1.1 The Concessionaire shall undertake appropriate and relevant incremental testing, including as set out in Schedule 4.1 (Concessionaire Solution), of the Services prior to the Testing of the Milestone Deliverables.

1.2 All Testing of the Milestone Deliverables conducted by the Concessionaire shall be conducted in accordance with the obligations set out in this Schedule.

1.3 Unless explicitly stated to the contrary in Schedule 4.1 (Concessionaire Solution), the Concessionaire shall provide and operate all equipment required for Testing, including the Test Tools, Test Environments, Test Data and Test Assets necessary in order to perform its Test obligations.

1.4 The Testing Procedures, Test Strategy and Test Plans shall align with the Verification Activity Plan.

1.5 If there is any conflict between this Schedule, the Verification Activity Plan and/or the Test Strategy, the conflict shall be resolved in accordance with the following order of precedence:

(a) this Schedule;

(b) the Verification Activity Plan; and

(c) the Test Strategy.

2 Verification Activity Plan

2.1 The Concessionaire shall comply with the Outline Verification Activity Plan from the Effective Date.

2.2 The Outline Verification Activity Plan is set out in Annex 1 (Outline Verification Activity Plan).

2.3 Within thirty (30) Working Days of the Effective Date, the Concessionaire shall submit to TTL for Approval a draft Detailed Verification Activity Plan which shall be consistent with the Outline Verification Activity Plan and as a minimum shall:

(a) provide the framework for all Testing required to Achieve the relevant Milestones and Key Milestones set out in the Implementation Plans;

(b) set out the approach, principles, processes, organisation, controls and stakeholders for the Testing of the Milestone Deliverables;

(c) make explicit reference to the mechanism adopted by the Concessionaire for validating the completeness of requirements delivery through the use of a requirements traceability matrix; and

(d) be consistent with and comply with the requirements of this Schedule.

2.4 If the contents of the draft Detailed Verification Activity Plan is Approved pursuant to Paragraph 2.3, it shall replace the Outline Verification Activity Plan from the date of TTL's notice of Approval.

2.5 The Concessionaire shall review and update the Verification Activity Plan as required to ensure that it remains current and fit for purpose.

2.6 Any changes to the Verification Activity Plan shall be submitted to TTL for Approval.

2.7 The Concessionaire shall require that all Sub-contractors delivering Testing implement at least equivalent controls to those set out in the Verification Activity Plan.

3 Preparation and Agreement of the Test Strategy and Test Plans

3.1 The Concessionaire shall identify a test manager for the purpose of co-ordinating its responsibilities in the preparation and agreement of the Test Strategy and each Test Plan, and the preparation and undertaking of Testing (the "**Test Manager**").

3.2 The Concessionaire shall, in accordance with the Verification Action Plan, ensure that the Test Strategy and each Test Plan is proportionate and appropriate to the nature of the Milestone Deliverables being Tested. As such, the Concessionaire shall consult with TTL, the relevant member of the TfL Group and relevant third parties (including, for example, the ESN Coverage Supplier and the Mobile Network Operators) that may be involved in the Testing regarding the preparation of the Test Strategy and each Test Plan. In particular, the Concessionaire shall consult regarding the acceptability and relevance of the proposed scope, duration and timing of the Tests, the proposed sources of Test Data, the Test Environments and any proposed TTL, TfL Group or third party (including the ESN Coverage Supplier and the Mobile Network Operators) responsibilities in preparing for, monitoring or undertaking the Tests.

3.3 TTL reserves the right to create and conduct its own tests within the Testing Procedures, including developing associated test specifications and directly managing such tests, and TTL may consult the Concessionaire in regards to such tests. The Concessionaire shall take account of TTL's requirements in this respect when preparing each Test Plan and allocate the necessary resources and time.

3.4 TTL reserves the right to provide Test Data for use within a Test. The Concessionaire shall consider and comply with any of TTL's reasonable requirements in this respect when preparing each Test Plan.

3.5 The Concessionaire shall provide all other Test Data that is required to allow the Test to be performed, and shall ensure that such Test Data is both relevant and adequate for the purposes of the Tests for which it is being used. The Concessionaire (or TTL where it has supplied the Test Data) shall ensure that the proposed sources and use of Test Data would cause neither the Concessionaire nor TTL to breach any of its applicable obligations under the Data Protection Legislation. In particular, the Concessionaire shall not use any TTL Data for Test purposes without TTL's prior written consent.

3.6 The Concessionaire shall ensure that to the extent reasonably possible, the Tests set out in the Test Strategy and the Test Plans are designed in such a way as to minimise any potential disruption to TTL or any member of the TfL Group.

3.7 In planning the Tests the Concessionaire shall consider what third party (including, for example, the ESN Coverage Supplier and the Mobile Network Operators) involvement is appropriate. The Concessionaire shall consult with any such third parties regarding the planning of Tests accordingly.

4 Test Strategy

4.1 The Concessionaire shall comply with the Outline Test Strategy from the Effective Date.

4.2 The Outline Test Strategy is set out in Annex 2 (Outline Test Strategy).

4.3 Within sixty (60) Working Days of the Effective Date, the Concessionaire shall submit to TTL for Approval a draft Detailed Test Strategy which shall be consistent with the Outline Test Strategy and the Verification Activity Plan, and as a minimum shall:

(a) define the Test activities to be undertaken against the Milestone Deliverables;

(b) set out (or justify any reasons for not setting out, as relevant):

(i) the applicability and extent of Testing;

(ii) the scope, objectives and assumptions of the Testing approach in relation to the Milestone Deliverables;

(iii) the Test methodology to be used by the Concessionaire, ensuring this is consistent with the Verification Activity Plan;

(iv) the Testing process and controls;

(v) the Testing lifecycle of the Milestone Deliverables which shall define what Testing is to be undertaken and why, including as a minimum:

(A) the Test types and techniques to be carried out by the Concessionaire, including what non-functional Testing is to be included (if any);

(B) assumptions regarding any prior testing that TTL or any member of the TfL Group has undertaken on TTL Infrastructure;

(C) an overview of the Test Success Criteria for the Milestone Deliverables and which Test Plan Template they relate to;

(D) the Test Environments;

(E) the Test Data strategy;

(F) the Test Tools and Test Assets (e.g. the use of stubs, simulators, automated test equipment, test management tools, etc.);

(G) the strategy for Test Issue management;

(H) the Concessionaire's Test organisation;

(I) Test design inputs;

(J) Test deliverables;

(K) the overall Test period;

(L) how the Testing will be managed and details of how/when/what information will be reported to TTL;

(M) the Test measurement approach;

(N) how testing will be continuously improved;

(O) the risks and issues;

(P) the role of TTL and any dependencies the Concessionaire may have on TTL;

(Q) the role of any third parties (including, for example, the ESN Coverage Supplier and the Mobile Network Operators) and any dependencies the Concessionaire may have on them;

(R) how information will be communicated to TTL; and

(S) the Test Issue Thresholds which shall be no greater than:

1) zero (0) Test Issues of Test Severity Level 1;

2) zero (0) Test Issues of Test Severity Level 2; and

3) for Test Issues of Test Severity Level 3 and Test Issues of Test Severity Level 4 at the tolerance levels determined by the Concessionaire and documented within the Test Strategy.

4.4 Inclusion of non-functional Testing shall also be considered within the Test Strategy. Where the Concessionaire determines that non-functional testing is not required, it shall document the rationale for this within the Test Strategy. As a minimum, Testing shall include the validation that the Performance Indicators in Schedule 2.2 (Performance Levels) can be met.

4.5 If the contents of the draft Detailed Test Strategy is Approved pursuant to Paragraph 4.3, it shall replace the Outline Test Strategy from the date of TTL's notice of Approval.

4.6 The Concessionaire shall review and update the Test Strategy as required in order to ensure it remains fit for purpose.

4.7 Any changes to the Test Strategy shall be submitted to TTL for Assurance.

5 Test Plans

5.1 A Test Plan Template for the each type of Milestone or Key Milestone which includes one (1) or more Milestone Deliverables is set out in Annex 3 (Test Plan Templates).

5.2 The Concessionaire shall develop Test Plans for each Milestone and Key Milestone that includes one (1) or more Milestone Deliverable, as set out in the Test Strategy.

5.3 The Concessionaire shall submit the Test Plans to TTL for Assurance as soon as practicable but in any case no later than twenty (20) Working Days (or such other period as the Parties may agree in the Test Strategy or otherwise agree in writing) prior to the start date for the relevant Testing (as specified in the Implementation Plans).

5.4 Each Test Plan shall be consistent with the relevant Test Plan Template, the Test Strategy and the Verification Activity Plan, and as a minimum shall set out (or justify any reasons for not setting out, as relevant):

(a) the relevant Test definition and the purpose of the Test, the Milestone or Key Milestone to which it relates, the Milestone Deliverables being Tested and, for each Test, the specific Test Success Criteria to be satisfied;

(b) a detailed procedure for the Tests to be carried out encompassing:

(i) the timetable for the Tests, including start and end dates;

(ii) the Testing approach, including the required inputs and anticipated results and a step-by-step procedure for executing the Test;

(iii) the dates and methods by which TTL can inspect Test results or witness the Tests in order to establish that the Test Success Criteria have been met;

(iv) the Test scripts, including a detailed procedure for the Tests to be carried out; and

(v) the specification of the required Test Data, including its source, scope, volume and management, a request (if applicable) for relevant Test Data to be provided by TTL, and the extent to which it is equivalent to TTL Data;

(c) the Test Environment(s) to be provided and utilised;

(d) the mechanism for ensuring the quality, completeness and relevance of the Tests;

(e) the format and an example Test Report;

(f) the process which TTL will use to review Test Issues and the Concessionaire's progress in resolving these in a timely basis;

(g) the Test schedule;

(h) the re-Test procedure, the timetable and the resources which would be required for re-Testing;

(i) the process for escalating unresolved Test Issues;

(j) any additional TTL or TfL Group requirements to be Tested; and

(k) Test resources.

5.5 Any changes to the Test Plan Templates shall be submitted to TTL for Approval.

5.6 Any changes to the Test Plans shall be submitted to TTL for Assurance.

6 General Testing Procedures

6.1 The Concessionaire shall ensure that all Concessionaire Personnel involved in the delivery of Testing are suitably trained and qualified.

