Schedule 6.2 – Annex 3 Outline Test Plan Templates

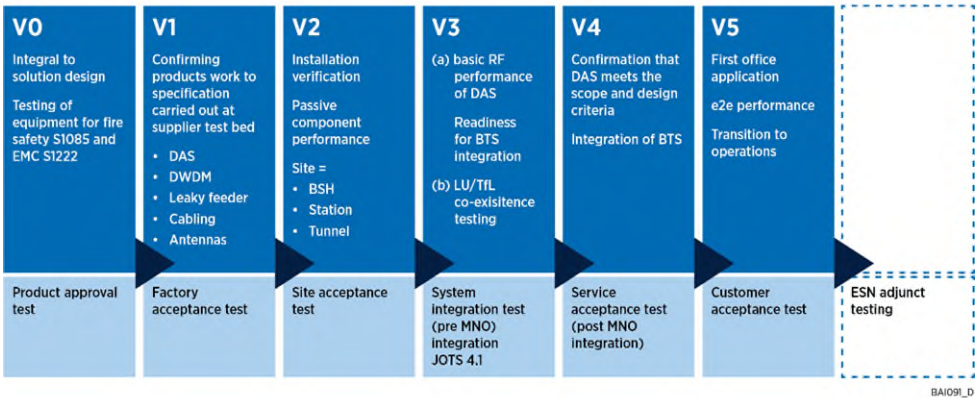
Contents

PART A – CMS/ESN BASE STATION HOTEL

CONTENTS

1 Introduction

The purpose of the document is to describe the test environment, tools, processes, test cases, inputs and outputs, across all applicable stages of the Concessionaire's V-Stage verification model (as described in Annex 2 (Outline Test Strategy) to this Schedule 6.2), for the technical subsystems in the appropriate Service Lines of the TCP project.



2 Scope of testing

As the Concessionaire's design is a common Base Station Hotel (BSH), the scope of this document covers BSH testing for both CMS and ESN Service Lines together.

Sequence	CMS and ESN Service Line	
1	BSH testing	←this document
2	Station testing	
3	Tunnel testing	

3 Testing dates/schedule

To be confirmed at final Test Plan Template submission.

4 Test plan manager

To be confirmed at final Test Plan Template submission.

5 Test environment

Individual environments pertaining to FAT, SAT and further stages of the V-stages will be described in the appropriate sections of the document. To be confirmed at final Test Plan Template submission.

6 Testing, inspection and handover of a Base Station Hotel

6.1 Tests

The Concessionaire's design partner for the Base Station Hotel reference has an extensive testing and handover process to conduct testing to prove the solution complies with the applicable BS/EN standards. This is testing is heavily focussed on the civil build. Throughout this document the "Supplier" is the Concessionaire's Subcontractor. As the BSH will be off TfL estate, Section 10 highlights the areas of interest for TfL, MNOs and the Home Office.

Reasonable notice shall be given to the Concessionaire prior to testing, so that they may witness the tests if they so desire.

6.1.1 Wiring Testing

Test all Building Management System (BMS) / controls and power wiring as described under Wiring Installation in this Specification and BS 7671.

Provide documentary evidence of all cable test results associated with BMS/controls and power wiring installation.

Report the extent of any failures identified during testing which may affect the installation programme.

Correct any wiring faults discovered during the testing and commissioning.

6.1.2 Network Testing

6.1.2.1 Fibre Testing

The fibre, once installed, shall be fully tested using, as a minimum, the following tests:

- Fibre Length & Losses
- Connector losses
- Splice Losses
- Fibre Defects

The Fibre testing tool shall provide a printout of the results for each segment.

These printouts shall be available prior to demonstration of the BMS and shall form part of the O&M manual.

Any Fibre found not to meet the necessary standards shall be replaced.

6.1.2.2 CAT Cable Testing

The CAT cabling once installed shall be fully tested using, as a minimum, the following tests:

- Pins connected correctly
- Cable Length
- Wire Map
- Open Pairs
- Shorts
- Reverse Pair
- Split Pair
- Attenuation
- Near End Crosstalk (NEXT)

- Power Sum NEXT (PS-NEXT)
- Far End Crosstalk (ELFEXT)
- Power Sum EFLEXT (PS- EFLEXT)
- Propagation Delay
- Skew
- Return loss

The network testing tool shall provide a printout for each cable installed. These printouts shall be available prior to demonstration of the BMS and shall form part of the O&M manual.

Any CAT cable found not to meet the necessary standards shall be replaced.

6.2 Inspection, testing and commissioning

The Supplier shall include all necessary time, labour and equipment to ensure complete and comprehensive testing and commissioning of all live systems and associated connectivity. The Supplier should include time and resource for client witness testing at this stage.

Once successfully tested, the complete and fully operational system(s) shall be demonstrated at length and in detail at varying loads to the Concessionaire and/or their representatives as part of the integrated systems testing as described within the Building Services and Particulars Specification document.

6.3 Handover

The Supplier shall provide all factory test records, inspection reports, keys, passwords and maintenance requirements for the plant. Additionally, any warranties shall be transferred to the Concessionaire for the 12-month minimum period. Any maintenance proposals shall be agreed within the handover period.

7 General Requirements

7.1 Maintenance and Warranties

The Supplier shall outline any spare parts/perishables required, along with a quotation to supply same these parts.

The Supplier should provide a maintenance scheme covering the following:

- 1-year ex. parts & labour with 8hr (or better) response time
- 1-year incl. parts & labour with 8hr (or better) response time

All plans are to indicate frequency of maintenance calls.

Any warranties are to be supplied direct to the Concessionaire and are to consist of 1 year’s defects liability as a minimum.

7.2 Record Documents

7.2.1 Provision of Record Documentation

The Supplier shall include, as a pre-requisite to Practical Completion of the Works that do not make up part of this document, comprehensive Record Documents finalised in detail and subject to the approval of the

Concessionaire. Great importance will be placed upon the quality, accuracy and completeness of the Record Documents and upon their being made available promptly. The Supplier shall also produce a simple but concise user guide.

7.2.2 Scope of Record Documentation

Record documents shall comprise, all as described in this Specification, with the following:

Record Drawings;

- Operating and Maintenance Instructions.

- All Record Documents shall be provided in triplicate.

Drawings shall also be presented in electronic format on a CD-R disk using a Revit or Autocad format on Release 14 or above. Drawing files shall be clearly labelled and shall be complete with all necessary associated files (e.g. X-refs, Blocks, etc.).

The Record Documents shall:

- Record clearly the arrangements of the various Sections of the Works as actually installed, and identify and locate all component parts thereof;

- Make it possible, using Block Schematic Diagrams, to comprehend the extent and purpose of the Works and the Method of Operation itself.

- Set out clearly the extent to which maintenance and Servicing is required and how, in detail, it should be executed.

- Provide sufficient and readily accessible information properly to facilitate the ordering spares and replacements.

- A list of the Record Drawings.

7.2.3 Record Drawings/Diagrams

The Supplier shall include in the operation and maintenance manual;

- Single line / Block diagrams of the internal equipment as manufactured & wired.
- Any logic, ladder, or otherwise, programming for the equipment on an open protocol format on a USB2.0 data storage device.

7.2.4 Operating and Maintenance Instructions

Operating and maintenance instructions shall comprise the following (all contained in volumes strongly bound in flexible covers and suitable for heavy usage over a long period) written to be read in conjunction with the Record Drawings:

- A general description of the scope, purpose and manner of working of each system and the apparatus forming part of the Works.
- A detailed description of the scope, purpose and manner of working of each system of automatic controls.
- Data on general design parameters and associated normal operating temperatures, pressures etc., based on the commissioning tests.
- Clear and comprehensive instructions for the starting up, running and shut down of each system or apparatus.

- Clear and comprehensive instructions for dealing with emergency conditions for each system or apparatus.
- Instructions in respect of any precautionary measure from time to time necessary (e.g. against corrosion or freezing).
- Instructions in respect of the care of apparatus normally subject to seasonal disuse.
- Instructions as to the nature, extent and frequency of servicing necessary, properly to maintain the equipment in good condition, and also as to the material to be used for the purpose. This information shall be supported by maintenance instructions provided by the suppliers of particular component apparatus.
- List of recommended spares.
- Manufacturers' literature.
- An electronic version of the Operating & Maintenance Manual shall also be provided in PDF format.

Copies of manufacturer data shall be supplied with regard to the nature, type and method of operation of individual maintenance instructions. Such data, in the form of individual booklets and the like, shall be indexed and cross-referenced to the operating and maintenance instructions and presented suitably protected in stout binders with D shaped rings.

Draft copies of all record drawings and instruction manuals shall be made available in advance of the handover date in order that the Concessionaire has the opportunity to comment, and the corrections/amendments recorded, thereby allowing sufficient time for the approved documents to be available.

7.2.5 User Manual

In addition to the detailed Operating and Maintenance Manual described above the Supplier shall provide a simple user guide giving a simple guide to using the supplier's plant equipment as a whole system.

Enc 8739-SP-02 S01 BMS Specification Appendix 01 Indicative BMS points list

8 Commissioning Strategy

8.1 Scope of Works

The contactor performing the works ("Contractor") shall be responsible for the full pre-commissioning and commissioning of the Works detailed within the document and must make all necessary allowances in terms resources. Commissioning procedures and standards to be used shall be submitted for review prior to commencement. The following apply:

- Pre-commissioning and commissioning procedures
- Provide an adequate notice period of at least 2 weeks of the planned commissioning start date.

The contractor shall allow for testing of the equipment on site 6 times over a 3-day period and shall provide the appropriate test certificates.

8.2 Standards

The codes and standards that are generally applicable to the work for this specification are listed in the Material and Workmanship Specification document. The list is not exhaustive, and all relevant standards, codes and guides are to be adhered to. The latest, current versions and amendments are to be used.

8.3 Testing and Commissioning

The Contractor shall carry out full works testing of the systems as described within this specification and the rest of the Contract Documents.

The Contractor shall ensure that all testing is carried out in accordance with the equipment manufacturer's guidelines and recommendations such that the equipment warranties remain valid.

The Contractor shall be responsible for the testing of all systems.

The Contractor shall develop a commissioning programme to ensure that all systems are approved for handover in accordance with the project schedule.

The Contractor shall use qualified personnel to carry out the commissioning whether those people be from the equipment manufacturer, in-house personnel or external consultants.

Allow the Concessionaire and its representatives to witness inspections, tests, commissioning, performance tests and the Integrated Systems Testing process (IST). The Concessionaire and its representatives will attend these as deemed necessary.

Ensure the Building Services Works have been fully inspected, tested, commissioned and checked before offering any equipment or systems to the Concessionaire so that the Performance Demonstration Tests can reasonably be expected to proceed without delays. Invite the Concessionaire to Performance Demonstration Tests only when the associated Building Services Works are complete, fully checked and commissioned and have passed the Contractor's acceptance tests and certified records have been submitted.

Submit method statements in advance of any test describing all aspects of the work required. Identify tests required on work before covering up during construction.

A final commissioning document and programme will be required 12 weeks prior to commencement of commissioning. The programme should include notice of inspections and tests to include, but not limited to the following:

- Manufacturers
- Concessionaire
- Statutory Authorities
- Utilities and Service providers
- Specialist contractors

The deliverables and responsibilities are discussed in more detail below.

8.3.1 General Requirements

This scope of works includes testing, commissioning, continuous operation, certification and setting to work of all mechanical works identified in the Specifications and Drawings.

Qualified personnel should be members of the Commissioning Specialists Association (CSA) to carry out pre-commissioning, commissioning and performance testing with an appropriate grade for the work.

Ensure the supervising commissioning engineer has a minimum of 5 years' experience in the commissioning and performance testing of building services installations.

Demonstrate final settings and operation of systems, sub-systems and components. Demonstrate that test results are within the tolerances permitted. Submit complete Commissioning & Testing Records.

It shall be necessary to co-ordinate all testing, commissioning and continuous run activities in order to ensure an integrated progression of systems testing, commissioning and performance testing/demonstrations.

The detailed design of any temporary or permanent installations required to support testing and commissioning activities shall be the responsibility of the Contractor.

This shall include but not necessarily be limited to:

- The Contractor shall be responsible for the final coordination of all testing and commissioning activities for the total systems provided under the Contract.
- Consequently, it shall be necessary for the Contractor to coordinate all commissioning and continuous run activities with, the Concessionaire in order to ensure an integrated progression of systems commissioning.
- The Supplier shall attend site for the purposes of co-ordination, planning and implementation of these works as directed by the Contractor.

8.3.2 Programme and Phasing

The Contractor shall develop and produce a fully integrated testing and commissioning programme. A testing and commissioning method statement shall be submitted by the Contractor for each type of system or piece of equipment to be tested and commissioned.
As a minimum, these programmes shall be sufficiently detailed to show the following phases of work:

- All Works Tests
- All Site Tests
- Cleaning of Systems
- Pre-Commissioning
- Commissioning
- Factory Acceptance Tests (FATs)
- Site Acceptance Tests (SATs)
- Continuous Run Operations
- Level 4 and Level 5 testing
- Submission of Documents

Instruction and Training of Concessionaires Personnel Organise or attend, as required by the Contractor, programming and progress meetings pertaining to testing and commissioning on an ongoing basis throughout the contract period, ensuring that programmes are updated at all times.

8.3.3 Documentation and Certificates

The Contractor shall submit Testing and Commissioning and Performance Testing method statements, data and manuals as required by the Contract Documents and as necessary to allow the project manager to plan, co-ordinate and implement the associated works as detailed below.

For on-site activities, these shall be separately identified.

The Contractor shall provide all necessary and appropriate documentation to the project manager to allow him to compile the documentation set out below.

The Contractor shall agree procedures for notices, witnessing, reporting and recording tests with all parties involved including Local Authorities and Statutory Undertakings, prior to the commencement of the works. The Contractor shall provide all necessary and appropriate assistance to the project manager.

The Contractor shall submit copies of the formal test certificates signed by the Contractor not later than 5 days after completion of successful tests.

8.3.4 Instruments and Equipment for Testing

The Contractor shall supply, check, recalibrate whenever necessary and maintain in good working order all instruments and equipment for setting out, measurements, gauging, inspection, commissioning and performance testing.

Provide any essential components and features necessary to enable the preparation, testing and commissioning of the Building Services Works.

Ensure that the provisions made for sectional commissioning are compatible with project constraints such as programme phasing and works sequencing.

The Contractor shall provide and install any supplementary tappings, fittings, test points, valves, purge points/valves, flushing points/valves, bypasses and the like (including all necessary supports etc) required to enable the performance of all testing and commissioning activities. Such additional facilities shall be deemed to be included in the Contract price by the Contractor whether or not they are specifically shown on the drawings.

8.3.5 Provision of Staff

The Contractor shall provide all necessary staff with the relevant skills and competence for all inspection, testing, commissioning and performance testing.

The Contractor shall arrange for the equipment manufacturer to be available on site during the site testing.

8.3.6 Attendance and Co-operation

The Contractor shall give at least seven days' notice to the Concessionaire of requirements for the attendance and co-operation by the Concessionaire or the Concessionaire's representative.

8.3.7 Notice to Concessionaire

The Contractor shall give at least seven days' notice to the Concessionaire of any commissioning or testing to be carried out to enable the Concessionaire or the Concessionaire's representative to witness all or any of such tests, etc.

8.3.8 Commissioning, Performance Testing Specifications and Manuals

The Contractor shall prepare and submit a set of testing and commissioning specifications and manuals. These shall be prepared in draft for review and comment by the Concessionaire's commissioning engineer at least 2 weeks prior to any testing, commissioning and performance testing activities. The manuals shall include, but need not be limited to:

- Factory, off-site and on-site testing, commissioning, acceptance testing, demonstrations, Concessionaire training and performance testing Method Statements and activity check list.
- Complete set of proposed test/commission forms, pro formas etc.

The Contractor shall produce this Specification incorporating all necessary data, documents and the like. It is essential that this document represents a comprehensive approach for the complete Works and associated interfaces.

Commissioning Method Statements shall be based on the current Codes of Practice and all applicable Standards. They shall describe the exact method that the Contractor adopt to commission an item of equipment. The Method Statements shall be approved by the Concessionaire or the Concessionaire's representative prior to any commissioning activity taking place.

8.3.9 Instruction of the Concessionaire's Staff

Prior to commissioning of the installation, the Concessionaire shall be appointing operating and maintenance staff or maintenance Contractor to undertake the operation and maintenance of the Works. The Contractor shall provide assistance to the Concessionaire's staff during the course of the installation to explain the purpose and function of the Works. This assistance shall be planned and organised by the Construction Manager.

The instruction shall cover the day to day running of the plant and systems. The location and function of all items listed on the Record Schedules shall be explained and the procedures given in the Operating and Maintenance Manuals for starting up, shutting down, isolating sections, emergency procedures, etc, shall be comprehensively explained and demonstrated to the Concessionaire's satisfaction. Such training periods shall not coincide with any other testing, commissioning or continuous run periods.

8.3.10 Works Prior to Commissioning

8.3.10.1 Tests

Commissioning and performance testing shall only be carried out on services after the installation has been tested and certified as detailed elsewhere in this Specification. These tests include but are not limited to:

- Hydraulic/pneumatic pressure tests of pipework
- Air leakage tests of ductwork
- Wiring tests of all power and controls cabling
- Purging, flushing and cleaning of all piped services systems.

8.3.10.2 Pre-commissioning Checks

Pre-commissioning checks shall ensure that all system components are correctly installed. Cleanliness of air and water distribution systems is essential.

In order to ensure that the appropriate system is in a satisfactory and safe condition before starting-up, checks shall be made in accordance with all relevant Codes and Standards.

All installation defects shall be rectified prior to commissioning, where the defect has any bearing on the commissioning of a system or systems.

All BMS inputs shall be point-2-point checked and basic functionality operational.

8.3.10.3 Pre-commissioning Works

Following the completion of installation, all equipment shall be pre-commissioned, set to work and commissioned. The Contractor shall conduct these tests to ensure the safe and correct setting to work of the equipment supplied under the Contract.

The Contractor shall detail the tests required which shall include, but not be limited to the following:

- Check all electrical connections to ensure that they are correct.
- Primary injection tests of site installed CTs to prove ratio and polarity
- VT ratio and phasing tests and connection of directional relays
- Secondary injection testing of relays with actual settings to prove operating times using recognised test equipment, e.g. Omicron test set. Prove tripping and alarms.
- Proving of all signalling to interfacing packages
- Generators
- Physical inspection of panels for correct installation, alignment and labelling (including cables and all components). The manufacturer shall also check that the correct control fuses/ MCBs are fitted in all panels.
- Complete discharge test of 30V DC control system and simulation of all alarms.
- CT ratio checks and polarity checks.
- Insulation resistance tests and continuity checks on all secondary circuit wiring to current transformers, control, inter tripping and auxiliary circuits.

Note: In the above, continuity checks need only to be made on those parts of the wiring which would not otherwise be proved either by functional tests, or until the switchgear is energised, [e.g. inter-tripping circuits to which the final connection cannot be made at the time of testing].

- Functional checks on all closing and tripping circuits and for manual operation of circuit-breakers; control tripping circuits; earthing and isolating equipment if inherent in the equipment.
- Functional test of auto-changeover device.
- Functional check on all alarms and transmission to the site wide BMS.
- All wiring within control panels shall be checked for loose connections, correct terminations and compliance with the wiring diagrams.
- Wiring terminations to all control equipment shall be checked for compliance with the wiring diagrams, and interlocks with other equipment, as shown on the electrical and controls wiring diagrams.
- Sub-Contractor's and Contractor's electrical test records to ensure that the Equipment is safe to operate.
- Carry out any further electrical tests necessary to ensure the equipment is in a safe and satisfactory condition to operate.
- Check operation of all safety devices
- Check all hydraulic systems shall be thoroughly cleaned and fully purged and/or flushed to ensure removal of any residual matter within the pipework systems.
- Check that all residual chemical deposits are removed from the system prior to commissioning.
- Check that all strainers shall be removed and cleaned, during and after flushing and immediately prior to balancing of the system. Advance written notice, of an agreed duration (but not less than 1 week), shall be given to the Concessionaire prior to removal and cleaning of strainers.
- Check the installation of valves, mountings, pipe and fittings
- Check the installation and connection to field mounted control devices.
- Check the connection of field mounted control wiring and piping to control equipment, terminals and panels.
- Check any field cleaning, flushing, hydrostatic and pneumatic testing of the installed equipment. Flushing and cleaning of the hydraulic systems shall continue until it can be demonstrated that the system has been cleared of all debris and contaminating matter. No hydraulic system shall be left empty once any chemical cleaning and flushing procedures have been completed.
- Check lubrication
- Check rotation of drives
- Check and confirm power consumption of all electrical equipment (e.g. fans, pumps, heaters etc.)
- Carry out short running tests on all items sufficient to demonstrate the general operation of the Equipment and the operation of controls, control valves, instruments etc.
- Carry out any field testing of the installed works control system and interface with the BMS.
- Check operation of safety valves
- Preliminary noise level tests
- All ventilation systems shall be fully tested, completely cleaned of any obstruction, debris and superfluous matter prior to commissioning. All dampers shall be set in the open position and all access covers shall be secured in position.
- No polluting matter, solid or liquid shall enter existing water courses, water supplies, storage tanks, or other body of water. The Contractor shall ensure that the disposal of all test fluids and materials is in full accordance with all applicable codes and standards.
- Tests required by the Insurance Authority and Statutory Authorities
- The Contractor shall submit a written report of satisfactory completion of each phase of work to the Construction Manager.
- Any fault shall be rectified immediately on discovery.

8.3.10.4 Factory Acceptance Tests (FATs)

FATs may be required to provide proof that the manufacturer has provided BSH equipment capable (HVAC, UPS, Generators) of meeting the specified duties and functions before delivery to site.

The Contractor shall arrange and agree works test procedures with the manufacturer in accordance with relevant Codes and Standards. The Contractor shall witness all works tests and sign test certificates after successful testing. The Concessionaire and the Concessionaire's representative shall have the right to attend all works tests and the Contractor shall provide sufficient notice of proposed testing.

The Contractor-witnessed test certificates shall be provided together with all other commissioning documentation.

8.3.10.5 Commissioning

Commissioning is defined as "the advancement of an installation from static completion to full working order to specified requirements". Commissioning includes the setting to work and regulation of an installation. Commissioning is deemed to be complete when all regulation work is concluded to the satisfaction of the Concessionaire.

The regulating or balance of fluid's flow rate shall ensure final distribution of services is in compliance with design requirements. Balancing shall comprise the following activities:

Initial Scan: during which flow rates, are measured and system characteristics such as index run, pump and fan performance are identified.

No balancing should occur until initial scans have been completed and approved.

Balancing during which distribution circuits are balanced to achieve design performance. Incomplete systems shall be balanced against artificial resistances such as by-pass lines incorporating commissioning valves on hydraulic circuits and calibrated perforated plates on air system simulating the final resistances.

The BMS shall have been fully commissioned and operational as part of these activities.

8.3.10.6 Site Acceptance Testing (SAT)

SAT is the evaluation of a system which has been commissioned and is operating within the tolerances as set out in the Specifications and the relevant Codes and Standards.

Performance testing is deemed to be complete when conducted and demonstrated to the satisfaction of the Concessionaire. The Contractor shall make all provisions for the performance testing of all the mechanical & electrical works.

All measurements and operational details shall be recorded as performance tests proceed and shall be submitted as Performance Test Records in the Commissioning Manuals.

The Contractor shall give the Concessionaire at least seven days' notice of his intention to carry out a performance test. All such tests shall be witnessed and certified by the Contractor.

Performance tests shall be carried out to demonstrate all the operational, safety, interlock and control features of the system in full compliance with the Specifications and associated Contract Drawings.

The performance tests shall include but not be limited to the following:

- Transformer
- Generator
- Switchgear
- ATS
- UPS modules
- All other LV switchboards & Distribution boards
- Battery systems

- Monitoring and control
- All Cooling components required to fulfil a fully functioning system
- AHU
- Pumps
- Fans
- Dampers
- Adiabatic systems
- Security systems, Door Access Intruder, CCTV
- Fire Detection & Suppression Systems

8.3.10.7 Heat load test in the Data Hall

Portable rack mounted heaters shall be provided for the continuous IST heat load test that shall be carried out – these are to simulate live server loads, the contractor shall provide a number of load banks (equal to the max design IT load that is to be installed) to the data hall and associated cabling to connect up to the busbar system. These load banks shall be used for the commissioning; and also used for the IST. The contractor shall also provide appropriate attendance for IST.

Once full load has been achieved the following tests shall be carried out;

The commissioning tests shall include the following:

- Failure of the '+1 cooling units'. Other cooling units should all ramp up to maintain the room condition within the design limits.

The following should be recorded during the tests:

- Data Hall temperature and humidity (continuously) with additional commissioning sensors. The sensors shall be provided by the engineer.
- All BMS points as per BMS specification.
- Power consumption

8.3.11 Conditions for Performance Testing HVAC Systems

Test instruments shall include a comprehensive temporary installation of portable recorders to simultaneously record temperature and humidity measurements within the Data Hall. Location of test instruments shall be in positions to be agreed but typically shall be within the cold aisles and general spaces.

The recordings shall, in each case, be made during a 3-day period, continuously. The Contractor shall allow for portable heaters to be installed over this period and shall vary the load in the space to prove the control system operates satisfactory (25%, 50%, 75% and 100% loadings).

8.3.12 Continuous Operation & Performance

Carry out System Continuous Operation & Performance (COP) Tests to demonstrate that the Building Services Works are operating correctly, controls are properly adjusted, systems interact as intended, and that the systems maintain conditions within the building in accordance with the Building Services Documents.

COP Demonstration Tests include monitoring the following parameters:

Key

T	Temperature

H	Humidity
A	Air Movement
N	Noise & Vibration

Types of COP Demonstration Tests are shown in the table below:

Type	Description
[7] Day	Test performance of the system operating continuously, in normal automatic mode, 24 hours per day, for [7] consecutive days
Summer	Test performance of the system operating in summer for a continuous period of at least [24] hours during which the outside wet bulb temperature is within [3°C] of the external design wet bulb temperature for at least [3] hours
Winter	Test performance of the system operating in winter for a continuous period of at least [24] hours during which the outside dry bulb temperature is within [6°C] of the external design temperature for at least [3] hours
Day	Test the performance of the system operating during the daytime from [08.00] to [19.00].
Night	Test the performance of the system operating during the night-time from [19.00] to [08.00].