6.2 The following procedures shall apply to the Testing of Milestone Deliverables:

(a) the Concessionaire shall conduct the Testing in accordance with the relevant Test Strategy and Test Plan and the timescales specified therein;

(b) the Concessionaire shall provide TTL with all reasonably necessary assistance and information in connection with the conduct of the Testing;

(c) if any third parties (including, for example, the ESN Coverage Supplier and the Mobile Network Operators) are involved in a Test, the Concessionaire shall provide them with all reasonable assistance and information in connection with the conduct of any such Tests; and

(d) if the Concessionaire, in meeting its obligations under this Schedule, consults or otherwise directly works with any third parties (including, for example, the ESN Coverage Supplier and the Mobile Network Operators), the Concessionaire shall provide TTL with reasonable visibility of such interaction.

6.3 Prior to the commencement of Testing, the Concessionaire shall conduct such activities as are necessary to ensure that the relevant Milestone Deliverable is ready for Testing, and shall, if required by the Test Strategy, demonstrate this to TTL in accordance with any entry criteria specified in the Test Strategy.

6.4 If required by the Test Strategy, the Concessionaire shall hold a formal Test readiness review to demonstrate to TTL that all of the entry criteria specified in the Test Strategy have been successfully met and that the Concessionaire is ready to start Testing. The Concessionaire shall provide a formal written record of this review to TTL within two (2) Working Days following completion of the review.

6.5 If required by the Test Strategy, the Concessionaire shall hold formal Testing completion reviews to demonstrate to TTL that the exit criteria specified in the Test Strategy have been successfully completed and met. The Concessionaire shall provide a formal written record of this review to TTL within two (2) Working Days following completion of the review.

7 Availability of Test Information

7.1 The Concessionaire shall make available to TTL (either as required by the Test Strategy or on request) all information produced for the purposes of Testing, including:

(a) the Test approach;

(b) the Test sequence;

(c) the Test Data;

(d) the Test scripts;

(e) the expected results;

(f) the actual results (including all Test Issue reports);

(g) the Test Issue Management Log;

(h) the plan to remediate any Test Issues;

(i) the Test Environment configurations;

(j) the configuration of elements passing through the Test (including which versions of what software and hardware are to be Tested in each Test);

(k) the details and configurations of any Test Assets used;

(l) written confirmation that the Test has been conducted in accordance with the relevant security requirements set out in Schedule 2.4 (Security Management);

(m) the requirements traceability matrix for the purpose of demonstrating linkage between the Tests and the TTL Requirements;

(n) the Test Report; and

(o) the Test Certificate.

8 Testing

8.1 The Concessionaire shall, during the conduct of any Tests, maintain an up-to-date record of all Test results, whether successful or unsuccessful.

8.2 The Concessionaire shall keep evidence of the Test results that failed or passed, and shall ensure all Tests are repeatable.

8.3 The Concessionaire shall perform the following, as may be required in the relevant Test Plan:

(a) demonstrate to TTL that the Concessionaire has in place the necessary personnel, accommodation, Test Environments, equipment, facilities and other resources to provide the Testing of the Milestone Deliverable;

(b) undertake the Test, or activities required in connection with the Test;

(c) provide reasonable notice to TTL of no less than;

(i) five (5) Working Days prior to commencing Testing at each Tunnel Section; and

(ii) twenty (20) Working Days prior to commencing Testing at all other locations,

so that, if necessary, TTL can arrange for a Test Witness to attend the Test in accordance with Paragraph 10.

8.4 TTL reserves the right to require the Concessionaire to provide TTL with visibility via read access to the Concessionaire's Test Tools and the Concessionaire shall take account of TTL's requirements in this respect when preparing the Test Plan.

9 Test Issues and Reports

9.1 The Test Manager shall document all Test Issues encountered during the Test, and shall categorise each Test Issue as one (1) of the following:

Test Severity Levels	**Definition**
Test Severity Level 1	The failure causes a non-recoverable condition where it is not possible to continue using a component (or components) of the Milestone Deliverable being Tested and which results in a severe impact to the performance of the Service processes, or Telecommunications Infrastructure, for which no satisfactory workaround exists.
Test Severity Level 2	The failure causes major impairment of one (1) or more component (or components) of the Milestone Deliverable being tested, or causes a major impairment of one (1) or more critical Service process or elements of Telecommunications Infrastructure, irrespective of whether a workaround exists; or the failure causes major impairment to one (1) or more non-critical Service process or elements of Telecommunications Infrastructure for which a satisfactory workaround does not exist.
Test Severity Level 3	The failure causes minor impairment of one (1) or more component (or components) of the Milestone Deliverable being tested, or causes

	a minor impairment of one (1) or more critical Service process or elements of Telecommunications Infrastructure irrespective of whether a workaround exists; or the failure causes a major impairment to one (1) or more non-critical Service process or elements of Telecommunications Infrastructure for which a satisfactory workaround does exist.
Test Severity Level 4	The failure is a cosmetic inconvenience / annoyance such that it does not hinder the Services.

9.2 The Concessionaire shall notify TTL of such categorisation pursuant to Paragraph 9.1 and if TTL does not agree with such categorisation, TTL may, acting reasonably, require the Test Manager to re-categorise Test Issues into different Test Severity Levels.

9.3 As part of the Testing of the Milestone Deliverables the Concessionaire shall be responsible for setting-up and maintaining a log of Test Issues (the "**Test Issue Management Log**") and process.

9.4 The Concessionaire shall be responsible for updating the Test Issue Management Log and for ensuring that its contents accurately represent the current status of each Test Issue at all times.

9.5 The Concessionaire shall run the Tests as defined by the relevant Test Plan and shall provide to TTL in relation to each Test:

(a) a template of the Test Report not less than two (2) Working Days (or such other period as the Parties may agree in writing) prior to the date on which the Testing is planned to end; and

(b) the final Test Report within five (5) Working Days (or such other period as the Parties may agree in writing) of completion of Testing.

9.6 Each Test Report shall report on the Testing conducted in respect of a Milestone Deliverable, including:

(a) an overview of the Tests conducted;

(b) identification of the relevant Test Success Criteria that have been satisfied;

(c) identification of the relevant Test Success Criteria that have not been satisfied together with the Concessionaire's explanation of why those criteria have not been met;

(d) the Tests that were not completed together with the Concessionaire's explanation of why those Tests were not completed; and

(e) the specification for any Test Environments used throughout the Tests and any changes that were applied to that Test Environment during the Tests.

9.7 The Test Manager shall analyse and attempt to resolve each Test Issue according to the Test Issue management and Test Strategy procedures (as included within the Test Strategy).

9.8 A Test shall be recorded as successful if, having completed all the planned Tests, the number of Test Issues unresolved at the end of the relevant Test does not exceed the Test Issue Thresholds for that Test.

10 Test Witness

10.1 TTL may, in its sole discretion, require the attendance at any Test of one (1) or more Test Witnesses, each of whom shall have appropriate skills to fulfil the role of a Test Witness and may be TTL Personnel and/or appropriate and relevant personnel of third parties.

10.2 The Concessionaire shall give the Test Witness access to documentation and Test Environments reasonably necessary and requested by the Test Witnesses to perform their role as a Test Witness in respect of the relevant Tests.

10.3 The Test Witness:

(a) may review the Test documentation;

(b) may attend and engage in the performance of the Tests so as to enable TTL to gain an informed view of whether a Test Issue may be closed or whether the relevant element of the Test should be re-Tested;

(c) shall not be involved in the execution of any Test;

(d) may be required to verify that the Concessionaire conducted the Tests in accordance with the Test Success Criteria and the relevant Test Plan;

(e) may produce and deliver their own, independent reports on the Testing, which may be used by TTL when determining if it is satisfied that the applicable Test Success Criteria have been met;

(f) may raise Test Issues on the Test Issue Management Log in respect of any Testing; and

(g) may require the Concessionaire to demonstrate the modifications made to any Milestone Deliverable before a Test Issue is closed.

11 Test Success

11.1 When the Concessionaire considers that the applicable Test Success Criteria for all Milestone Deliverables associated with a Milestone or Key Milestone have been met and there are no outstanding Test Issues in excess of the applicable Test Issue Threshold, the Concessionaire shall issue to TTL:

(a) a Test Certificate in the form set out in Annex 5 (Test Certificate), together with the relevant Test Report; and

(b) any other information required by the relevant Test Strategy.

11.2 If TTL is satisfied that the applicable Test Success Criteria has been met and there are no outstanding Test Issues in excess of the applicable Test Issue Threshold, TTL shall promptly notify the Concessionaire that it is satisfied by countersigning the Test Certificate.

11.3 If there are any Test Issues outstanding when TTL countersigns the Test Certificate pursuant to Paragraph 11.1, the Concessionaire shall resolve such Test Issues in accordance with the timescale specified in the Test Plan and relevant plan to remediate the Test Issues.

12 Test Failure

12.1 If, upon receipt of a Test Certificate from the Concessionaire pursuant to Paragraph 11.1, TTL is not satisfied that the applicable Test Success Criteria have been satisfied and/or there are outstanding

Test Issues which in TTL's reasonable opinion are in excess of the applicable Test Issue Threshold, TTL:

(a) shall promptly notify the Concessionaire in writing of the reasons for such determination; and

(b) may extend the timetable for the Tests set out in the Test Plan by such reasonable period as TTL may determine (provided always that such extension shall not be deemed to result in the change of any Milestone Date in respect of any Key Milestone).

12.2 Where the failure to satisfy the Test Success Criteria results, in the failure (in whole or part) by the Concessionaire to meet a Key Milestone, then without prejudice to TTL's other rights and remedies, such failure shall constitute a Notifiable Default for the purposes of Clause 29.1 (Rectification Plan Process).

12.3 For the purposes of Paragraph 12.1 and in respect of PIM testing of leaky feeder only, TTL shall not be entitled to consider that the Test Success Criteria have not been satisfied if the pass/fail criteria set out at Paragraph 8.5.4 Part C of Annex 3 of Schedule 6.2 (Outline Test Plan Template – CMS/ESN Tunnel) have not been met provided that the Tests demonstrate performance at least of the standard achieved during verification by the Concessionaire of such leaky feeder, in accordance with the Allowable Assumptions in Annex 7 of Schedule 7.1 (Fees and Charges).

13 Issue of Milestone Achievement Certificate

13.1 TTL shall determine whether or not to issue a Milestone Achievement Certificate in respect of a given Milestone or Key Milestone in accordance with the provisions set out in Paragraph 6 of Schedule 6.1 (Implementation Plans).

14 Works Funded By Grants Services Assurance Process

14.1 The Concessionaire shall undertake the assurance activities set out in the Works Funded By Grants Services Assurance Process.

14.2 On Achievement of a Works Funded By Grants Group, the Concessionaire shall be entitled to the receipt of a payment associated with that Works Funded By Grants Group in accordance with the provisions of Schedule 7.1 (Fees and Charges).

Annex 1 - Outline Verification Activity Plan

Verification Activity Plan

		Signature	Date
Prepared by	<Name> Project Manager		
Prepared by	<Name> Operations Representative		
Prepared by	<Name> Sponsor		
Prepared by	<Name> HSE Adviser		
Prepared by	<Name> Project Engineer		
Prepared by	<Name> Maintenance Representative		
Reviewed by	I approve this deliverable as the designated technical authority for the relevant engineering discipline and am accredited to do so. Discipline Engineer		
Approved by	I confirm that this deliverable meets the requirements of the relevant Pathway Product Description and that all consultation comments have been addressed to the satisfaction of consultees. <Name> Project Manager		
Distributed to	<Name>	Suppliers covered by the VAP	

1 Introduction

1.1 The strategic objective of the Commercial Mobile Services (CMS) Service Line is:

(a) to deliver a neutral host Active Distributed Antenna Solution suitable for use by all the UK's Mobile Network Operators (MNOs), supporting 4G and other technologies as needed. This network will be commercialised by providing access to the MNOs and connecting their equipment at Base Station Hotels across London. This will provide end users on the London Underground (LU) direct access to their services.

1.2 The Concessionaire will enter into a contract with the ESN Coverage Supplier for the implementation and service management of ESN services.

1.3 The strategic objective of the Fibre Service Line is:

(a) to deliver a fibre network utilising TfL's tunnel and ducting and using LU stations as the Points of Presence (PoPs) for that network.

1.4 The strategic objective of the Wi-Fi Service Line is:

(a) to improve Public Wi-Fi by adding a new open access model, as well as supporting the existing SIM-based authentication (EAP-SIM). The new open access service aims to allow all users access to the current Public Wi-Fi service via a simple login.

1.5 The strategic objective of the Streetscape Service Line is:

(a) To facilitate the rollout of MNO 4G and 5G small cells equipment and IoT units, by commercialising TfL Assets.

1.6 TfL may also be allocated funding from various sources, including the DCMS LFFN programme and may receive further Grant Funding through other national and local government funding initiatives. TfL may request the Concessionaire deliver such schemes.

2 Scope of work activity for which the VAP applies

2.1 Location of the activity is as set out in Annexes 1 to 3 of Schedule 2.1 (Services Description).

2.2 Extent of the activity is to design, plan, build, test operate and maintain active and passive telecommunications infrastructure across the London Underground estate.

2.3 Assets to be affected by the works are outlined below:

(a) Station Building Entry Points (BEPs);

(b) Station Computer Equipment Rooms (CERs), Station Computer Rooms (SCRs);

(c) Cable Management System / Containment / Conduit;

(d) Cabling, including CAT6a UTP cable, Optical fibre runs, power feeds;

(e) Power systems;

(f) Cabinetry – telecoms grade cabinets, including power (UPS) and cooling systems;

(g) Station (Front of House) – installation of Low Power Radio (LPR) nodes;

(h) Station (Front of House) – installation of High Power Radio (HRN) nodes;

(i) Station (Back of House) – installation of Low Power Radio (LPR) nodes;

(j) Station (Back of House) – installation of High Power Radio (HRN) nodes;

(k) Station (ground level) – installation of a Point of Presence cabinet;

(l) Tunnels – installation of radiating cables ('leaky feeder');

(m) Tunnels – installation of fibre optic cables; and

(n) Tunnels – installation of mid tunnel High Power Radio (HRN) nodes.

3 Interfaces

3.1 This project focusses on telecommunications systems throughout the estate.

3.2 Interfaces to other TfL assets are:

(a) Airwave, over the Connect TETRA radio system;

(b) Customer Information Systems (CIS);

(c) CCTV (Station, One Person Operation and Long Line);

(d) Advertising (Exterion Media);

(e) Signalling;

(f) Power Supervisory Control and Data Acquisition (SCADA);

(g) Station Services;

(h) Lifts;

(i) Escalators;

(j) Building Management Systems;

(k) Station Management Systems;

(l) Fire System; and

(m) Public Address / Voice Alarm (PA/VA) Systems.

3.3 Key TfL projects:

(a) 4LM (Four Line Modernisation)

(b) Bank & Monument Redevelopment

(c) Crossrail

(d) Northern Line Extension

(e) individual station upgrades.

3.4 External interfaces:

(a) End user mobile customers;

(b) station staff;

(c) Unions;

(d) TfL management;

(e) DLR;

(f) Network Rail;

(g) Neighbours;

(h) English Heritage;

(i) local authorities;

(j) utilities;

(k) Mobile Network Operators;and

(l) key contractors.

4 Organisation

4.1 Below is a list of key stakeholders involved in the verification and assurance process:

Stakeholder	**Organisation/Directorate and Job Title**	**Key interest**
	Systems Engineer	System Performance Engineering
	Head of Signalling Engineering	EMC
	Systems Performance Engineer	Power & Cooling Engineering
	Project Manager	Programme Delivery
	Head of Engineering Information	Product Acceptance and Registration Materials Compliance
	Senior Product Manager	Radio and Wireless
	Director of Health, Safety & Environment	Occupational and Operational HSE & Assurance
	Station Managers	Station Access and Works Assurance
	Fire Engineer	Fire compliance
	Head of Access	Railway Access co-ordination
	Head of Technical & Data	Security of information technology

	Head of Civil Engineering	Cutting, Drilling and Fixing
	Principal Premises Engineer	Control of Asbestos
	Senior Station Strategy Manager	Customer Facing Aspects of Temporary Works
	Professional Head of Mechanical and Electrical Engineering	Electrical Services
	Head of Permanent Way	Gauging and clearances of equipment
	Head of ICT Engineering	Telecommunications Philosophy and Principles
	The Communications Engineer	Interface with operational Information systems Wired and Wireless Communication Systems
	Head of Profession – Power – TfL Engineering	Matching electrical loads to low voltage supplies
	Chief Information Security Officer	Information Security
	Director of Strategy and Network Development	CMS Sponsorship and Governance
	Principal Infrastructure Protection Engineer	Works Near Mains Services and Infrastructure

5 Information management

5.1 The Concessionaire will be using the Pathway process and agreed document management tools, including SharePoint, to manage records (as further described in Schedule 8.4 (Document Management)).

5.2 In terms of test report repository and sharing systems, BAI will utilise a cloud-based tool to provide read access to TfL.

6 Verification requirements

Assessment of Risk

6.1 The assessment of risk to the operational railway, its staff and customers will be undertaken in collaboration with TfL via progress meetings and workshops.

6.2 The Concessionaire provides verification of key suppliers through formal procurement and due diligence, together with the appropriate ISO accreditations. Formal project governance is in place and aligned to TfL Pathway, enabling project stage gate reviews to provide assurance.

6.3 In terms of known areas of potential high risk or non-compliance, the overall HSE risk is considered to be LOW, where suitable and proportionate control measures are applied. Top HSE hazards have been identified together with the associated risks and controls. Risk assessment is applied throughout the lifecycle from design through to decommissioning.

6.4 In accordance with TfL Safety Certificate and Safety Authorisation, the Concessionaire will liaise with TfL as necessary to determine if the TfL Quantified Risk Assessment (QRA) requires to be updated in relation to the works undertaken. The Concessionaire will also work with TfL HSE to jointly complete Risk Based Intrusion assessments and will update our outline surveillance activities in response to this assessment.

6.5 The Concessionaire's System Engineering Management Plan governance allows for design change control. Requirements are fed in via a System Design Review and through preliminary and detailed design reviews to provide a baseline design that meets all the agreed requirements and is suitable to progress into build. Design changes beyond point are catered for via an Impact Assessment process. These changes can be identified at any part of the lifecycle.

6.6 Surveillance activities will be carried out on key suppliers including Quality Audits, external ISO accreditation and Factory Acceptance Test visits.

6.7 The Concessionaire has relevant expertise and experience with the reference supplier for the Distributed Antenna System element of the Commercial Mobile Service, SOLiD Technologies, gained through design and rollout activities in Toronto and New York. The Concessionaire's main strategic partner for installation – Installation Technology Ltd – has extensive experience on London Underground, including Wi-Fi, ESN enablement and PCN Trial works.

6.8 In summary, the Concessionaire's conclusion is that the perceived risk that the TCP work activity presents to TfL is LOW.

7 Compliance Requirements

7.1 Compliance against the standards and requirements for the relevant disciplines will be reviewed by the project engineers. Key compliance requirements for this project are:

(a) TfL Standards;

(b) HSE Legislation;

(c) TCP requirements;

(d) Product Approval;

(e) Fire compliance;

(f) EMC compliance;

(g) Electrical compliance;

(h) Gauging and clearances; and

(i) Statutory obligations processes.

7.2 Compliance requirements will be identified, captured and verified via the following means:

(a) Design reviews;

(b) Surveys;

(c) Concessionaire Risk Register

(d) Risk workshops

(e) Peer reviews

(f) Quality assurance inspections

(g) Fire inspections and sign-off

7.3 The Concessionaire will deal with non-compliances through project governance – particularly focussing on testing and verification results and feedback loops towards the main equipment and solution suppliers. This will be informed by approved design documentation, survey records, test results, stage gate reviews, surveillance reports (audits and inspections).

8 Establishing (Assessment) Criteria

8.1 TfL has several processes in place that can be utilised to assess different aspects. A standardised rating using continuous assessment using RAG (Red, Amber, Green) status will be used to flag issues, observations, minor and major non-conformities. The Concessionaire will liaise with TfL for peer reviews and lessons learned from similar programmes to assist critique of verification assessment criteria.

9 Verification Activities

Surveillance

9.1 Quality engineers from the Concessionaire will inspect locations and perform surveillance activities, including:

(a) Audit

(b) Monitoring/inspection

(c) Investigation

(d) Data capture / trend analysis

9.2 This will include measuring the delivery of the solution, installed as per the scope of works and to the appropriate regulations and standards. All change requests / variations will be considered, and a checklist-based approach utilised to achieve station sign-off.