Carry out COP Demonstration Tests as listed below:

System	7 days	Summer	Winter	Day	Night
Heating	T		T	T	
Ventilation	T/A/N	T/A/N	T/A/N	T/A/N	T/A/N
Air Conditioning	T/H/A/N	T/H/A/N	T/H/A/N	T/H/A/N	T/H/A/N
Process Cooling	T/H/A/N	T/H/A/N	T/H/A/N	T/H/A/N	T/H/A/N

Provide a comprehensive temporary installation of portable recorders to simultaneously record temperature and humidity measurements in each area to be tested in addition to the trend logs recorded by the BMS. Install a recorder to monitor the outside air temperature and humidity, located as close as possible to the BMS outside air sensor. Agree the locations of test instruments.

Complete individual performance tests for related systems, submit and obtain ‘A’ status for test records before starting the COP Test.

Allow for any special visits to site and provide any necessary attendance during the Defects Liability Period to set up, monitor and remove test and recording equipment.

Variable speed fans and pumps shall be demonstrated over their full working range including the maximum and minimum flow rates.

The continuous operation of systems shall not be commenced until performance tests have been completed to the satisfaction of the Concessionaire and all related Records have been submitted and reviewed.

A programme and method statement of procedures to be implemented and records to be taken shall be submitted by the Contractor for agreement prior to commencement of the COP.

The entire plant and systems shall then be subjected to a continuous operation and performance test to ensure and demonstrate that all apparatus, materials and systems are in full and correct working order; that all controls and operating services are properly adjusted; that all plant items and units are performing correctly; and that the systems provide required temperature, pressures, flow rates and conditions within the building.

The minimum duration for the continuous operation tests shall be sufficient to prove safe whilst in automatic mode working to set point, there is sufficient monitoring and communication to site personnel to be informed of faults on the equipment (via BMS, fire detection, etc). A detailed report with full Records of System Operation shall be submitted after completion of the run including timings and variations in operation.

Should all or any part of the systems fail to perform during the period of continuous system operation, the fault shall be rectified, and the continuous operation run re-commenced.

Where the performance of the Building Services Works fails to meet the requirements of the Building Services Documents, submit a method statement for the proposed remedial works including measures to be taken to prevent any delay to the programme for the Works.

Rectify any defects that become apparent during inspection, testing, commissioning and performance testing. Retest defective parts of the Building Services Works, and any associated interdependent systems, and demonstrate that the Building Services Works operate in accordance with the Building Services Documents.

Submit without delay any record that indicates that any part of the Building Services Works inspected or tested does not comply with the Building Services Documents along with a proposal for rectification.

Acceptance of the system does not absolve the Contractor from their responsibility to provide a fully operational system, even if defects appear during the warranty period, notwithstanding that a defect was not apparent at the time of commissioning.

Carry out fine tuning and adjustment of the systems for 12 months from Practical Completion including environmental testing and monitoring.

8.3.13 Integrated System Testing (IST)

The integrated systems test (IST/Black Building Test) is to ensure that the operation of all building services installed within the building work as a whole following the successful completion of the individual system commissioning procedures.

Allow adequate time in the construction and commissioning programme for IST to be carried out in the presence of the Concessionaire and / or its representatives.

The test is to prove the many interfaces and interactions with all other systems and their cause and effect. The test is to confirm the building operation under different building failure conditions to ensure that the

correct operation and start up procedures occur and that all systems interact correctly with each other. Failure conditions include but are not limited to:

- Complete Power Fail
- Partial Power Fail
- Failure of Standby Generator/UPS systems

All Fire Conditions to test the cause and effect strategy for the building/development:

- Smoke Extract Systems and their zoning
- Critical Cooling Systems
- Fire Fighting Systems – Sprinklers, Wet risers, Gas Suppression systems etc.

Correct System return of all plant following reinstatement/ correction of the above scenarios.

Allow for compiling a detailed event procedure for each system detailing the expected reaction under each situation and provide adequate resources to manage and control this testing procedure.

Allow for specialist subcontractors personnel including but not limited to BMS, IAC's, Chillers, Standby Generators, UPS, Lighting Control, Fire Alarm, Security, IT systems and Lifts, etc. to be available for the duration of the IST to monitor their individual systems.

Mains failure conditions shall encompass the failure of the incoming service and all submain failures. Failures of standby generators/UPS shall also be simulated.

Once all other testing has been successfully completed a partial integrated system test (IST) shall be carried out by simulating a power failure. The partial IST shall be undertaken in collusion with the building's maintenance engineers.

During the IST the Contractor shall be responsible to provide all necessary test instrumentation with a valid calibration certificate.

The tests shall simulate a multitude of scenarios and the recorded results will be compared with the predicted results to ensure the entire facility operates cohesively. The tests for record could include the below list, this list is not exhaustive and should be amended to suit the final design and systems being installed:

Integrated System Testing – possible scenarios:

- Utility HV Failure
- Transformer A Failure
- MPDU A – Failure
- MPDU A - Reinstate
- MPDU B - Failure
- MPDU B – Reinstate
- Gen A - Failure
- Gen B - Failure
- EPO system
- Mains - Reinstate
- AHU Unit 1 - Failure
- AHU Unit 2 - Failure
- AHU Unit 3 - Failure
- AHU Unit 4 - Failure
- UPS Room A Cooling unit 1 - Failure
- UPS Room A Cooling unit 2 - Failure
- UPS Room B Cooling unit 1 - Failure

- UPS Room B Cooling unit 2 – Failure
- Fibre Intake B Cooling unit 1 - Failure
- Fibre Intake B Cooling unit 2 - Failure
- UPS A - Failure
- UPS A Battery Autonomy test
- UPS B - Failure
- UPS B - Battery Autonomy test
- UPS Fibre Intake- Failure
- UPS Fibre Intake Battery Autonomy test
- Bypass procedure A
- Bypass procedure B
- Fire Damper systems and Gas Extract fan
- Data Hall Fire Extinguishant Systems
- General building Fire system
- Vesda Systems
- Leak detection systems

The Contractor shall provide an IST method statement during the Construction Phase of this project.

8.3.14 Submission and Certification of Records

The Contractor shall perform, and certificate all works testing in accordance with the relevant Technical Specification(s).

Such tests shall include but are not limited to:

- System Identification
- Date of Test
- Design Date
- Individual Equipment Identifications Reference
- Number of Tests Referenced Test Procedure and/or Method Statement
- Reference QA/QC Procedure Performance Tests
- Pressure Testing (Piping and Ductwork) Continuity, etc.
- Tests (Electrical/Controls Installations)
- Control Panel Functioning Tests
- Works Tests (Various), as specified and required to meet local authority or other authorities with jurisdiction.

All certification properly witnessed and neatly prepared, in a format previously agreed with the Concessionaire shall be submitted to the Concessionaire's engineer. Complete sets of data shall be submitted on all equipment and systems to be tested and commissioned. Submittals shall be as required and in the form agreed before submission, to show the design figures and final operating values at which the systems and equipment were set. The settings of all dampers and controls, etc, shall also be recorded.

All records and submitted data shall be typed, neat, well ordered and dated, uniquely numbered and clearly referenced to the item tested by means of serial, chassis, or other manufacturer's reference number permanently marked in a conspicuous position on the item concerned.

Records, Certificates and relevant data shall be submitted to Statutory and/or Local Authorities (or other authority having jurisdiction) as may be required.

All Records shall be certified by the Contractor to confirm that the item referred to has been shown under test to meet the requirements of Specifications, Contract Drawings, Codes, Standards, Statutory and Local Authority Regulations requirements (or other authority having jurisdiction) wherever applicable.

Immediately upon completion of the Commissioning Work the following shall be submitted:

- Schedules of all fluid and air terminals, flow rates, pressures, temperatures and velocities with each pump, compressor, fan or other equipment system detailed on a separate sheet.
- Schedules of all equipment/plant items giving details and duties obtained, stating current, full load current, speed and characteristic curve with site performance point clearly marked after all adjustments have been made to meet design values.
- Schedules of fan and pump details and duties obtained, current consumed, full load current, speed and characteristic curve with site performance points clearly marked after all adjustments have been made to meet design values.
- Schedules of all regulating valves, dampers, flow rates and other device settings.
- Schedules of all electrical equipment identifying application, types, starting, current, full load current and overload setting.
- Schedules of all automatic, semi-automatic and manual element and system settings.
- Schedules of all venturi meters, and orifice plates, meters and other flow/mass measuring devices with flow rates.
- Confirmation of setting up of all airflow terminal devices.

All items included in the Schedules shall be uniquely numbered and cross referenced to the Record Drawings.

8.3.15 Commissioning and Commissioning Records

Maintain records and certificates of inspections, testing, commissioning and performance testing undertaken demonstrating compliance with the Building Services Documents and other recognised standards including those carried out by third party testing agencies, and manufacturers.

Retain records on site and make the records available to the Concessionaire on request.

Ensure inspection, testing, commissioning, and performance testing records are dated, and are clearly and uniquely referenced with the agreed equipment identification codes. Ensure equipment identification codes are permanently marked and clearly visible after installation.

Certify that the Building Services Works have been tested to recognised standards and the requirements of the Statutory Authorities, the Statutory Undertakings/Utility Suppliers, and service providers.

All distribution systems shall be balanced to provide the duties, pressures, flow rates and capacities and final system balance schematic with due regard to the elimination of noise generation.

The Contractor shall demonstrate and certify:

- All air, water and other fluid flow rates, pressures and temperatures at all main, branch and terminal locations.

- Acoustic and vibration transmission tests to demonstrate full compliance with all pertinent acoustic and vibration criteria.
- Full operating, duty and electrical data for all rotating equipment, central plant, and all other system equipment.
- Full automatic, semi-automatic and manual control device settings and operating parameters.
- Internal environmental conditions (temperature, air movement and humidity).

Where equipment and system operating points, duties or other parameter are noncompliant or if noise generation exceeds the acceptance levels specified, the Contractor shall provide all relevant information to the Concessionaire, with proposals for reworking to bring systems/equipment into compliance with specified requirements. All measurements and operational details shall be recorded as commissioning work proceeds and shall be subsequently submitted as Commissioning Records in the Testing and Commissioning Manual.

All air distribution system dampers shall be clearly marked in an approved manner when the individual system has been balanced.

All hydraulic regulating devices shall have their final regulated positions recorded on the Commissioning Manuals.

All dampers and hydraulic regulating devices shall be locked in their final regulated positions in an approved manner, on completion of final system balancing.

The final balance of all air and hydraulic systems shall be demonstrated to the satisfaction of the Concessionaire.

Commissioning Records shall be submitted and shall certify that the results are within the allowed tolerances. System performance tests shall not proceed until the certified Records have been submitted.

8.3.16 Performance Demonstration and Concessionaire Training

Following completion of the continuous system operation, the Works shall be fully operationally demonstrated to the Concessionaire's personnel by the Contractor. The demonstrations are not the performance tests and should in no way be combined with them. Such demonstrations shall be performed in such a way as to fully instruct the designated Concessionaire's personnel in all the operational features of the Works.

Such demonstrations shall be completely programmed in advance with the Concessionaire.

The Contractor shall submit the extent of the training and the proposed programme.

The training programme shall include:

- Routine Sampling and Testing
- Routine maintenance daily, weekly, monthly, yearly
- Cleaning procedure
- Removal of internal components
- Removal of rotating parts
- Preventative maintenance
- Fault analysis

- Performance proving procedure
- Starting procedures
- Stopping procedures
- Operation of all safety devices
- Emergency Procedure

The Contractor shall, as directed by the Concessionaire:

- Programme and co-ordinate the training of the Concessionaires' appointed representatives.
- Manage all training sessions to ensure that all Contractors' personnel and Specialist Suppliers provide the required level, quality and content of training.
- Organise and present training sessions by the Contractors' personnel and their Specialist Suppliers.
- Liaise with the Concessionaire to ensure that documentation is available and adequate for such training sessions.
- Obtain written confirmation from the Concessionaire that the training has been satisfactorily completed.
- Monitor progress of the training and provide progress reports against the agreed programme.

8.3.17 Inspection and Testing Certificates

8.3.17.1 General Inspection

The Contractor shall test each plant item as specified herein and as required by British Codes and by applicable Insurance Agencies. Tests shall be witnessed by all required parties and written certification of same furnished to the Concessionaire. The Contractor shall co-ordinate all testing and commissioning with the Construction Manager.

Inspections and tests shall be carried out in accordance with specified or approved procedures and the results shall be judged in accordance with the specified Standards or other agreed criteria including criteria defined in the Specification.

8.3.17.2 Statutory Approval Testing

The Contractor shall be responsible for ensuring that all tests and approvals required by Statutory Authorities are duly performed by an approved Insurance Authority and the relevant approval documents issued, free of charge, to the Construction Manager. The Contractor and the Insurance Authority shall co-operate to ensure that the statutory requirements are met and the cooling towers are accepted onto the statutory register where required. The name of the Insurance Authority shall be stated by the Contractor for approval by the Construction Manager at the time of Tender. The Contractor may nominate an Insurance Authority in lieu of the Contractor's Insurance Authority.

8.3.17.3 Supply Works Test Certificates

Works tests certificates shall include, whenever applicable, full information to enable the item tested to be identified, such as project title, Contractor's name, manufacturer's nameplate or serial numbers, the location in the Supply Works and the delivery or batch which the sample represents.

8.3.18 Testing Records

The Contractor shall maintain records of all inspections, and testing performed to substantiate conformity with the Contract Documents including those carried out by the Contractor and/or third-party testing agencies, together with manufacturers' or Contractors' certificates of test.

All records shall be retained on site and made available to the Concessionaire on request. On completion of the Works all records shall be handed over to the Concessionaire unless otherwise directed.

These records shall include, as appropriate, but not be limited to, project title, Contractor's name, the identification of the element, item, batch or lot, the nature and number of the observations and tests, the dates of testing, the name and signature of the person responsible for the testing, the number and type of deficiencies found, and details of any corrective action taken.

Any record, which indicates that any part of the Works inspected or tested does not comply with the Contract Documents, shall be submitted without delay in order that the Contractor's proposals for rectification may be assessed.

8.3.19 Control of Time

The Contractor shall co-operate with any other Suppliers and Contractors who may be working on, adjacent to, or connected with the Supply Works. In positions where construction Works and installations are adjacent to or in the vicinity of the Supply Works, co-operate in every respect with the Concessionaire to determine the most suitable sequence of installation.

8.4 System Cleanliness

8.4.1 Pipework Systems

Provide equipment, labour, materials, consumables, facilities, licenses, supplies of water and such like to carry out thorough flushing of pipework systems.

Flush systems effectively in both directions.

8.4.2 Ductwork Systems

All ductwork shall be kept clean and free from dirt and dust during the construction process. No specialist cleaning shall be required.

8.5 Guides & Standards

- BS 5930 Code of Practice for Site Investigations
- 1999 BS 8313 Accommodation of Building Services in Ducts
- 1997 BSRIA AG 11/92 Design for Maintainability
- 1992 BSRIA TN 10/92 Space Allowances for Building Services Distribution Systems - 1992 Detail Design Stage.

9 Handover, Operation & Maintenance

9.1 O&M Manuals & Record Drawings

9.1.1 General Requirements

Provide O&M Manuals and Record Drawings in hard copy and electronically. All documentation submitted should be suitably listed / indexed as part of the final submission.

Provide O&M Manuals, Record Drawings and other information necessary to enable the healthy, safe and efficient operation of the building for the entire the Building Services Works.

Include only relevant manufacturers' information. Ensure that manufacturers provide original literature as part of their plant and equipment orders.

Electronically scan any manufacturer's literature not in electronic format.

Modify and update operating details to reflect the agreed commissioning results.

9.1.2 Dedicated Volumes

Provide O&M Manuals in separate dedicated volumes to enable the types of user listed in the table below to easily obtain the information they need.

User Type	**Level**
Employer's Occupier	Non-Technical
Employer's Facility Manager	General Technical
Employer's Maintenance Staff	Specialist

9.1.3 Standards

O&M Manuals and other Handover Information in accordance with the recommendations of relevant industry standards and guides, including the following publications:

- BSRIA BG1/2007
- BSRIA BG2/2004
- BSRIA TN15/95
- BSRIA AG 1/87.1
- CIBSE Guide M:2008
- CIBSE TM31
- CIBSE TM 39
- Additional Information
- Provide the additional information identified below in the O&M Manuals and on the Record Drawings.
- Provide O&M information for each and every system.
- Schedules of all equipment settings and actual values maintained during commissioning.
- In a separate section, schedules of all energy and water meters including the particular service description, type, location, identification and method of measurement. Schedule all meters in the building including those provided by Others. Arrange the meter schedules so that they can be incorporated into the Building Logbook.
- Procedures for seasonal changeovers.
- E-mail addresses of manufacturers and suppliers.
- Defects records.
- A list of consumables.
- Provide design information based the Building Services Documents updated to include any agreed changes.

9.1.4 Room & Equipment Referencing

Agree the room reference code system before use including identifiers for:

- Building
- Level
- Room Type
- Room Number

Agree the equipment reference code system before use including identifiers for:

- Building
- Level
- System Type
- System Number
- Component Type
- Component Number

9.2 Statutory Examinations

Arrange statutory examinations required. Obtain satisfactory examination reports.

9.3 Familiarisation and Training of Operational and Maintenance Staff

Provide the Handover information in accordance with the standards given prior to Practical Completion

Provide training and assistance to the Employer's staff prior to Practical Completion including the requirements given below.

Explain and demonstrate the Building Services Works, O&M Manuals and Record Drawings to the Employer's satisfaction.

Provide training in the form of both classroom sessions and tours of the building systems.

Allow for a repeat session for each topic where operating staff are unavailable or cannot be released simultaneously.

Submit copies of the training presentation for the Employer's future reference.

Keep records of the training sessions including any certificates of competence.

9.4 Special Tools and Instruments

- Provide complete sets of special tools, instruments and keys together with suitable instructions, identification and storage at Practical Completion as listed below.

Item	Quantity
Special tools and instruments (sets per item of equipment)	2
Standard tools e.g. levers, plant and equipment keys, etc.	3
Plantroom keys (sets per door, cabinet or panel)	3

- Provide a minimum of three robust, lockable toolboxes or tool cabinet in each plant room.
- Obtain a signed receipt for all items issued.

9.5 Spares and Consumables

Provide spares and consumables as recommended by the manufacturer of the equipment concerned. Include the items identified below:

Item	Quantity
AHU Filters	1 set per AHU
Fan Belts (if applicable)	1 set per fan
Pump Belts (if applicable)	1 set per pump
Humidifier Cartridges	1 set per humidifier
Bespoke Luminaires	1% (2 minimum)
Lamps	1% (3 minimum)
Miniature Circuit Breakers	1 per rating/type
Fuses	3 per rating/type
Fire Alarm – Automatic Detectors	2 per type

9.6 Water and Fuel

Provide supplies of fuel and water at Practical Completion as identified below:

Item	Quantity
Cold & Potable Water	Full tank capacity
Oil	Full tank capacity

10 Specific telecoms verification to be performed at Base Station Hotel

10.1 MNO Labelling

All MNO entities will be clearly labelled in the Base Station Hotel. This will include

Identification of:

- Cabinets within the BSH
- BTS equipment within a cabinet
- Functional BTS models and ports

- RF feeder cables
- Connectivity between BTS and DAS Headend
- Identification of optical fibre (backhaul to MNO Core Network, other fibre)
- Transmission cabinet labelling
- Connectivity between PSU cabinets and BTS

A clear numbering and colour coding scheme will be jointly formulated between the MNO community and BAI.

10.2 Active equipment verification

10.2.1 Optical equipment

The Optical Fibre commissioning tests will be added here when the Test Plan template is up issued from outline to final status.

10.2.2 DAS equipment

The DAS Headend commissioning tests will be added here when the Test Plan template is up issued from outline to final status. The outline tasks are as follows:

- AC, DC power and earth cabling check.
- Basic tests on DMS3000Pro GENESIS DAS Management System.
- Check RF connectivity at Head end:
  - BTS to UPOI
  - UPOI to DAU
  - DAU to DCU
- Check BTS (Node B, eNB) RF power input level at UPOI.

10.3 Tests for additional ESN capability

BAI will execute witness testing for the Home Office and ESN Coverage supplier to highlight the BSH capability for

- lockable cages
- redundant power
- diverse fibre routing

Details to be finalised when this document is up issued from outline to final.

10.4 BSH Operations Pack to MNOs

BAI will produce a document for MNOs outlining as a minimum:

a) Floorplans of BSH
b) Contact details of Clerk of Works. BSH Logbook
c) Access instructions for BSH Hotel

- Planned Work
- Entry into Building
- Fire Evacuation Route

d) Intruder Alarm instructions
e) Fire Alarm Controls

f) Operating fan unit instructions
g) Log-ins for BMS
h) Power solution

- Power routing
- Main power Board
- Distribution boards
- Meters
- UPS
- Generators
- Contact details

i) Air conditioning/chiller units

- Outline
- Contacts

j) Fault Control process

- Flowchart

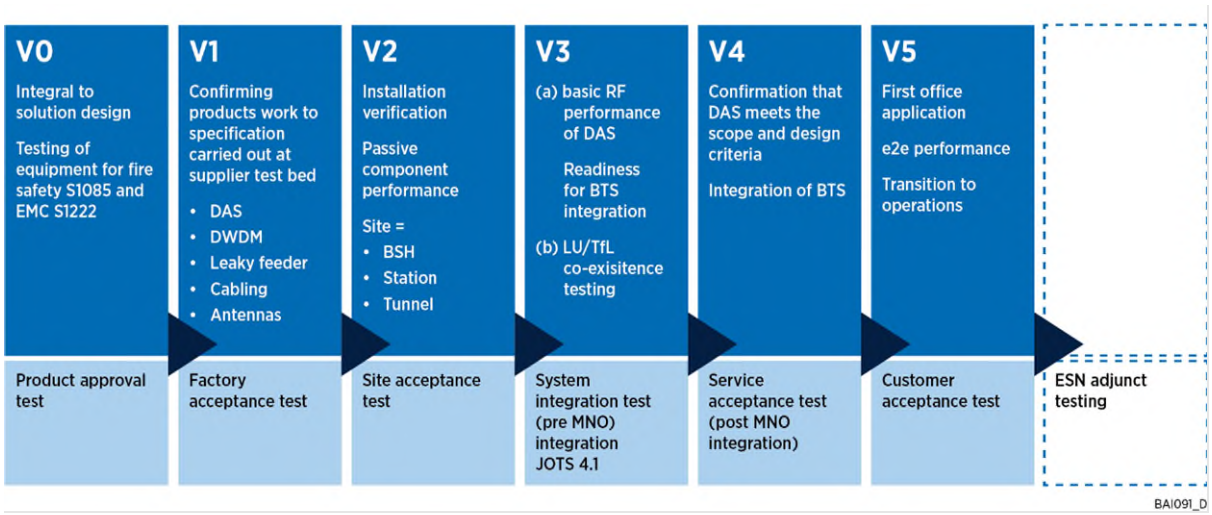
- Contact details

PART B – CMS/ESN STATION

CONTENTS

1 Introduction

The purpose of the document is to describe the test environment, tools, processes, test cases, inputs and outputs, across all applicable stages of the Concessionaire's V-Stage verification model (as described in Annex 2 (Outline Test Strategy) to this Schedule 6.2), for the technical subsystems in the appropriate Service Lines of the TCP project.



2 Scope of testing

The scope of this document is CMS and ESN / Station.

Sequence	CMS and ESN Service Line	
1	BSH testing	
2	Station testing	←this document
3	Tunnel testing	

3 Testing dates / schedule

To be confirmed at final Test Plan Template submission.

4 Test plan manager

To be confirmed at final Test Plan Template submission.

5 Test environment:

Individual environments pertaining to FAT, SAT and further stages of the V-stages will be described in the appropriate sections of the document. To be confirmed at final Test Plan Template submission.

6 Test Stage V0 - Product approval

All active and passive equipment to be installed within the Locations set out in Annex 1 to 3 of Schedule 2.1 (Services Description), as proposed by the Concessionaire, will be logged and managed using the Mobile Services project Equipment Register, detailing data including: part and model numbers, description, dimensions, weight, bespoke installation notes and pictorial information. Where equipment has been identified on TfL's Approved Product Register (APR) as approved, the associated data will be reviewed and checked before being logged on the Project Equipment Register as approved with the associated TfL approved reference number.

Identification and due diligence of the equipment not listed on the APR, will enable the fire materials and electromagnetic compatibility (EMC) compliance testing process to be commenced as soon as possible, due to this being a critical action before any installation works can commence.

- Fire Materials Testing

Testing will be conducted against project test requirements and TfL Category 1 standards (as described in Schedule 2.3 (Standards)) stated in the following documents (this includes stipulated British Standards):

- 1-085 Fire safety performance of materials
- S1085 Fire Safety Performance of Materials - Stations and Tunnel Infrastructure

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

- Power supply information
- Ancillary equipment details needed for normal information
- Material breakdown of the equipment (combustible and non-combustible) including weights and paint coatings
- Equipment specification sheets
- Copies of existing fire material compliance test report and test certificates (if available)
- Confirm if the equipment has any local or remote thermal cut-offs.

Upon receipt of the above data, this is logged onto the project Equipment 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.

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

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.

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 standards and the tests required by the project, 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 of each equipment is identified, weighed and the data along with the analysis of each equipment/component and its compliance and deviation to TfL standards is recorded on the register for that specific product. The outcome of the above is discussed with the lead TfL Fire Engineer, yielding the following options:

- Option A: fire testing is not required. If so, the project will proceed with the TfL concession process to complete fire material compliance approval
- 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. Then follow the fire testing process
- Option C: fire testing is required. Follow the TfL fire testing process.

For equipment that will be fire materials tested, a test plan is created for each piece of equipment in consultation and approval by 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.

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, TfL Fire Engineer and manufacturer. A concession application is created by the Concessionaire's materials engineer and is submitted by the Concessionaire's sponsor to: SQE.StandardsSecretariat@tube.tfl.gov.uk

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.

o 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):

- S1222 Electromagnetic Compatibility (EMC)
- S1193 Electromagnetic Compatibility (EMC) With LU Signalling System Assets.

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

- Power supply information
- Ancillary equipment details needed for normal operation
- Which ports on the proposed equipment to be used when it is been installed
- Equipment specification sheets
- Copies of existing EMC test report and test certificates (if available).

Upon receipt of the above data, this is logged onto the Project Equipment 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.

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.

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.

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 and approval by the 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.