10 Assurance Evidence

10.1 The TCP project is a significant piece of work and may be subject to scrutiny by the DRACCT depending on the risk basis.

10.2 The Concessionaire will fully participate in any verification assessment including, presenting and reviewing documentation related to design, specification, compliance of products, VAPs, Factory Acceptance Tests, test schedules, use of competent contractors, certificates of conformity for materials used, technical conformity including Electrical and EMC compliance, risk assessment reports and surveillance reports highlighting Snagging and outstanding works and Concessions granted to provide the overall required assurance to TfL.

11 Approval, Review and Revision of the VAP

11.1 This Verification Activity Plan will be updated as and when changes occur to the TCP project or which require the process for verifying activities to be altered. Any change to the VAP will be subject

to consultation with the main stakeholders. Any such VAP change will be approved by the Project Manager.

11.2 The first scheduled review of this VAP is to move from Outline VAP to Detailed VAP within 30 Working Days of the Effective Date, in accordance with Paragraph 2.3 of this Schedule 6.2.

12 Records

12.1 All records from Verification and Surveillance activities will be stored as per formal TfL protocol. Where the project is installing new greenfield assets, the project will hold all records and drawings within the project's documentation management system.

12.2 Alongside this VAP document is the Test Strategy (Annex 2 to this Schedule 6.2) which outlines the approach and methodology in more detail. Under each Service Line, individual Test Plan templates reside with details of the verification activities.

13 Glossary of Terms

Abbreviations

13.1 The following abbreviations are used in this document:

Table 13.1 – Abbreviations	
Abbreviations	**Definition**

Definitions

13.2 The following definitions are used in this document:

Table 13.1 – Definitions	
Term	**Definition**

14 Reference Documentation

Table 14.1 – References	
Document Id	**Title**

15 Example of Verification Activity Table for Potential Undesirable Outcomes

Project Phase

15.1 Directorate / Asset Discipline:

Potential Undesirable Outcome	Mitigating Controls	Risk Level (H/M/L)	Verification Activity		
			What (the verification activity)	Who (person responsible)	When (and how often)
Existing installed passive infrastructure not fit for purpose.	Access to full test results to validate.	M			

16 Example of Verification Activity Table for Routine Verification

Project Phase

16.1 Directorate / Asset Discipline:

Routine Verification Requirements (Minimum verification activities to provide assurance / confidence)	Verification Activity		
	What (the verification activity)	Who (person responsible)	When (and how often)

Annex 2 – Outline Test Strategy

Programme: TCP

Project(s): CMS/ESN, Fibre Services, Wi-Fi & Streetscape

Document reference: TCP-BAI-ENG-SYS-T-TS_060320-0001

TCP Test Strategy

		Signature	Date
Prepared by	<Name> Project Manager		
Prepared by	<Name> Operations Representative		
Prepared by	<Name> Sponsor		
Prepared by	<Name> HSE Adviser		
Prepared by	<Name> Project Engineer		
Prepared by	<Name> Maintenance Representative		
Reviewed by	I approve this deliverable as the designated technical authority for the relevant engineering discipline and am accredited to do so. Discipline Engineer		
Approved by	I confirm that this deliverable meets the requirements of the relevant Pathway Product Description and that all consultation comments have been addressed to the satisfaction of consultees. <Name> Project Manager		

Distributed to	<Name>	Suppliers covered by the VAP

1 Introduction

1.1 The Concessionaire Agreement operates across several Service Lines. These are:

(a) Commercial Mobile

(b) Fibre

(c) Streetscape

(d) Public Wi-Fi

1.2 Together with:

(a) ESN

(b) Works Funded by Grants

2 About this document

2.1 The Concessionaire has a proven track record of delivering testing services to enable our major network programmes globally. This Test Strategy complies with the Concessionaire's UK Test Policy and its purpose is to state the structure, aims and objectives of the requirements in this Schedule 6.2 (Testing and Assurance), Schedule 2.1 (Services Description), Schedule 2.2 (Performance Levels), Schedule 4.1 (Concessionaire Solution) and Schedule 13 (ESN Service Management Requirements).

2.2 This document forms part of the suite of Testing documents as highlighted below in Table 1.

Table 1

	Verification Activity Plan	**Test Strategy**	**Test Plan Templates**	**Testing Certificates**
TCP Programme level	X	X	N/A	N/A
CMS Service Line and ESN Service Line			Station Tunnel BSH	X
ESN Service Line			BSH implementation (ESN requirements) Annex 3 location Supplemental tests	X

Fibre Service Line			PoP	X
Streetscape Service Line			Streetscape	N/A
Wi-Fi Service Line			Public Wi-Fi Authentication Service Content Filter Service Internet Service	X
Grant Funded Works				X

3 Scope for which the Test Strategy applies

3.1 The purpose of this document is to describe the overall Test Strategy across the entire Telecommunications Commercialisation Project and its Service Lines.

3.2 Where variances between Service Lines exist, these will be highlighted. Specific test plans themselves will not be in this Test Strategy and will reside within the dedicated Test Plan Templates.

CMS Service Line

3.3 Location of the activity is as set out in Annexes 1 to 3 of Schedule 2.1 (Services Description).

3.4 Extent of the activity is to design, plan, build, test operate and maintain active and passive telecommunications infrastructure across the London Underground estate.

3.5 Assets to be affected by the works are outlined below:

(a) Station Building Entry Points (BEPs);

(b) Station Computer Equipment Rooms (CERs), Station Computer Rooms (SCRs);

(c) Cable Management System / Containment / Conduit;

(d) Cabling, including CAT6a UTP cable, Optical fibre runs, power feeds;

(e) Power systems;

(f) Cabinetry – telecoms grade cabinets, including power (UPS) and cooling systems;

(g) Station (Front of House) – installation of Low Power Radio (LPR) nodes;

(h) Station (Front of House) – installation of High-Power Radio (HRN) nodes;

(i) Station (Back of House) – installation of Low Power Radio (LPR) nodes;

(j) Station (Back of House) – installation of High-Power Radio (HRN) nodes;

(k) Station (ground level) – installation of a Point of Presence cabinet;

(l) Tunnels – installation of radiating cables (‘leaky feeder’);

(m) Tunnels – installation of fibre optic cables; and

(n) Tunnels – installation of mid tunnel High Power Radio (HRN) nodes.

3.6 A high-level topology of the ADAS system is shown below in Figure 1:

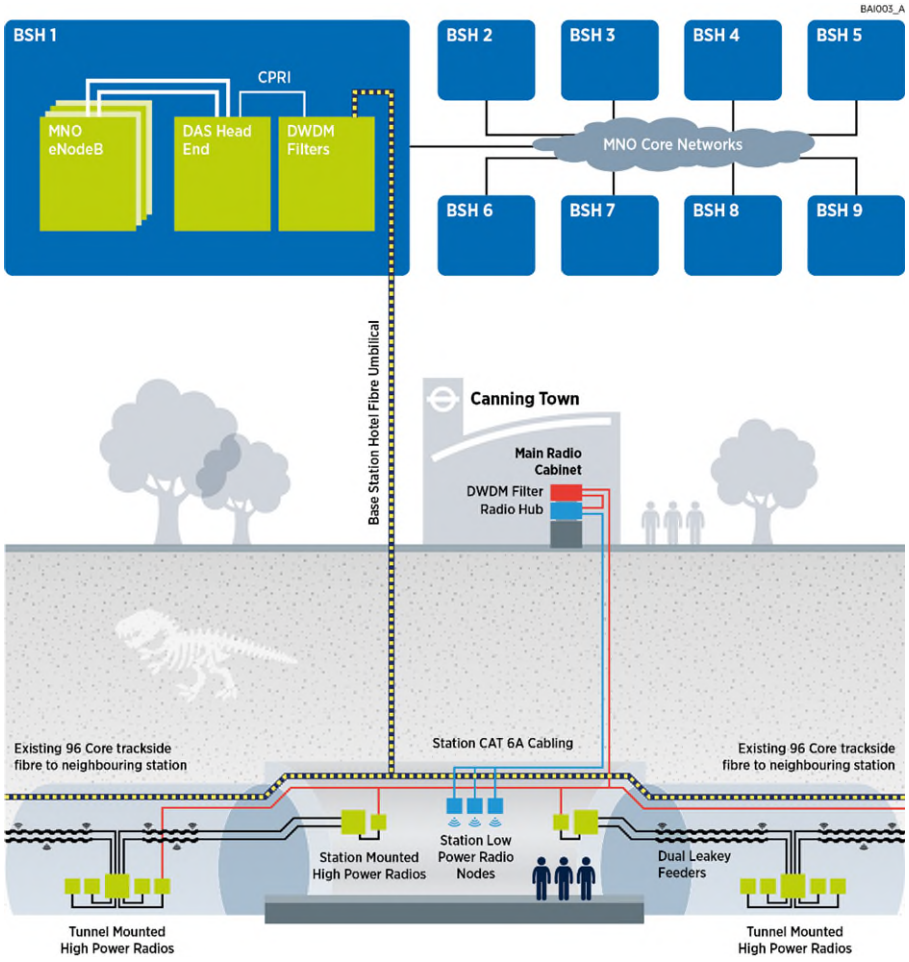

Figure 1

Fibre Service Line

3.7 The CMS Service Line relies on the existing 96 core optical fibre network installed underground. In addition, an overlay Fibre Service Line optical network will be deployed.

3.8 This is a single, highly available, resilient and high capacity optical network for new communications services for London. The network will provide connectivity for both current and future applications. These include:

(a) ISP services via Fibre To The Premises (using Grant Funded works vehicle);

(b) Increased Data Centre interconnectivity;

(c) Facilitate connection to Streetscape assets such as 4G/5G small cells, hotspots and IoT technology;

(d) Dark Fibre product offering to customers; and

(e) Lit Services capability.

3.9 The optical network comprises an underlying physical fibre plant layer, with the option to leverage DWDM technology to provide the lower layers of connectivity. On top, a Lit Services network can be deployed. This will be utilised to activate the full capacity of the fibre infrastructure.

3.10 The key components that require testing and validation are:

(a) The main eight hundred and sixty-four (864) count commercial fibre;

(b) Splice boxes, cable trays, Optical Distribution Frames;

(c) The Points of Presence (PoPs); and

(d) DWDM equipment.

Wi-Fi Service Line

3.11 The key elements under test are the Authentication (AAA) system, content filtering system and captive portal service.

Streetscape Service Line

3.12 The Streetscape Service Line will commercialise TfL street-based assets. The primary use cases being MNO Small Cells for 4G and 5G. This will comprise passive infrastructure such as CCTV poles and lamp posts that host the small cells. Backhaul transmission, typically fibre, will connect back to Points of Presence which will aggregate the traffic and transport via the Concessionaire's network back to the MNO Core Network.

4 Applicability and extent of testing

4.1 The foundations of the Test Strategy are the Verification Stages (V-Stages) described in Section 7.

4.2 The V-stages are shown in Table 2 below for the TCP Programme, with main applicability shown for each Service Line.

X = required. (X) = optional

Table 2

Stage	Name	Service Line			
		CMS/ESN	Fibre	Wi-Fi	Streetscape
V0	Materials compliance/approval	X	X		
V1	FAT	X	(X)	(X)	
V2	Site Acceptance testing	X	X		(X)
V3	System Integration testing	X	X		(X)

V4	LU co-existence	X			
V5	Service acceptance testing Including E2E Performance test	(X)	X		(X)
	ESN adjunct testing	X			

5 Test Activities against Milestone Deliverables

5.1 The test activities against Milestone deliverables is shown below in Table 3:

Table 3

Milestone	Service Line	Outcome	Testing Required to enable Milestone
MS 1-7	CMS	Station Delivered	V0-V5
MS 8 - 14	CMS	Tunnel Section Delivered	V0-V5
MS 15A-I MS 23A-I MS 24A-I (ESN BSH Test certificates)	CMS ESN	Base Station Hotel LLD Delivered (same BSH are used for both networks)	V1-V4
MS 25-29	ESN	Stations Delivered	V0-V5, Adjunct testing
MS 30-33	ESN	Tunnel Segments Delivered	V0-V5, Adjunct testing
MS 34-38	ESN	Combination of point locations, tunnels, sidings and station locations	V0-V5, Adjunct testing
MS39	ESN	ESN Complete	BSH Test Certificates BSH As-Builts All Station (ESN) Complete Milestones All Tunnel Sections (ESN) Complete Milestones All ESN Annex 3 Locations Complete Milestones
FS1-4	FS	PoPs delivered	V0-V2, V4
SS1	SS	Streetscape assets commercialised	(V1-V5)
WF1	WF	Availability of public Wi-Fi	V1-V5

		Authentication Service Content Filtering Service Internet Service	

6 Concessionaire's Test Methodology

Overview

6.1 The Concessionaire's established test methodology will be adapted for the test activities that the Concessionaire is responsible for completing. All test processes will be led by the Concessionaire's Test Manager, working closely with vendors, contractors, TfL, MNOs and other parties. Each test activity will be managed by a Test Activity Lead and will follow the test process phases illustrated in Figure 2 and described below:

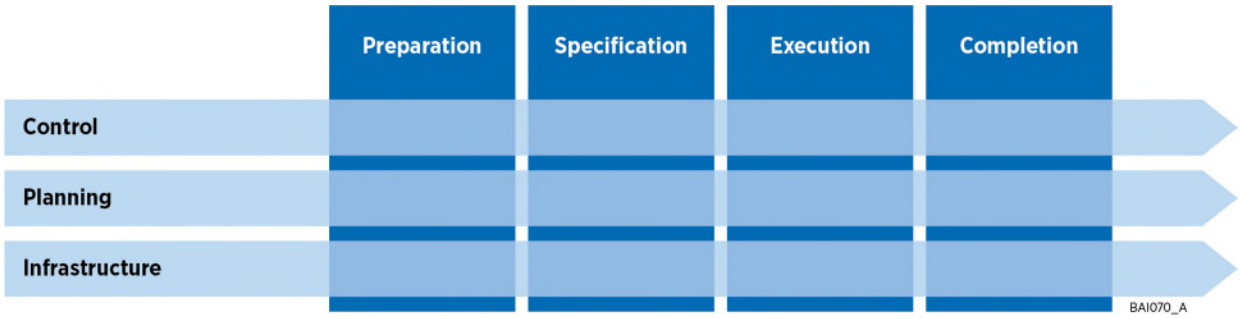

Figure 2

(a) **Control**. Throughout the test lifecycle, controls ensure that test activities are correctly executed, monitored and, if necessary, adjusted. The Test Manager will play a central role in the control aspects of testing.

(b) **Planning**. The Test Manager and Test Activity Lead formulate a coherent approach that is supported by stakeholders to execute the particular test assignment. Details will be provided in Test Plan Templates.

(c) **Infrastructure**. The setting and maintaining of test infrastructure which is required to be used in the various test phases. This is the stage during which the Test Environment approach will be developed in detail.

(d) **Preparation**. In this phase, a 'testability' review is carried out and this early review is used to improve quality and prevent suboptimal testing downstream.

(e) **Specification**. The actual tests are written in the Specification phase.

(f) **Execution**. The tests specified above are executed. Following a complete testing segment, the passed and failed test cases will undergo a review. Failed test cases will be re-run during subsequent test cycles, described in the detailed test plans.

(g) **Completion**. The test assignment is concluded in the Completion phase. This phase also offers the opportunity to learn lessons from experiences gained in the project.

Concessionaire V-Model. Based on Standards, rooted in practicality

6.2 This Test Strategy is based on the industry standard Verification & Validation model, formalised in IEEE 1012 which has found widespread application in engineering and defence programmes. This model provides concrete assistance in how to implement an activity and its work steps.

6.3 The framework is shown below in Figure 3:

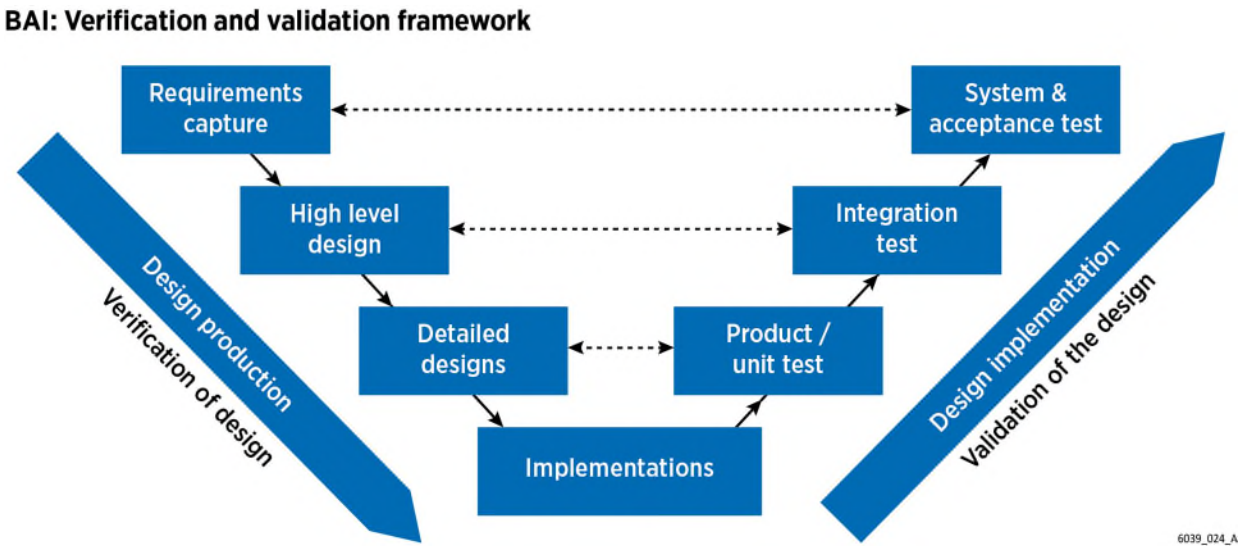

Figure 1

6.4 Validation can be expressed by the query "Are you building the right thing?" and verification by "Are you building it right?". This document focusses on the right-hand Verification arm of the model.

6.5 The Concessionaire UK bases its Verification testing on ISO/IEC/IEEE 29119 which defines the vocabulary, processes, documentation, techniques and a process model for testing. In terms of test result irregularities, IEEE 1044 is employed, which outlines standard classification for anomalies (record, classify, identify impact).

7 Test process

7.1 The Concessionaire has established a 6-stage approach. It is aligned with the ESN High Level Design and ESN A7 Response (refer to Paragraph 9 of Schedule 4.1 (Concessionaire Solution)), as ESN (and CMS) are the most complex and demanding of the Service Lines. The 6-stage approach will be used for other Service Lines within the TCP project.

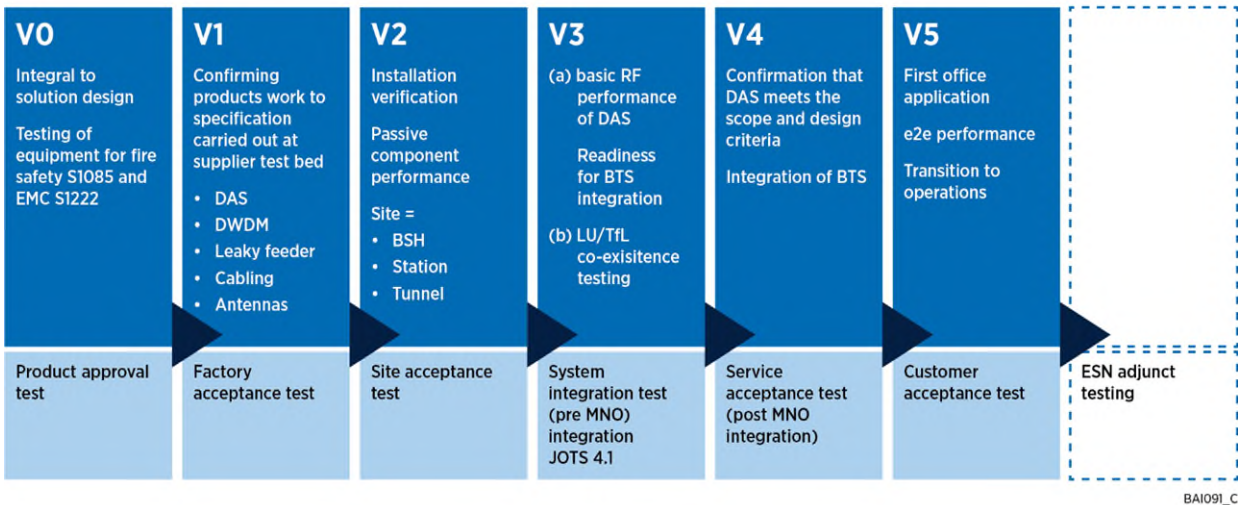

Figure 2 V-Process

Product Approval Process V0

7.2 Testing will be conducted against project test requirements and TfL Category 1 standards as stated in the following documents:

(a) 1-085 Fire safety performance of materials; and

(b) S1085 Fire Safety Performance of Materials - Stations and Tunnel Infrastructure.