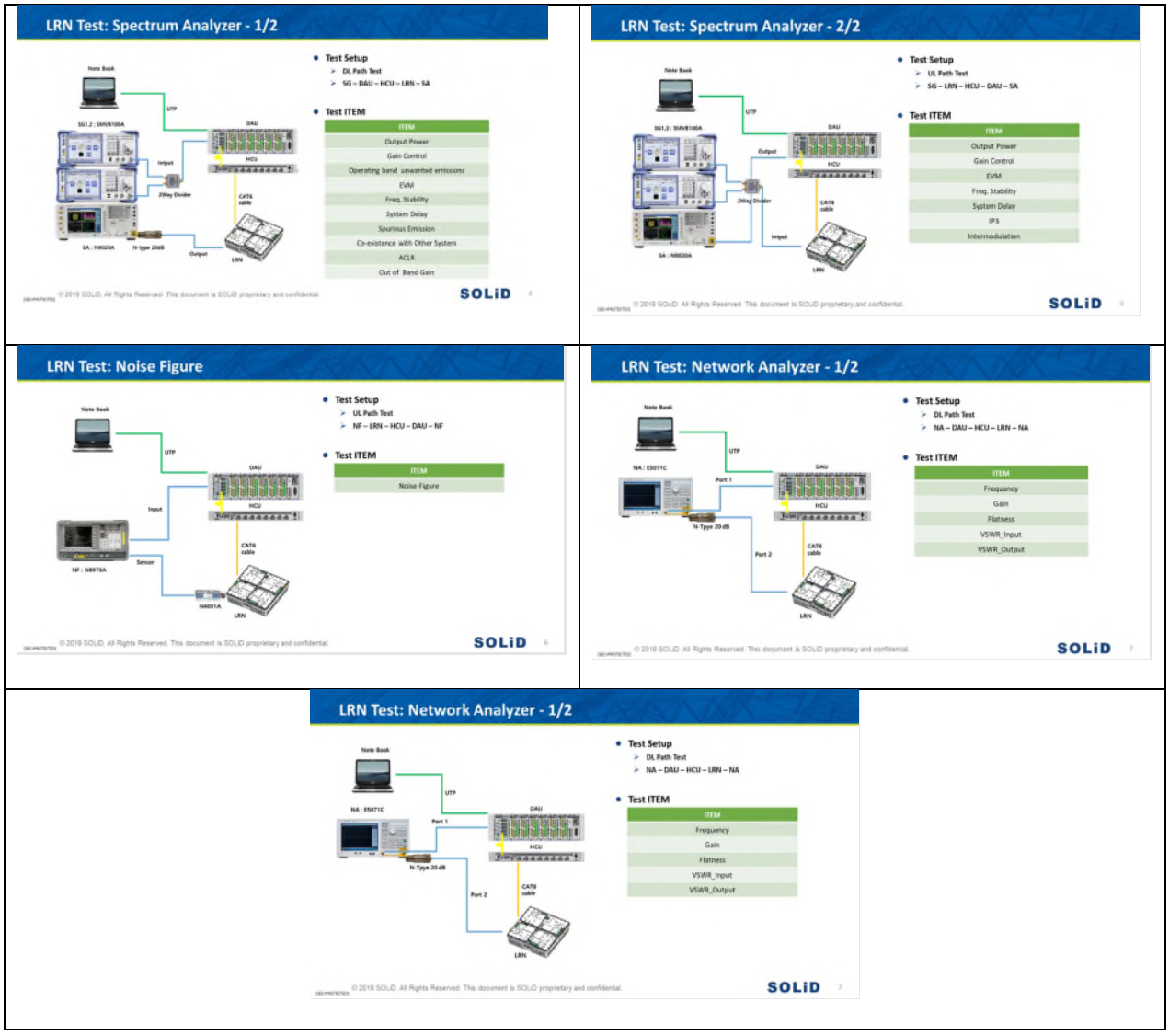
Once the testing has been completed, the results will be analysed, and the test report is produced by the Test House. The test report is reviewed and discussed amongst the Concessionaire's materials engineer, TfL EMC Engineer and manufacturer. If the testing results in a pass, the TfL EMC Engineer will approve 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 register and the Concessionaire is notified.

7 Test Stage V1 - Factory Acceptance Test (FAT)

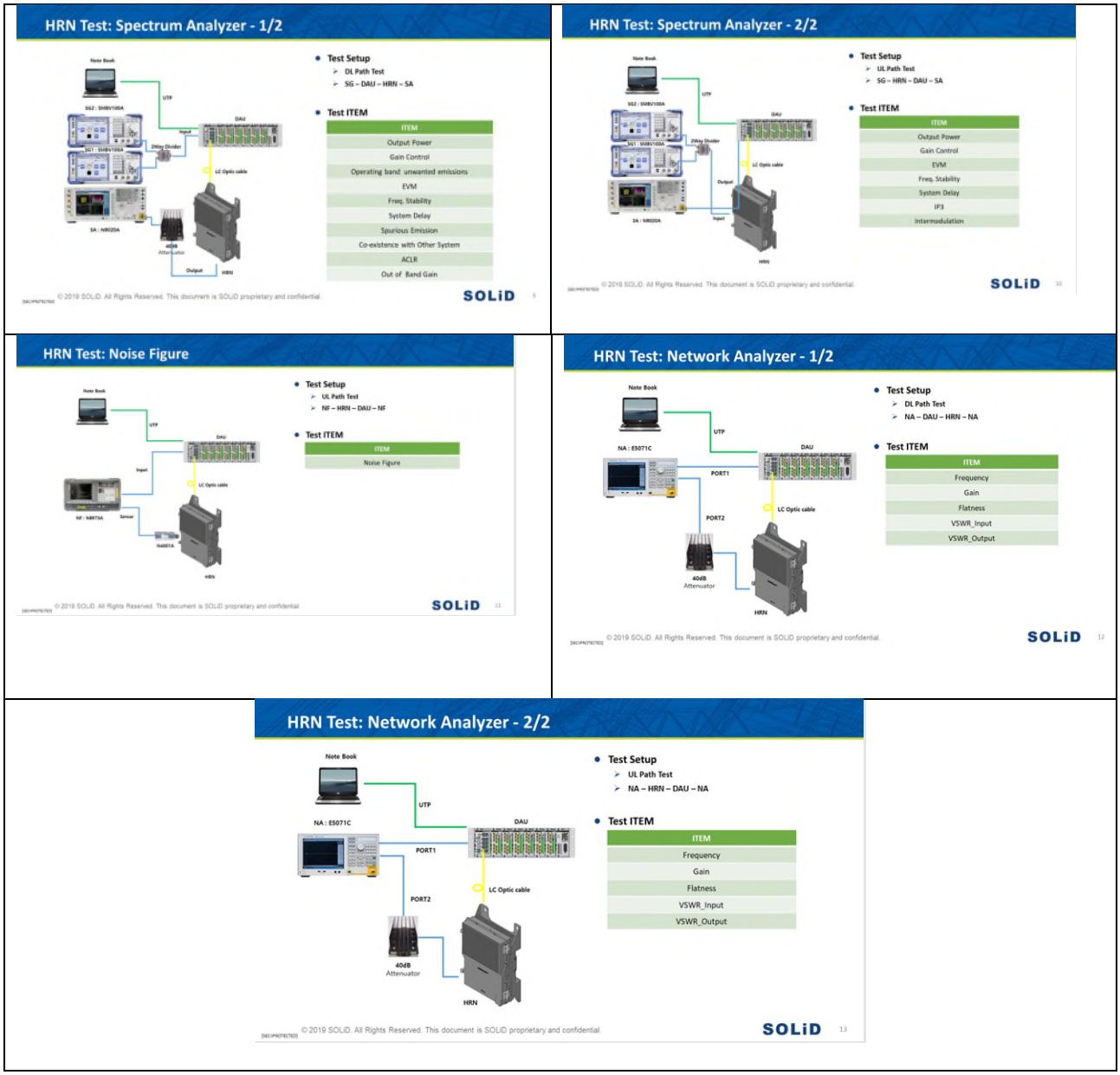
o DAS system

The equipment supplier will be responsible for demonstrating the product specification, per frequency band, typically in the Uplink (UL) and Downlink (DL) direction.

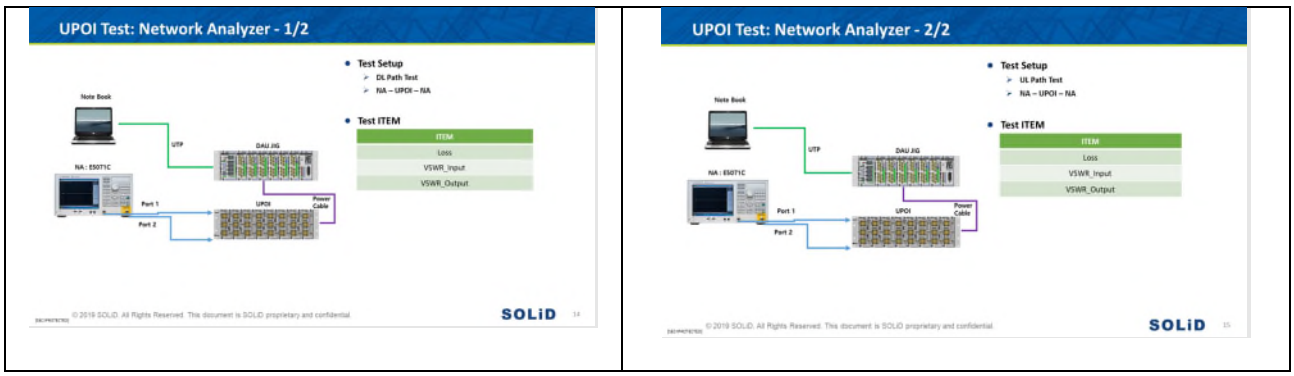
The indicative Low Power Radio (LPR) testing scheme is shown below:



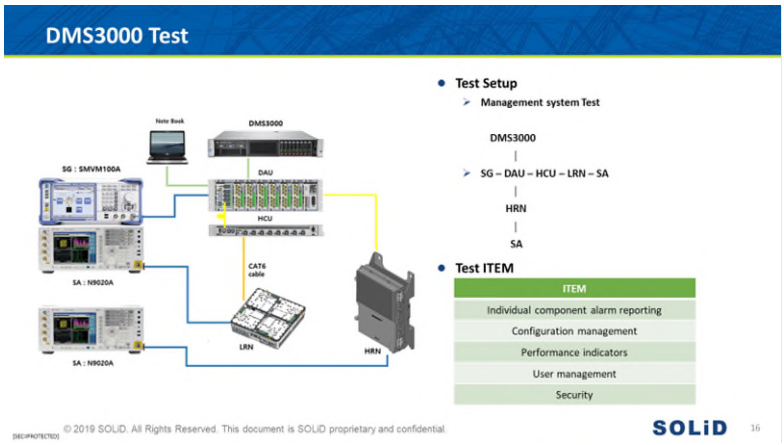
The High Power (HPR) testing scheme is shown below:



The UPOI testing scheme is shown below:



The Network Management testing scheme is shown below:



o DWDM system for CMS/ESN traffic

The Factory Acceptance testing will be carried out at the UK HQ of either the Concessionaire's reference DWDM vendor or DAS vendor. The testing methodology and test scripts will highlight the interoperability between SOLiD Genesis Active DAS, and the ADVA G.Metro Passive WDM solution.

The testing shall ensure that products utilise standard interfaces and protocols to communicate and transport information. The testing shall also confirm that the functionality and performance of the overall system is not impacted using 3rd party components such as Small Form-factor Pluggable (SFP) optical transceiver.

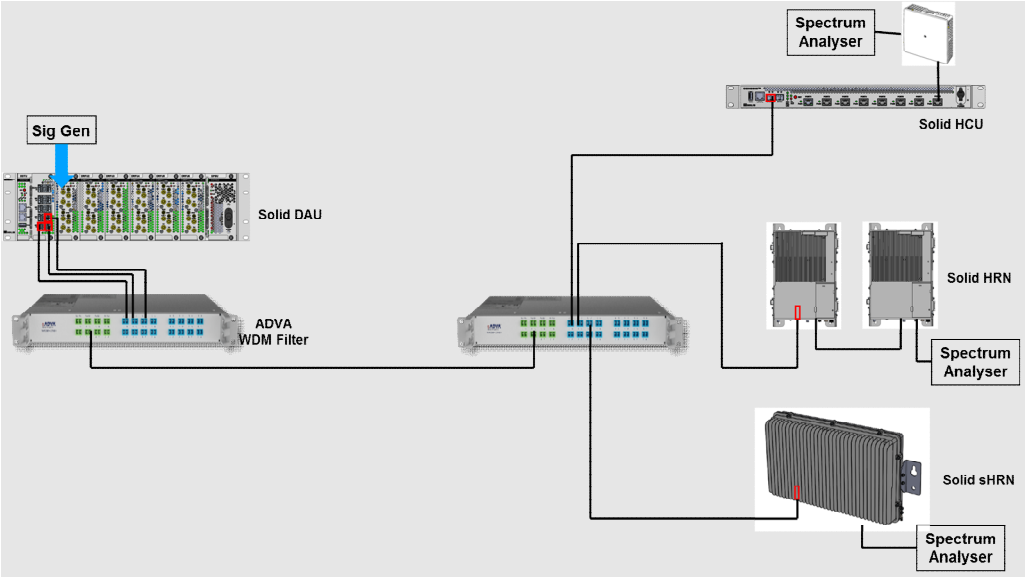
The following parties shall provide the equipment under test as follows:

Item	Solid	ADVA
Solid DMS	✓	
Solid DAU	✓	
Solid HCU	✓	
Solid HRN	✓	
Solid Slim HRN	✓	
Solid Optical Switch 8x8	✓	
ADVA G.Metro SFP+		✓
ADVA WDM Filter		✓
Optical Fibre patch cables (single mode)	✓	✓
Optical Fibre spool (single mode G652.D)		✓

Optical attenuators (various)		✓
RF Signal Generator	✓	
Spectrum Analyser	✓	

Before commencement of the interoperability test, the correct functionality of the Solid DAS will be checked prior to introduction of the ADVA SFPs and WDM filters into the optical path.