7.3 For Fire safety, the Concessionaire and its partners will work closely with the manufacturer to secure the following inputs:

(a) Power supply information;

(b) Ancillary equipment details needed for normal information;

(c) Material breakdown of the equipment (combustible and non-combustible) including weights and paint coatings;

(d) Equipment specification sheets;

(e) Copies of existing fire material compliance test report and test certificates (if available); and

(f) Confirm if the equipment has any local or remote thermal cut-offs.

7.4 Upon receipt of the above data, this is logged onto TfL's register of products approved by TfL for use in the London Underground ("Approved Product Register"). The receipt of each equipment identified as not being compliant will be required for further analysis and testing, with a spare unit procured by the Concessionaire for contingency.

7.5 Where existing test reports and certificates are available these will be analysed, and data recorded against each equipment item on the Approved Product Register.

7.6 Throughout the above process, the Concessionaire's materials engineer also works closely with the lead TfL Fire Engineer to inform and discuss the needs of the project and fire materials compliance plan.

7.7 The Concessionaire's materials engineer analyses the breakdown of materials for the equipment, using the data provided by the manufacturer and other information, validating this against TfL Standard S1085, whilst recording the information on the register. Each piece of equipment is unassembled (if necessary) and the combustible (i.e. plastic) and non-combustible components identified.

7.8 This validation will yield the following options:

(a) Option A: fire testing is not required. The project will proceed with the TfL concession process to complete fire material compliance approval;

(b) Option B: work with the manufacturer to modify some of the materials of the equipment to enable it to be compliant. Upon receipt of the revised equipment, re-start the process to analyse the equipment as outlined above; or

(c) Option C: fire testing is required.

7.9 For equipment that will be fire materials tested, a test plan is created for each piece of equipment in consultation with the TfL Fire Engineer, addressing the plan to test combustibility, smoke density, smoke emissions and toxicity. Simultaneously, a testing slot is booked with an accredited and independent UK test house as early as possible, subject to approval of the test plan. The test plan will entail the proposed test scenario, configuration set-up, how the test will be conducted, monitored and the success criteria against the different TfL and BS standards and project test criteria.

7.10 Once the testing has been completed, the results are analysed, and the test report is produced by the test house. The test report is reviewed and discussed amongst the Concessionaire's materials engineer, TfL Fire Engineer, and manufacturer. A concession application is created by the Concessionaire's materials engineer and is submitted by the Concessionaire sponsor to: SQE.StandardsSecretariat@tube.tfl.gov.uk

7.11 The outcome of this decision is recorded on the register and the Concessionaire is notified, with all associated supporting records referenced within for the LLD pack.

7.12 For Electromagnetic Compatibility, testing will be conducted and validated against project test requirements and TfL Category 1 standards as stated in the following documents (this include stipulated British Standards):

(a) S1222 Electromagnetic Compatibility (EMC); and

(b) S1193 Electromagnetic Compatibility (EMC) With LU Signalling System Assets.

7.13 The Concessionaire will work closely with the manufacturer to secure the following data:

(a) Power supply information;

(b) Ancillary equipment details needed for normal operation;

(c) Equipment specification sheets; and

(d) Copies of existing EMC test report and test certificates (if available).

7.14 Upon receipt of the above data, this is logged onto the Approved Product Register. The receipt of each equipment identified as not being compliant will be required for further analysis and testing, with a spare unit procured by the Project Management Team for contingency.

7.15 Where existing test reports and certificates are available, these will be analysed and data recorded, detailing whether the equipment passed or failed, if immunity and emissions failed and the level of test achieved.

7.16 Throughout the above process, the Concessionaire's materials engineer also works closely with the respective lead TfL EMC Engineer to inform and discuss the needs of the project and EMC compliance plan.

7.17 The Concessionaire's materials engineer analyses the data provided by the manufacturer and other information, validating this against TfL standards for EMC and the tests required by the project, whilst recording the information on the register. The outcome of the above is discussed with the lead TfL EMC Engineer, before a test plan is created for each piece of equipment in consultation with TfL EMC Engineer. Simultaneously, a testing slot is booked with an accredited and independent UK test house as early as possible, subject to approval of the test plan. The test plan will entail the proposed test scenario, configuration set-up, how the test will be conducted, monitored and the success criteria against the different TfL and BS standards and project test criteria.

7.18 Once the testing has been completed, the results will be analysed, and the test report is produced by the test house. The test report is reviewed and discussed amongst the Concessionaire's materials engineer, TfL EMC Engineer and manufacturer. If the testing results in a pass, the TfL EMC Engineer will issue a "no objection" notice for the use of the equipment. If the testing results in a fail, this will be discussed with the Concessionaire to ascertain the next course of action including whether a concession application is required to attempt to seek approval. The outcome of this decision is recorded on the Approved Product Register and the Concessionaire is notified. *Factory Acceptance Test V1*

7.19 All verification methods applied to this aspect of testing will be clearly laid out in an associated FAT Plan. The equipment supplier and the Concessionaire will ensure that suitable test methods are employed to demonstrate the functionality of the systems. The test rig must have been successfully commissioned and relevant documentation to support this will be provided to the Concessionaire in advance of the testing.

Service Line	**FAT – Reference partner & location**	**Setting**	**Equipment**
CMS	SOLiD R&D HQ, Seoul	Bespoke test rig and calibrated measurement equipment	High Power Radio (HRN) Low Power Radio (LRN) DAS Headend – Distribution & Aggregation Unit (DAU) Hybrid Copper Unit hub (HCU) Universal Point of Interface (POI) Network Management System (DMS3000)

Fibre	ADVA, York.	Test rig	FSP 150 Aggregation solution Ensemble Controller
Wi-Fi	Global Reach, United Kingdom	Test rig	
Streetscape	N/A	N/A	

7.20 The table below outlines the resource requirements that should be made available for FAT testing. TfL witnesses are optional:

Organisation	Role
Equipment Supplier	Test Manager / Co-ordinator
Equipment Supplier	Test Engineer
Concessionaire	Test Manager
TfL	Test Witness (optional)

7.21 The final system under test will be at a hardware and software level agreed between the Concessionaire and the manufacturer or customer and will be representative of the system release for the TfL network.

7.22 The equipment supplier will identify any test tools that will be used in test. This will include terminals, measuring equipment and any special test tools that may be required. A list of test software that is required to allow the tests to proceed will be supplied as part of the test plans for approval.

Site Acceptance V2

7.23 The purpose of this stage is to verify that the enabling infrastructure has been installed to the correct TfL standards and radio equipment positioned in the correct location.

Area	Responsibility
BSH testing (a) DAS Headend (b) Optical equipment (c) Fibre link to TfL station	Concessionaire
Station testing	Concessionaire (Installation Technology)

(d) Optical fibre within station (e) Deployment of DWDM equipment (f) CAT6a/UTC cabling within station (g) Power systems within station (h) Fixing of HRNs and LRNS	
Tunnel testing (i) Radiating cable (j) Mid tunnel HRN and power systems (k) Optical fibre (see Fibre Services domain)	Concessionaire (Installation Technology)
Fibre Services testing (l) PoP integration (m) PoP acceptance	Concessionaire
Streetscape testing (n) Asset service acceptance (MNO)	(Concessionaire)

7.24 Details of the required resource, equipment type, calibration requirements and purpose will be provided in the individual Test Plan templates.

System Integration V3

Basic functionality

7.25 System Integration is the next stage. In the CMS/ESN domain it confirms the basic connectivity and RF distribution of the DAS system. The purpose is to flag that the DAS system is ready for full BTS Integration from the MNO and whether it is meeting basic signal coverage targets on each applicable frequency band. Carrier Wave (CW) tests will be employed to achieve this.

7.26 For fibre services this stage will be met when customers are connected to the PoP.

7.27 For Wi-Fi this will include verifying the whole Global Reach platform for the capabilities required – essentially authentication and content filtering.

7.28 For the Streetscape Service Line, this stage would be confirming the connectivity and basic RF performance of the Small Cell or cluster of Small Cells. This may be carried out by the MNO itself, rather than the Concessionaire.

LU co-existence

7.29 The purpose of this stage is to perform tests related to co-existence with the activated CMS/EMS network and LU operational systems. Co-existence checks within the other service lines are not mandated. These systems include:

Signalling, Digital timetables Connect, CCTV.

7.30 TfL will work with the Concessionaire to specify these tests that will be carried out by TfL's suppliers. TfL will provide test equipment to its suppliers for analysis of their own systems

7.31 Testing will take place during Engineering Hours.

7.32 The output of the LU coexistence tests will be advised to the Concessionaire by TfL.

7.33 The proposal is to execute this set of tests once, rather than on a station by station basis.

Service Acceptance Test V4

7.34 Within the CMS/ESN domain this is confirmation that the DAS meets the scope and design criteria. This is achieved by integration of the BTS within the BSH.

7.35 All tests are carried out on the relevant frequency bands, per technology (2G, 3G , 4G as appropriate). Tests should be carried out in every DAS Zone/sector using an appropriate Scanning Receiver or UE (mobile device) in test mode. These tests will produce graphical ('snail trail') maps of coverage levels, together with indicative throughput testing (UL, DL, RTT ping test).

7.36 For fibre services, V4 stage would be met when external customers have connected to the PoP and testing end-to-end connectivity prior to service launch.

7.37 For Wi-Fi service line V4 face will be User Acceptance Testing to provide confidence in the end-to-end system.

7.38 For Streetscape service V4 covers post-integration with the MNO Core network to ensure the small cell solution meets the design criteria of the project. The Concessionaire may test this phase or the MNO, depending on the contracted arrangement. It will encompass coverage testing, speed tests, voice calls and Circuit Switched FallBack (CSFB) tests and throughput /speed tests.

Customer Acceptance Test V5

7.39 For CMS/ESN, in addition to further signal strength testing, this phase includes call testing (including CSFB), 999 calls, fast reselection to 4G, handover, throughput testing of various file sizes, mobility at ingress and egress points to the DAS system.

7.40 At this point, the system is ready for FOA. And following that, transition to Operations.

7.41 Depending on the nature of the contract for the Fibre Services circuit at the PoP with the external client, additional performance testing end-to-end may be performed at this stage.

7.42 V5 stage for Wi-Fi service line and Streetscape to be defined in final Test Strategy documentation.

8 Testing Lifecycle

Testing types and techniques

8.1 The test types and techniques will cover a variety of functional and non-functional testing. Testing may be manual orientated or automated, depending on the domain involved.

Assumptions

8.2 At each Test Phase, testing Assumptions will be logged in the RAID list, residing in the relevant Test Plan.

Test Success Criteria

8.3 Test success criteria will vary, phase by phase and domain by domain. Specific exit and success criteria will be listed within the individual Test Plan templates.

8.4 Common examples will be:

(a) Compliance with TCP requirements;

(b) All tests run, or any exceptions documented and agreed;

(c) Acceptance Criteria achieved (if applicable);

(d) No Open P1/P2 Faults;

(e) No more than 20 unresolved P3/P4 defects – mitigation for each one to be defined and agreed with Stakeholders;

(f) Test evidence signed off; and

(g) Test exit report agreed with project and business owners.

Test Environments

8.5 The test environment is crucial to test delivery for the TCP Programme and requires strict control in terms of configuration, access control and allocation. A change management process will be followed so that the test environments are always in a known state, enabling test teams to record the configuration build (hardware and software) on which each test was executed.

8.6 A library of configurations/versions will be maintained. Test plan templates will include specific details of test environment needs.

8.7 The expected test environments required are outlined in the individual Test Plan Templates.

Test Data Strategy

8.8 No live customer data will be used. Test Stubs will be used in several areas. The size of the dataset will be agreed between the Test teams and stakeholders for each testing phase.

Test Tools and Test Assets

8.9 The Concessionaire will ensure that it uses quality test tools, test assets and test rigs.

8.10 Details of the main tools are:

Stage	Name	Service Line			
		CMS/ESN	Fibre	Wi-Fi	Streetscape
V0	Product Approval Test	x	x	(x)	
V1	FAT	DAS test rig	DWDM test rig	Wi-Fi auth test rig	N/A
V2	Site Acceptance Test	x	x		
V3	System Integration Test (a) Basic performance (b) LU co-existence	x x	x		(x)
V4	Service Acceptance Test	x	x		(x)
V5	Customer Acceptance Test	x	x	x	(x)
	ESN adjunct testing	x			

Test Issue Management strategy

8.11 Issue Management is the process to make others aware of problems and then resolve the issue as fast as possible. This will be achieved via Governance / meeting structure outlined in Paragraph 8.13, and the RAID register outlined in Paragraph 8.23.

8.12 The register is a collaborative log used to manage issues by tracking them. Actions will be assigned to the issues so that clear responsibilities are defined. Progress will be monitored regularly. Issues will be ranked on impact. All resolutions will be checked to ensure resolution before being closed out and moved off the register.

Concessionaire Test Organisation

8.13 The Concessionaire's test organisation is at Figure 3.

8.14 The Concessionaire will appoint a Test Manager responsible for the creation of the Concessionaire Test Strategy, control of the delivery of all test activities within the strategy and coordination of the overall test process. Other duties will include escalating to the Project Manager any appropriate Risks and Issues, production of Weekly Project Review Board reports, creation of the Project Test Exit Reports. The Test Manager will also act as Tests Coordinator.

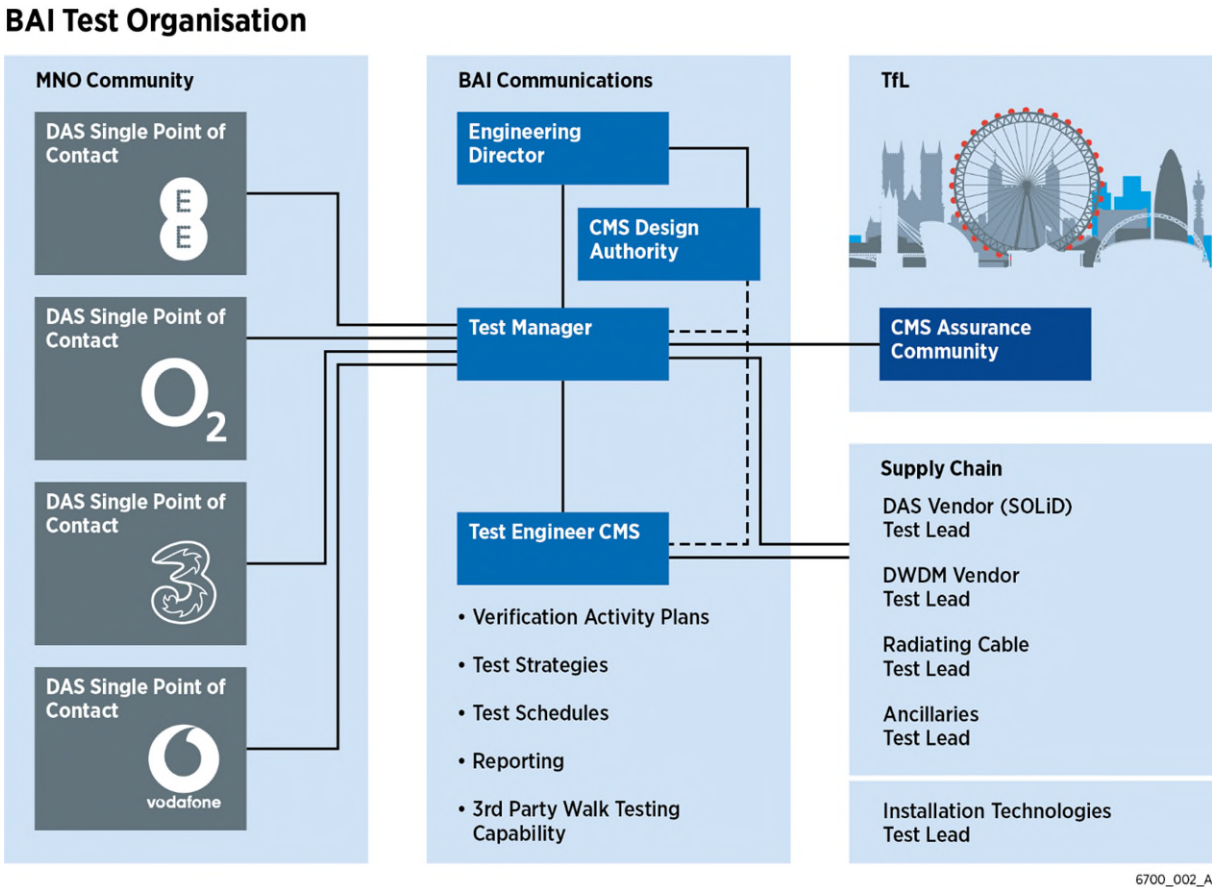

Figure 3 Concessionaire Test Organisation

8.15 All BAI test activities will be managed by the following governance:

Forum	Aim	Frequency
Quality Review Board (QRB)	Progress meeting with TfL updating on Concessionaire Quality initiatives	Quarterly
Test Steering Group (TeSG)	Sharing VAPs, Test Strategies, Test Planning with TfL Suppliers can be brought into the TeSG as required.	Monthly
Test Review Meeting (TeRM)	Testing Schedules Test Readiness Test Result Review Exit & Closure Acceptance	Weekly
Operator Testing Forum	With MNOs (for CMS), EE (for ESN), FNOs (for Fibre Services)	As contracted

Test Design inputs

8.16 Test Design inputs will vary with the phase. Common aspects include:

(a) High Level Designs;

(b) Low Level Designs;

(c) Key interfaces;

(d) Review meetings;

(e) User cases;

(f) MNO input; and

(g) Fixes from previous phase (if applicable).

Test deliverables

8.17 The Test Manager will ensure the following common standard deliverables are produced. Some variances may occur per V-stage. Milestone dates for these will be maintained in the final individual Test Plan Templates and Implementation Plan.

Phase	**Product**	**Scope of deliverable**
Planning	Test Strategy	Detailed test approach specifically designed to prove each phase of the testing requirements, for each Service Line.
Planning	Test Plan Template	For each stage identified in the Detailed Test Strategy, a Test Plan Template will be produced.
Control	Test Log	The Test Manager and activity lead will maintain a test log, recording decisions, issues and actions taken which have impacted any aspect of the test process.
Control	Status Report	The Project Test Lead will provide an overall status report during each of the test phases.
Preparation	Defects	For each test activity. Issues found with the test basis must have defects raised against them.
Preparation	Test Design Specification	For each test activity. A bulleted list of what will be tested at a granular level, that test cases can subsequently be produced.
Specification	Test Cases	For each test case activity.
Specification	Test Script / Procedure	For each test case activity.
Specification	Test Execution Schedule	For each test case activity. Tests should be realistically scheduled on a per-day basis.

Execution	Defects	For each test activity.
Execution	Status Report	For each test activity. Report types and detail to be agreed with suppliers and stakeholders.
Completion	Activity Test Exit report	For each test activity that produced a Test Plan template.

Test period

8.18 The Test Period for each set of Tests will be set out in the final Test Plans.

Test information management

8.19 Test records will be stored electronically. Initially a cloud-based tool will be utilised. The Concessionaire would plan to implement read access to key aspects of the test results for stakeholders. This is depicted in Figure 6 below.