The interoperability test confirms the correct functionality of the Solid DAS following integration of the ADVA SFPs and WDM filters into the optical path. The test architecture for the interoperability test is as follows:



The high-level test process is as follows:

		Pass/Fail
1.	Programme ADVA SFPs using Flexoptics programmer device. Record wavelengths.	
2.	Insert ADVA SFPs into Solid DAU and remote radio units	
3.	Set up test as shown above	
4.	Power on Solid DAU & observe power and status indicators showing normal operation	
5.	Power on Solid HCU & observe power and status indicators showing normal operation	
6.	Observe power and status indicators on Solid LRN	
7.	Power on Solid HRN & observe power and status indicators showing normal operation	

8.	Power on Solid Slim HRN & observe power and status indicators showing normal operation	
9.	Log into Solid DMS management platform & confirm all equipment is shown and no alarms reported.	
10.	Observe any & record any information on SFP status provided by DMS	
11.	Inject RF carrier wave at 1800 MHz into Solid DAU. Record transmit power of signal generator	
12.	Observe RF carrier wave on spectrum analyser. Record frequency and signal power	
13.	Repeat for all solid remote radio units	
14.	Leave final test running for 30 minutes. Observe any changes to spectrum analyser output Record frequency and signal level.	
15.	Insert optical attenuation in optical path to simulate various fibre lengths: • 5km • 10km • 15km • 20km Observe any changes to output on spectrum analyser Record frequency and RF power Repeat test for all Solid remote radios	

o Optical fibre

The Concessionaire's DAS design for CMS utilises the 96-core optical fibre already installed in the LU estate. Further witness / Factory Acceptance Testing of this fibre is therefore not required.

o FAT of Ancillary items

The Concessionaire's Factory Acceptance Testing focusses on the primary active electronics. Factory Acceptance testing of CAT6 cable, Antennas and ancillary components will not be carried out.

8 Test Stage V2: Site Acceptance Test (SAT)

o Test entry criteria

Successful pass of V0 and V1.

The required cable management system has been inspected and signed off.

o Sub Domain – station cabling test

Includes CAT6a, Electrical feeds and station fibre (24c).

The station installation outline test plan is shown in **Annex 1** of this document.

- Summary of values

Optical fibre

Wavelength	Splice	Connector	Reflectance	Overall loss	Attenuation
1310 nm	<0.3dB	<0.75 dB	>-50dB	Optical budget +/- 5%	0.4dB/km
1550 nm	<0.3dB	<0.75 dB	>-50dB	Optical budget +/- 5%	0.25dB/km

CAT6A

Install quality	Required maximum length	Test approach
ISO IEC 118011330	Max. Length 5m (patch in cabinet) + 90m (run) + 5m (link from terminating box to LRN unit) All variances to this design target, to be signed-off by exception.	Test to be carried out across full end-to-end points.

Power

Tests	Outcome
Installer to carry out appropriate continuity and insulation tests as per standards.	Electrical installation certificate NICIEC AC ICN18C for each circuit.

o Sub Domain - DAS test at power on

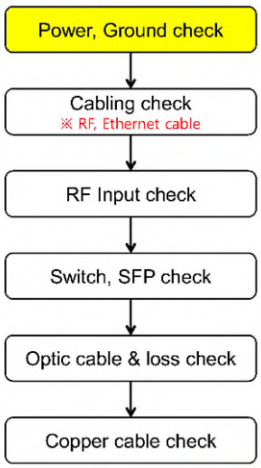
- Pre-requisites

This section outlines the process to be used to power up the equipment. Station Power Up shall not be performed before completing all CAT6A, fibre and power meter fibre testing, and testing of conductive cables.

- Station activation

Before the Power On

1. AC, DC Power, Ground cable check
2. RF cable connection check
   - Head end: BTS ↔ UPOI, UPOI ↔ DAU, DAU ↔ DCU
   - Hub & Remote: DAU ↔ HCU or HRN, HCU ↔ LRN,
   - Main HCU ↔ Additional HCU, Main HRN ↔ Additional HRN
3. Ethernet cable connection check: DAU ↔ Switch ↔ DMS
   - Switch Link check: L2, L3 without DHCP
4. BTS(Node B, eNode B) RF input power level check
   - UPOI: +47 ~ +30dBm
   - DAU: +30 ~ 0dBm
5. SFP insertion status & wavelength Check
6. Optic Cabling & optic loss check
   - Fiber connector type check (LC/PC)
   - Cabling routing check
7. Copper cable(CAT6A: recommend F/FTP, S/FTP) check
   - Length limit (up to 100meter)



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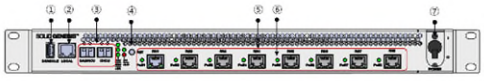
HCU Power On



No	Item	Description		
①	CON	Console interface port for debugging (USB-A)		
②	LOCAL	Web GUI interface or local graphic UI interface port (RJ-45)		
③	DAU/HCU EHCU (SFP+)	LED1	Off	LD and PD are normal
			Red	LD and PD are abnormal
			Green	SFP+ is plugged
		LED2	Off	SFP+ is not plugged
④	System	DAU	Green flicker	Transceivering comm. data with DAU
		HCU	Green flicker	Transceivering comm. data with daisy chained HCU
		LRN	Green flicker	Transceivering comm. data with LRN in turn
		ON	Green	Power is activated
		ALM	Green	System status is normal
			Red	System status is abnormal
		RST	-	Reset button
⑤	PORT1~8	LRN interface ports(RJ-45)		
		LED1 (Left)	Off	10Gbps link is not activated
			Green flicker	10Gbps link is activated
		LED2 (Right)	Off	10Gbps data is not transceivered
			Solid amber	10Gbps data is transceivered
⑥	PoE1~8	Indicator for PoE supply to LRN		
		Off	No PoE supplied to LRN	
		Green	PoE supplied to LRN	
⑦	Power	Power ON/OFF switch (I: On, O: Off)		

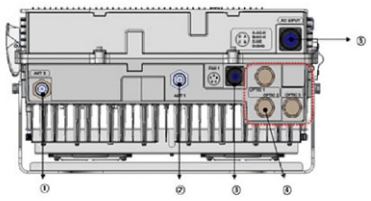
SOLiD

LRN Power On

No	Item	Description		
①	Eth/PoE	Data and power interface ports (RJ-45) with HCU		
		LED1 (Left)	Off	10Gbps link is not activated
			Green flicker	10Gbps link is activated
		LED2 (Right)	Off	10Gbps data is not transceivered
			Solid amber	10Gbps data is transceivered
②	System	ON	Green	Power is activated
		ALM	Green	System status is normal
			Red	System status is abnormal
③	E-ANT1~4	External antenna ports (SMA Female) 1 port for every side panel		

SOLiD

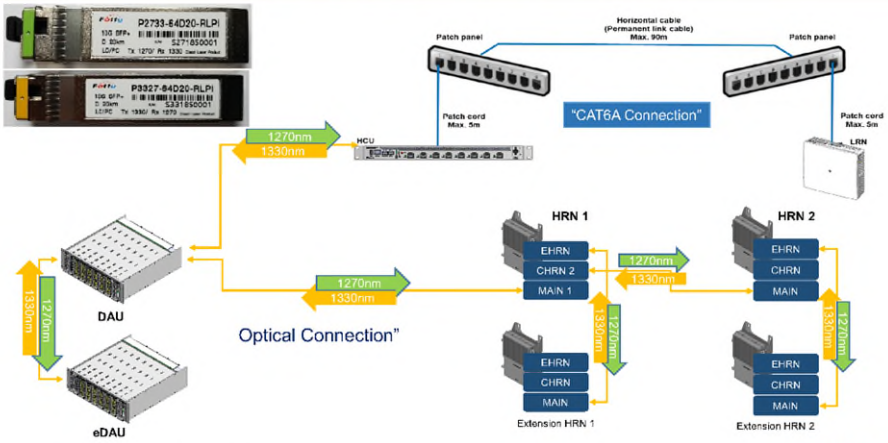
HRN Power On



No	Item	Description
①	ANT2	Antenna port 0(4.3-10_Female) if MIMO is required(Reserved)
②	ANT1	Antenna port 1(4.3-10_Female)
③	FAN1	External Fan port
④	OPTIC1/2/3	Optical port OPTIC1: From/to DAU OPTIC2: From/to Cascaded HRN OPTIC3: From/to Expansion HRN
⑤	AC INPUT	AC Input Port 

SOLiD

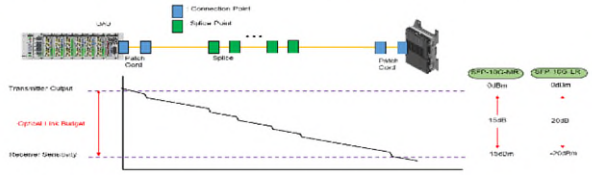
Insert of SFP-10G & cable connection



SOLiD

Fiber Optic Cabling check

- GENESIS™ System Optical link budget from transmitter to receiver



- GENESIS™ System SFP-10G Receiver overload

Part Number	Transmitter power	Receiver Sensitivity	Overload power	Wavelength	Required optical attenuator*
SFP-10G-SR	-5~1dBm	-11.1dBm	0.5dBm	850nm	Not required
SFP-10G-MR-27T SFP-10G-MR-33T	0~5dBm	-15dBm	0.5dBm	1270nm 1330nm	4.5dB
SFP-10G-LR-27T SFP-10G-LR-33T	0~5dBm	-20dBm	-8dBm	1270nm 1330nm	13dB

***. It recommend optical attenuator when it installs short distance or low optical loss.**

***. Mixed between SFPs' utilization**

- SFP-10G-SR doesn't allow for mixing with SFP-10G-MR and SFP-10G-LR
- SFP-10G-MR can use with SFP-10G-LR within no overload power, but it is highly recommended to use the same type of SFP in pair.

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Optic Fiber Plant Preparation

- **Measure Fiber Losses**
  - Optical loss for each fibers should be within its expected range.

Part Number	Distance	SMF/MMF	Duplex type	Optical Link budget	Types of optical connector
SFP-10G-SR	300m@OM3 400m@OM4	MMF	Duplex(2fibers)	5dBo	LC/PC
SFP-10G-MR-27T SFP-10G-MR-33T	20km	SMF	Bi-directional(1fiber)	15dBo	LC/PC
SFP-10G-LR-27T SFP-10G-LR-33T	30km	SMF	Bi-directional(1fiber)	20dBo	LC/PC

- **Check the Optical link budget &Receiver overload**

Part Number	Transmitter power	Receiver Sensitivity	Overload power	Wavelength	Required optical attenuator*
SFP-10G-SR	-5~1dBm	-11.1dBm	0.5dBm	850nm	Not required
SFP-10G-MR-27T SFP-10G-MR-33T	0~5dBm	-15dBm	0.5dBm	1270nm 1330nm	4.5dB
SFP-10G-LR-27T SFP-10G-LR-33T	0~5dBm	-20dBm	-8dBm	1270nm 1330nm	13dB

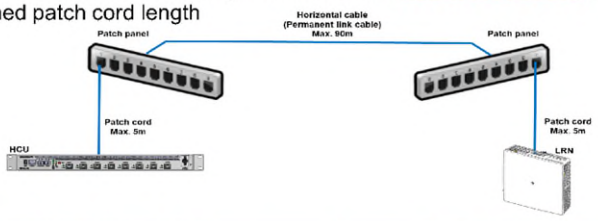
***. It recommend optical attenuator when it installs short distance or low optical loss.**

- **Clean and Cover Fiber Connections**
- **Connect Fiber**

SOLiD

CAT6A Connection

- **Labeling Fibers: Must attached RF and optical cabling map in front of rack in order to verify**
- Cabling horizontal and channel length limit. It should **not exceed 100m** including horizontal cable and combined patch cord length