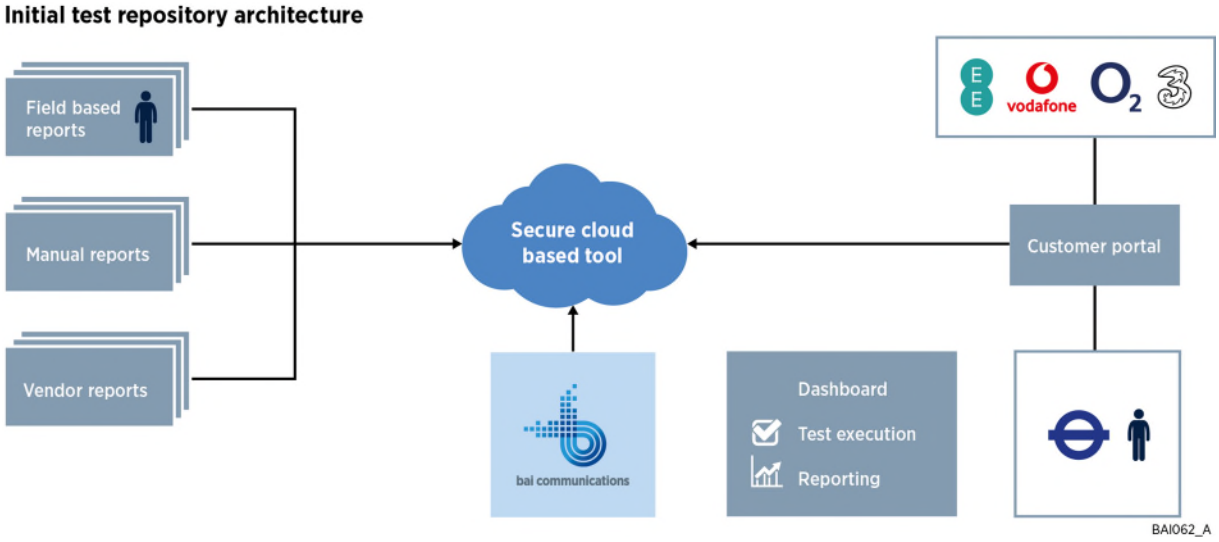

Figure 6

8.20 The Concessionaire may assess the feasibility of moving towards a more automated system for testing and report handling.

Test Measurement approach

8.21 The Concessionaire approach is to use test environments that mirror real-world configurations, utilising tools to generate realistic test data for the purposes of testing.

Continuous Improvement of Testing

8.22 The Concessionaire will establish well-defined periodic regular reviews between relevant teams and project suppliers to track status and implement test process improvements. The measurements obtained in the various stages of test will be benchmarked and worked through improvements in the test lifecycle.

Test Risks and Issues

8.23 At each Test Phase, all RAID items will be identified in the Test Plan. During the testing, the RAID will be managed by the Test Lead and peer reviewed.

Test Dependencies

8.24 The main dependencies towards both TfL and other third parties is shown in the following table:

Service Line	Stage	Dependencies	Dependent party
CMS, ESN	V0 – Equipment Approval		TfL
CMS, ESN	V5 – LU co-existence		
CMS			MNOs
ESN			TfL, HO, EE
Fibre Services			TfL, Customers
Streetscape			TfL, MNOs, Customers

Information sharing

8.25 Communication with suppliers, stakeholders and customers is critical.

8.26 Internally, the Concessionaire will be managing the Test Phases daily, agreeing day plans, schedules and resolving issues.

8.27 Depending on the phase weekly calls to highlight key points to stakeholders will be arranged, supported by emails with reports, RAID items, test status and progress.

Test Issue thresholds

8.28 The following thresholds will be employed throughout the TCP Project. Each test failure case will be assigned a Priority P1 to P4 by the Concessionaire – aligned to TfL's Test Severity Levels outline in the table below.

Test Severity Levels (TfL)	Definition	Concessionaire Classification
Test Severity Level 1	The failure causes a non-recoverable condition where it is not possible to continue using a component (or components) of the Milestone Deliverable being Tested and which results in a severe impact to the performance of the	P1 Critical

	Service processes, or Telecommunications Infrastructure, for which no satisfactory workaround exists. **0 Test issues of Level 1 severity.**	
Test Severity Level 2	The failure causes major impairment of one (1) or more component (or components) of the Milestone Deliverable being tested, or causes a major impairment of one (1) or more critical Service process or elements of Telecommunications Infrastructure, irrespective of whether a workaround exists; or the failure causes major impairment to one (1) or more non-critical Service process or elements of Telecommunications Infrastructure for which a satisfactory workaround does not exist. **0 Test issues of Level 2 severity.**	P2 Major
Test Severity Level 3	The failure causes minor impairment of one (1) or more component (or components) of the Milestone Deliverable being tested, or causes a minor impairment of one (1) or more critical Service process or elements of Telecommunications Infrastructure irrespective of whether a workaround exists; or the failure causes a major impairment to one (1) or more non-critical Service process or elements of Telecommunications Infrastructure for which a satisfactory workaround does exist. **for Test Issues of Test Severity Level 3 and Test Issues of Test Severity Level 4 at the tolerance levels determined by the Concessionaire and documented within the Test Strategy.**	P3 Minor
Test Severity Level 4	The failure is a cosmetic inconvenience / annoyance such that it does not hinder the Services. **For Test Issues of Test Severity Level 3 and Test Issues of Test Severity Level 4 at the tolerance levels determined by the Concessionaire and documented within the Test Strategy.**	P4 Superficial
		P5 Other. Cases where system function satisfactory and as specified, but other related issue e.g. error in non-safety critical documentation,

		change recommendation arising out of test, product development request or other observation that is not a known issue.

9 Non-Functional Testing

9.1 An element of non-functional testing will be carried out. Examples include:

(a) V5 – First Office Application for CMS. Focus on e2e performance, experience, teething issues with operational matters; and

(b) Adjunct testing for ESN. Support to provide confidence to key Stakeholders, User Groups. Stressing the Service Management functions to ensure fit for purpose.

10 Approval, Review and Revision of the Test Strategy

10.1 This Test Strategy will be updated as and when changes occur to the TCP project or which require the process for verifying activities to be altered. Any change to the Test Strategy will be subject to consultation with the main stakeholders. Any such Test Strategy change will be approved by the Project Manager.

10.2 The next scheduled review of this Test Strategy will be undertaken to prepare the Detailed Test Strategy within sixty (60) Working Days of the Effective Date.

11 Glossary of Terms

Abbreviations

11.1 The following abbreviations are used in this document:

Table 11.1 – Abbreviations

Abbreviations	Definition
ADAS	Active Distributed Antenna System
BER	Bit Error Rate
BTS	Base Transceiver Station (Base Station)
BSH	Base Station Hotel
CQI	Channel Quality Indicator
CW	Continuous Wave
DAU	Distribution Aggregation Unit
dB	Decibel
dBi	Decibel isotropic
dBm	Decibel milliwatts

DL	Downlink
EIRP	Effective Isotropic Radiated Power
EMF	Electromagnetic Fields
EVM	Error Vector Magnitude
HPR	High Power Radios
HRN	High Power Radio Node
JOTS	Joint Operator Technical Specification
ICNRP	International Commission on Non-Ionizing Radiation Protection
kW	Kilo Watt
LOS	Line of Sight
LPR	Low Power Radio
LRN	Low Power Radio Node
LTE	Long Term Evolution (4G)
MIMO	Multiple Input Multiple Output
MNO	Mobile Network Operator
NMS	Network Management System
NOC	Network Operations Centre
PIM	Passive InterModulation
PoE	Power over Ethernet
RF	Radio Frequency
RSRP	Reference Signal Received Power
TfL	Transport for London
SISO	Single Input, Single Output
SNR	Signal to Noise Ratio
UE	User Equipment (mobile device)
UL	Uplink
UPOI	Universal Point of Interface

UMTS	Universal Mobile Telecommunications System
VSWR	Voltage Standing Wave Ratio

Definitions

Table 11.2 – Definitions

Term	Definition

12 Reference Documentation

Table 12.1 – References

Document Id	Title

Annex 3 – Test Plan Templates

Please refer to the document entitled Schedule 6.2 (Testing and Assurance) Annex 3 (Test Plan Templates) which is incorporated into this Agreement.

Annex 4 – Works Funded By Grants Services Assurance Process

1 Works Funded by Grants Services Assurance Process

1.1 Connectivity requirements for Works Funded by Grants Services are outlined in WGT2(a) and WG2(b) to supply Gigabit-capable Customer Products to the address specified and inside the premises at the address specified.

1.2 Based on the DCMS, Beneficiary Terms and Conditions Gigabit Broadband Voucher Scheme 20 May 2019, version 5.0, all connections supported must fulfil BOTH of the following characteristics:

(a) be capable of delivering broadband connectivity to the premises at or above 1Gbps upload or download at the time of delivery of the connection without the need for future hardware upgrades or modification (excluding CPE – it is not mandatory to deploy 1Gbps capable CPE from the outset if this is not required to deliver service); and

(b) deliver a minimum of 100Mbit/s to the premises. The upgraded broadband service must deliver a "step change" in service which is at least a doubling of speeds compared to the service currently being consumed.

2 Definition

2.1 The definition "capable" means capable of delivering 1Gb connectivity, the speeds are upload or download, not necessarily at the same time.

3 Process

3.1 Once the final connection has been made, the Concessionaire will confirm that the infrastructure supporting the service can deliver 1Gb connectivity to the customer within ten (10) working days of the order.

3.2 The fibre install will have been tested during the build out phase and standard OTDR tests to assess the quality of the bearer.

3.3 As the Internet can be variable due to time of day, contention and so on, the Concessionaire' approach will be to test out the ethernet circuit using a hosted FTP server in the Concessionaire's Base Station Hotel.

3.4 Once the Network Interface Device (NID) has been installed at the customer premises, a Concessionaire engineer will run a FTP client at the customer end and use FTP to transfer a series of known size of test files in each direction (download and upload) to calculate the upload and download and average speeds running at layer 7 of the OSI model. A test record for the premises will be produced and stored. This will verify the connection on a pass/fail basis related to the criteria above in order to confirm the infrastructure supporting the service can deliver 1Gb connectivity.

Annex 5 – Test Certificate

To: **Transport Trading Limited**

FROM: **BAI Communications Limited**

[***Date***]

Dear Sirs,

TEST CERTIFICATE

Milestone Deliverable(s): [***insert description***]

We refer to the concession agreement (the **Agreement**) relating to the provision of the Services between **Transport Trading Limited** (**TTL**) and **BAI Communications Limited** (the **Concessionaire**) dated [***date***] and with agreement number [insert number].

Capitalised terms used in this certificate have the meanings given to them in Schedule 1 (Definitions) of the Agreement.

We confirm that the Milestone Deliverables listed above have been Tested successfully in accordance with the Test Plan relevant to those Milestone Deliverables.

There are no outstanding Test Issues ***OR** This Test Certificate is issued on the condition that any Test Issues are remedied in accordance with the plan to remediate any Test Issues attached to this certificate*.

**delete as appropriate*

Yours faithfully

[***Name***]

[***Position***]

acting on behalf of **BAI Communications Limited**

Assured by:

[***Name***]

[***Position***]

acting on behalf of **Transport Trading Limited**