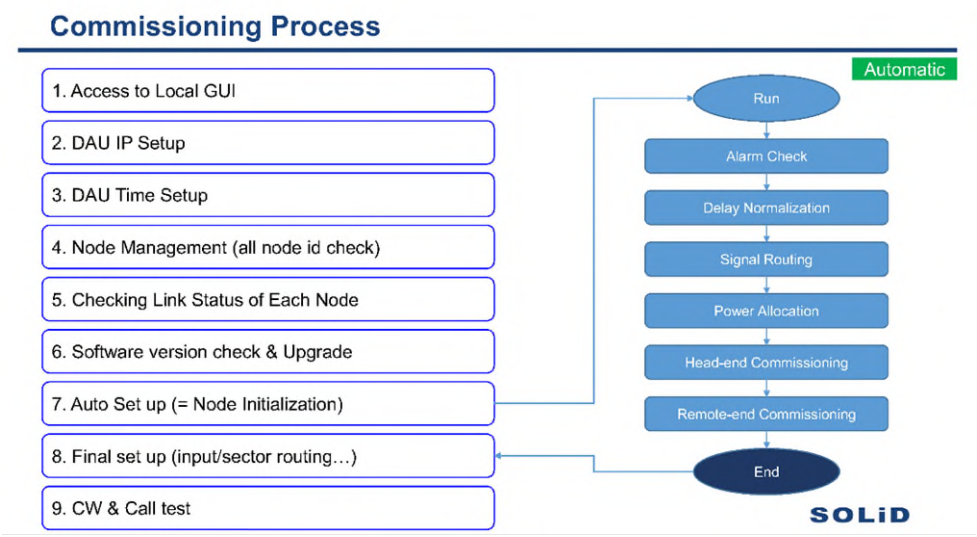


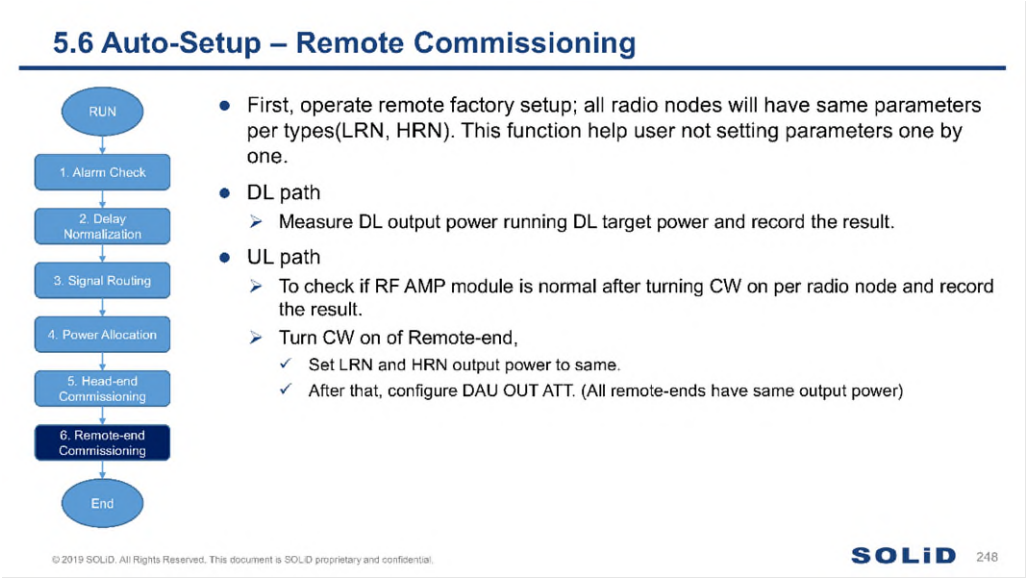
Maximum length of horizontal cable	Maximum combined length of all patch cord
90m	10m
85m	15m
80m	20m
75m	25m
70m	30m

SOLiD

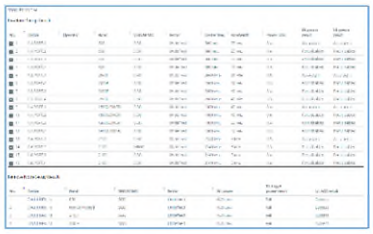
9 Test Stage V3: System Integration (pre MNO)

o Test Stage V3a: Basic Performance





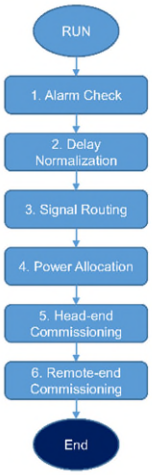
5.7 Auto-Setup – Result



- It provides a result of auto commissioning operation. User can see the result on "Commissioning Result"
  - DL result: the result of checking DL gain of DRFU
  - DL REF PWR: DL target level
  - DL PWR: the result of checking the level
  - UL result: the result of checking UL gain of system
  - UL PWR: UL target level
  - UL PWR: the result of checking the level
  - If DRFU port is disabled or there is no RF AMP in radio unit to be connected, it shows "Non BSSM" message because it could not running auto commissioning.

    *BSSM stands for Band, Sector, SISO and MIMO.
- For remote commissioning result, user can see the result clicking each node on the tree as following
  - DL Target PWR Result
  - UL AGS Result

5.8 Auto-Setup – Commissioning for Specific Band & Remote



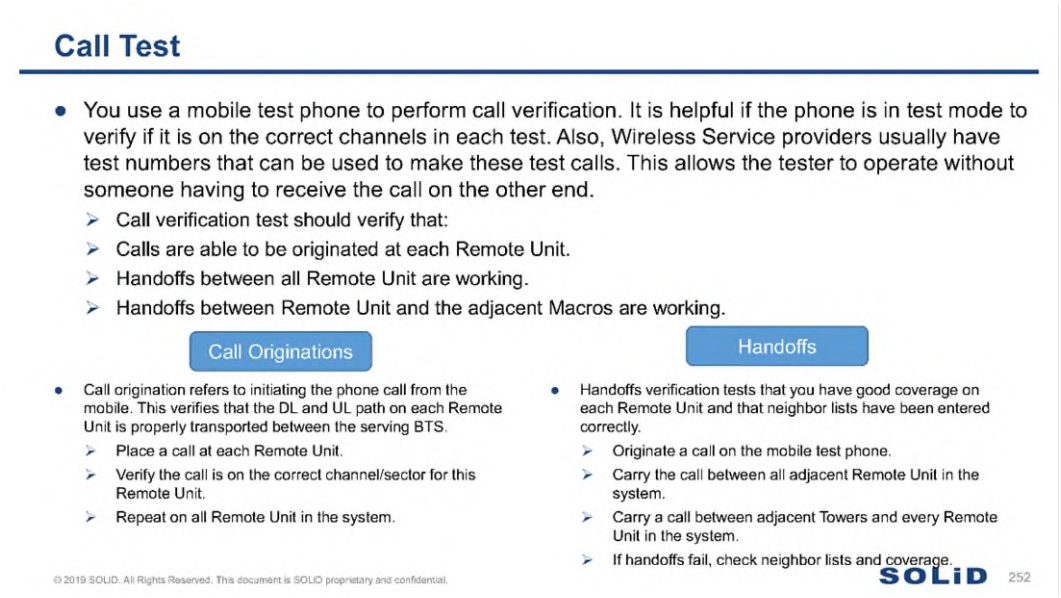
- This mode is used **<u>to initialize new additional nodes or band units</u>**.
- Select [Specific Band & Remote], then click [Run] button.

Final Setup – Manual Configuration

After 'AUTO SETUP' process, perform manual configuration based on site environment.

Choose configuration category as below:

- **Delay Normalization**
  - Use user-defined value if necessary (requested by operators)
  - MUST USE BIGGER VALUE than the one measured by AUTO SETUP
- **Signal Routing**
  - Setup sectors & SISO/MIMO manually.
- **Power Allocation**
  - Distribute output power manually for new DRFU band.
- **Head-end Commissioning**
  - Check UL/DL Gain by Head-end
- **Remote-end Commissioning**
  - Check UL/DL Gain by Remote-end



Prior to MNO BTS integration at the BSH, post-build Carrier Wave (CW) testing is executed. This test is to check that the coverage requirement levels for each of the services is met for the MNOs, as per JOTS 4.1.

The DAS must be free of alarms. The CW testing confirms whether the DAS meets the design coverage criteria. A CW signal is injected at the headend. This causes the remote units to activate. A UE or scanner is employed, and the area is walk tested to collect signal strength measurements for all frequency bands and every DAS zone/sector. The CW walk tests result in a graphical (snail trail) map.

The testing report will include as a minimum:

- Venue under test
- Test equipment used
- Summary of intended design coverage Polygons
- A summary of VSWR/return loss testing if applicable
- After testing the measurement data will be processed and analysed, with respect to coverage, coverage gaps, sector dominance, coverage overlap between sectors and between external coverage
- Written testing outcome and conclusion of if the design targets have been shown to be met. Any exceptions to the design to be explained with cause(s) and discussed and mutually agreed with the MNOs.
-

o Test Stage V3b: LU Co-existence tests

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

- Connect (train CAB driver communications)
- Signalling
- WiFi
- Digital timetables
- CCTV

▪ Pre-requisites

A station and associated tunnel segment completed and connect to a BSH. ADAS is energised by at least one MNO, connected by to Core Network, to allow test traffic (not generical public).

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.

Testing will take place during Engineering Hours.

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

Note, TCP programme assumptions is that LU Co-existence test is carried out once on an initial station and adjacent tunnel segment per Line.

10 Test Stage V4: Service acceptance (Post MNO BTS integration)

This testing is to validate the coverage and performance of the live MNO coverage, when integrated to the ADAS within public station areas.

Coverage, quality, call testing and basic throughput testing will be undertaken for all MNOs.

The tests will include the following:

Idle Mode walk tests: Using a scanner to capture all MNOs, frequency bands, serving and neighbour cells covering the following:

- 2G: RxLev/RxQual/Best Server
- 3G: RSCP/EcNo/Best Server
- 4G: RSRP/RSRP/Best Server
- DAS Zone overlap plots

The above will be presented as snail trail heatmaps on station floor plans for each test conducted, producing a plot for each frequency & technology per MNO.

Dedicated Mode walk test: Walk tests shall be repeated with a UE (User Equipment) in a call to ensure coverage and quality are sufficient to hold a call throughout the public areas of the station. The test also validates that the ADAS sectorisation is correct to ensure handover between neighbouring sectors as per the station sector plan.

- 2G: RxLev/RxQual/Serving cell
- 3G: RSCP/EcNo/ Serving cell
- 4G: RSRP/RSRP/ Serving cell

The test mobile shall not be locked to a band such that it is free to move between frequency layers freely. The above will be presented as snail trail heatmaps on station floor plans for each test conducted.

11 Test Stage V5: Customer acceptance

o CMS requirements.

Subject to the arrangements with the individual MNOs, end-to-end performance testing may be carried out, with connection back to the MNO Core Network.

The includes:

Call tests:

- CSFB/VoLTE call test per DAS Zone
- Fast Reselection time to 4G

Data tests:
File transfer tests using the FTP protocol shall be undertaken to validate the performance of 3G and 4G data services:

3G FTP:

- Download (50MB file)
- Upload (20MB file)
- RTT Ping

4G FTP:

- Downloads (200 MB file)
- Upload (100 MB file)
- RTT Ping

The test shall be undertaken twice per DAS zone in the station, at the centre and cell edge. The test shall be undertaken at least once per DAS zone for each band in the station and shall use the Radio Opt: Traffic Monitor Plus mobile application.

Test Set Up

Idle Mode Walk Tests

Idle mode walk tests will be undertaken using a backpack mounted RF scanner as shown below. The scanner will allow the tester to capture all MNOs spectrum bands that are radiating in the station.

Dedicated Mode Walk Tests

Dedicated mode testing will be undertaken using a backpack mounted test mobile setup shown below and controlled from a tablet computer. This will cover mobility scenarios such as handover between sectors.

The test backpack contains a number of test mobiles, capable of measuring and recording signal level and quality, as well as other network KPIs. Sufficient test mobiles will be provided to ensure that all MNOs can be tested in one walk tests.

Walk Test Methodology:

All station walk tests shall be conducted following the methodology set out in JOTS using the following rules to ensure sufficient data is captured to present an accurate representation of coverage and performance.

Passages <=7 metres wide
Passages not more than 7m wide shall be surveyed along a route defined by the centreline of the passage with a tolerance of +/- 1m.

Passages >7 metres wide
Passages wider than 7m shall be surveyed along routes on both sides of the passage at a distance of 2 +/- 1 m from the passage walls.

Rooms<=5 metres wide
Rooms with an average width of not more than 5m shall be surveyed on routes around the internal perimeters, at 1 +/- 1m from the perimeter wall. Where this route is not accessible then the nearest public accessible route shall be taken.

5m < Room width <=10m
Rooms with an average width of between 5 and 10m shall be surveyed on routes around the internal perimeters, at 1 +/- 1m from the perimeter wall and along a centreline parallel to the longest wall of the room. Where this route is not accessible then the nearest publicly accessible route shall be taken.

Room width >10m
Rooms with an average width greater than 10m shall be surveyed on routes around the internal perimeters, at 2 +/- 1m from the perimeter wall and along zigzag route sweeping the floor area. The pitch of the zip-zap route shall be not more than 4m. Where this route is not accessible then the nearest public accessible route shall be taken.

Stairs and escalators
Stars and escalators shall be surveyed along the centre line of the stair or escalator. Where multiple stairs or escalators are located within the same passageway or bore, then the survey routes shall be along the stair or escalator located nearest to the centreline of the passageway or bore. Where stairs and escalators are contained within separate passageways or bores, they shall be treated as separate stairs and escalators.

Port of entry (entrances and exits)
Entrances and exits shall be surveyed along a centre-line route normal to the entry or exit doorway, or as near as is practically possible by the general public. The route shall be extended to at least 20m on either side of the port of entry.

Pass Criteria:

The following levels shall be utilised for each of the tests conducted above:
Idle & Dedicated Mode Walk Tests

2G	**Pass Criteria**
RxLev	>-95dBm
RxQual	>7
Best Server	As per sector plan
3G	
RSCP	>-105dBm
Ec/Io	>-13dB
Best Server	As per sector plan
DAS Zone overlap	+/- 5dB

4G	
RSRP	>-105dBm
RSRQ	>-13
Best Server	As per sector plan
DAS Zone overlap	+/-10dB

Test Report Output
Coverage and quality plots, shall be presented as heat map snail trails plotted on station floor plans, covering the area under test.

The plots shall be formatted using the following threshold levels and colour schemes:

GSM:

	RxLev (dBm)
	≥–55
	-55,-65
	-65,-75
	-75,-85
	-85,-95
	-95,-98
	-98,-101
	-101,-103
	-103,-106
	<-112

	RxQual
	1,3
	-4
	5
	6
	7

UMTS:

	RSCP (dBm)
	≥–55
	-55,-65
	-65,-77
	-77,-87
	-87,-97
	-97,-100
	-100,-106
	-106,-109
	-109,-112
	<-112

	Ec/Io (dB)
	>-4
	-4,-8
	-8,-10
	-10,-13
	<-13

LTE:

	RSRP (dBm)
	≥–65
	-65,-80
	-80,-95
	-95,-105
	-105,-110
	-110,-113
	-113,-116
	-116,-118
	-118,-121
	<-11

	RSRQ (dB)
	-4, MAX
	-7,-4
	-10,-7
	-13,-10
	MIN, -13

	SNR (dB)
	->20
	14,20
	6,14
	-0,6
	<0

Full log files will be made available in all cases, to be used in cases where further/deeper analysis becomes necessary. These will either be via Nemo or TEMS related systems, or a CSV export containing specific agreed data fields, accompanied by a Geo-Located Tab File for the floor plan. The log file naming convention will follow this format: *Operator_Technology_State_Location_Date_Time*.

o ESN requirements.

The ESN High Level Design document 10.5 calls for specific test measurements to be made in the venue under test. These will be carried out by the Concessionaire. Access to ESN Coverage Supplier UEs and SIMs will be required.

Testing will include signal strength measurements (RSRP) and Quality (SNR) levels.
In addition cell reselection, handover and voice quality and delay will be tested. End user throughput at the ESN UE will be measured and reported. Throughput levels are for guidance only, as the Concessionaire does not control the spectral assets and BTS capabilities of the ESN Coverage supplier.

12 Test Stage - ESN adjunct testing

o First-on-Air scenario

The TfL ESN High Level Design document calls for a first on air scenario (First Office Application or FOA) agreed between TfL and ESN Coverage Supplier in order to validate the system and processes.

Aim of first on air trial is to test in real deployment all defined criteria and procedures, evaluate their feasibility and transfer to Operations and Service Management.

Key in this activity is to provide stakeholders with confidence around the system. For ESN, this would include:

- ESN Coverage Supplier
- TfL
- Home office
- User community
  - Police
  - British Transport Police
  - Fire
  - Ambulance services

PART B - ANNEX 1 – STATION INSTALLATION AND SITE ACCEPTANCE TEST TEMPLATE

TELECOMMUNICATIONS COMMERCIALISATION PROJECT ON BEHALF OF BAI

Document Title:	TCP – Station Installations Test Strategy
Document Reference:	TBA

For TCP Installation Design

INSTALLATION TECHNOLOGY

TELECOMMS COMMERCIALISATION PROJECT

Revision	Purpose of Issue	Originated	Reviewed	Authorised
P01	For Approval			
Date:				
P02	Expanded Text			
Date:				

Client Endorsement

	Role	Name	Signature	Date
Reviewed by	Project Engineer			
Accepted by	Project Manager			

Contents

1 Introduction

1.1.1 TCP is installing passive and active equipment in stations and tunnels to support the implementation of 4G LTE infrastructure for public cellular connectivity, TCP and to support the Home Office Emergency Services Communications Programme.

1.1.2 This test strategy addresses installations in stations only. The test strategy for passive infrastructure installed in tunnels is addressed in a separate document (TCP Tunnel RF Cable Installation Test Strategy).

2 Scope of Testing

2.1.1 This testing strategy addresses those components of the TfL / TCP solution required in stations installed as enabling works by the TCP Project that will eventually be used to support the network hubs and radio amplifiers required by the TCP infrastructure. This is as described in the:

a) TCP High Level Design; and

b) The Low-Level Design specification produced for each of the Stations in scope for TCP.

2.1.2 The specific elements addressed by this strategy are:

a) Power installations;

b) Structured Cabling Systems including

(a) Class EA / Cat 6a cabling;

(b) Single Mode Fibre optic

(c) New Cable Management Systems; and

c) Cabinets.

2.1.3 We will be testing the quality of the installation using standardised performance measurement techniques as referenced by ISO IEC 11801.

3 Expected Test Results

3.1.1 In addition to visual inspections the following tests will be performed:

3.1.2 The copper F/UTP Class EA (Category 6a) Permanent Link (PL2) horizontal cabling will be tested to ISO 11801 using properly configured and calibrated automatic test equipment undertaking and recording the results of the following tests:

(a) Wire Map

(b) Length

(c) Propagation Delay

(d) Delay Skew

(e) DC Loop Resistance

(f) Insertion Loss

(g) NEXT (Near-End Crosstalk)

(h) PS NEXT (Power Sum Near-End Crosstalk)

(i) ACR-N (Attenuation to Crosstalk Ratio Near-End)

(j) PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)

(k) ACR-F (Attenuation to Crosstalk Ratio Far-End)

(l) PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)

(m) Return Loss

The testers used and the analysis software shall be capable of issuing a Pass / Fail certificate for each cable. Note that any marginal passes (star passes) will be investigated and, if necessary, will be the subject of re-work until a good pass is obtained.

The numerical values for the results for each test vary by length, cable type, combination of the individual tests carried out on the cable and the test limits set. However, if the test set is configured correctly for the cable under test, the Pass / Fail Certificate automatically generated will be sufficient evidence to assure the performance of the cable.

3.1.3 The expected result for each cable will be a PASS providing:

a) The test set is within calibration i.e. the date of the last successful calibration is less than 12 months from the date of the cable test.

b) The cable is of the type approved for use by the project being of Class EA / Cat 6a rating of F/UTP construction (continuous foil sheath with drain wire over four solid unshielded twisted pairs of 23AWG cross section, or greater cross sectional area, for each conductor).

c) The Nominal Velocity of Propagation (NVP) is taken from the cable manufacturer's data sheet, the box or reel containing the cable or the print on the cable itself as appropriate.)

d) The test limits are set to test against ISO IEC 11801:2010 Amendment 2 or 11801:2017 Class EA

e) The Permanent Link parameter is set to PL2 (i.e. a Permanent Link comprising a single F/UTP cable run of 90m or less with a shielded Class EA rated keystone jack terminating each end of the cable)

3.1.4 For Fibre, the architecture created by the design calls for point to point single mode Permanent Links in the building backbone e.g. the backbone fibre between the Building Distribution Cabinet and various Zone Distribution Cabinets. These Permanent Links will be checked for length, polarity and insertion loss against a manually calculated or tester derived loss budget. Each individual fibre link will be tested in both directions at 1310nm and 1550nm wavelengths using a correctly calibrated and configured Insertion Loss Measurement test set.

3.1.5 NB: Bi-directional testing is not strictly necessary nor is it mandated by the various standards bodies, but they are a feature of the test sets used and allow cable length and hence acceptable link loss to be calculated by the test set rather than manually.

3.1.6 In compliance with TIA/EIA-526-7 "Measurement of Optical Power Loss of Installed Single mode Fibre Cable Plant" and IEC 61280-4-2 edition 2, "Fibre-Optic Communication Subsystem Test Procedure – Part 4-2: Installed cable plant – Single mode attenuation and optical return loss measurement", the following information should be recorded during the test procedure:

(a) 1. Names of personnel conducting the test

(b) 2. Test equipment used (manufacturer, model, serial number and calibration date)

(c) 3. Date of test

(d) 4. Optical source wavelengths, spectral width

(e) 5. Fibre identification

(f) 6. End point locations

(g) 7. Test direction

(h) 8. Reference power measurement (when not using a power meter with a Relative Power Measurement Mode)

(i) 9. Measured attenuation of the link segment

(j) 10. Acceptable link attenuation (i.e. Loss Budget)

(k) 11. Cable Length

(l) 12. Polarity

Expected Results: The fibre cores (24) within each single mode cable will be presented on patch panels in logical straight through sequence on bulkhead connectors thus creating a series of optical Permanent Links between the two locations. Within a station the length of the single mode fibre run is not critical and typically will not exceed 1 km with typical losses of between 0.4 dB and 1.0dB / km.

Maximum component losses are defined in the standards and it is therefore possible to work out a loss budget for each link. e.g. for a 1 km OS1a tight buffer cable with bulkhead LC connector at each end the loss budget would be:

1km x 1.0dB cable loss + 2 connectors x 0.75dB = 2dB

This is within the 3.5dB insertion loss limit allowed by the standards bodies for an individual Permanent Link within a station. In practice we would expect to see component losses of much less than 0.3dB per splice and 0.75dB for each mated connector.

3.1.7 For Electrical Circuits, design of power feeds will be in accordance with BS 7671:2018

(a) External earth fault loop impedance

(b) Continuity of protective conductors

(c) Insulation resistance between live conductors

(d) Insulation resistance between live conductors and Earth

(e) Protection by separation of circuits

(f) Basic protection by barrier or enclosure

(g) provided during erection

(h) Polarity

(i) Earth fault loop impedance

(j) Verification of phase sequence

(k) Functional testing of assemblies

(l) Verification of voltage drop

4 Testing process

4.1 Data Cabling

4.1.1 Every copper and fibre Permanent Link installed by the project will be inspected and tested to the specifications outlined in section 3 of this document.

4.1.2 Cables will be inspected on installation and an inspection checklist for cabling as described in Annex C will be produced.

4.1.3 Where new CMS has been installed to support new data cabling an inspection checklist for CMS as described in Annex D will be produced.

4.1.4 Each copper data cable will be tested with a Fluke DTX 1800, LANTEK 3 Tester (or similar unit) remote unit and test heads to conduct the test described in 3.1.2. These tests are automatically performed by the unit when correctly configured.

4.1.5 All test sets selected for use on this project record the test results against pre-defined test limits which can be downloaded along with the test results using the appropriate analysis software e.g. Linkware software for Fluke testers and IDEAL Anywhere for Lantek which then produces a detailed test report which will be incorporated into the station as built documentation,

4.1.6 Test Failure Actions for Copper Data Cabling: In the case of faulty Class EA / Cat 6a cables, replacement / re-termination of the keystone jacks or replacement of the entire cable run are the only permitted remedial actions. The removal of a faulty section of damaged cable and replacement with a good section is prohibited. There is no acceptable repair strategy for such cables recognised by this project.

Where the only non-compliances recorded relate to an overlength cable the following process shall be followed:

Review and Concession Process for Over length Copper Data Cables

Any test failures including "Star Passes" will be rectified by the original installation team and re-tested. There is no need to notify test failures to the supplier's Technical Assurance Review Board, providing any fault is rectified in a timely manner and certainly before test documentation is handed to the customer, with the following exception:

All over length Class EA (Cat 6a) cables i.e. those exceeding 90m are to be notified to the Supplier's Technical Assurance Review Board along with the suggested remedial option put forward or concession.

4.1.7 Test Failure Actions for Fibre Optic Cables: The Insertion Loss Measurements will be analysed to identify the type of fault e.g. abnormally high Insertion Loss at 1310nm but expected results at 1550nm there is most likely a bad splice somewhere, while if high at 1550nm but OK at 1310nm suggests a bent cable. Faults near to the patch panel can be found using a Visible Light Fault Locator and appropriate action undertaken to rectify the problem. Otherwise it will be necessary to use an OTDR to find the distance from the end of the cable where the problem is to be found. Cables will be re-positioned, re-spliced, re-terminated or replaced as appropriate.

4.2 Power installations

4.2.1 An Electrical Design Engineer will produce the Inspection Test Plan for each station. The Inspection Test Plan will detail the following:

ii) Item to be tested, of one of the following types:

(a) Building Distribution Cabinet installation and power distribution and earthing arrangements within the cabinet (including functional earth)

(b) Zone Distribution Cabinet or Auxiliary Cabinet and power distribution and earthing arrangements within the cabinet (including functional earth)

(c) High Power Radio (HPR) Unit Installation including power distribution and earthing arrangements (including functional earth)

iii) Area/ Location of the item (SSID).

iv) Each asset associated with item to be tested. Each asset type has a specific Inspection Checklist. The asset types are described below along with a reference to their inspection checklist in the Annex of this document:

(a) Cabinet – Inspection Checklist in Annex A

(b) Distribution Board – Inspection Checklist in Annex B

(c) Cabling – Inspection Checklist in Annex C,

(d) CMS – Inspection Checklist in Annex D

(e) Rotary Switch, JB and Earth Bar – Inspection Checklist in Annex E

v) On completion of the installation and visual inspections the following tests will be performed on each circuit with the results recorded on an Electrical Installation Certificate (example provided in Annex F):

(a) External earth fault loop impedance

(b) Continuity of protective conductors

(c) Insulation resistance between live conductors

(d) Insulation resistance between live conductors and Earth

(e) Protection by separation of circuits

(f) Basic protection by barrier or enclosure

(g) provided during erection

(h) Polarity

(i) Earth fault loop impedance

(j) Verification of phase sequence

(k) Functional testing of assemblies

(l) Verification of voltage drop

4.2.2 Electrical Installation Engineer will execute the test plan and produce the report.

4.2.3 The Electrical Project Manager will sign off the test report.

5 Test Reporting

5.1.1 An Installation Inspection and Test report will be produced for each station in scope of TCP. Each test report will include the following:

5.2 Copper and Fibre Data Cable Permanent Link Test Report

5.2.1 A test report will be generated using the automated reports produced from data downloaded from the test set using the manufacturer's analysis software augmented where necessary by manually recorded data. The test report will identify uniquely the station or operational building concerned and both the test report covering the station and the summary reports providing the results for each cable will be unambiguous about the make and model of components used, the names of the test team, the precise test limits used and the results obtained The test and summary reports must be sufficiently comprehensive when considered alongside other as built documentation available at the same time so that no additional information is required so as to assure the cable system installation.

5.2.2 The test report and Summary Reports will include all the results called for in Sections 3 and 4

5.2.3 A uniquely identified Visual Inspection Sheet will be produced for each cable, as defined in the Annex C of this document and photographic evidence is required of the position and content of all labelling on the associated patch panels and cabinets.

5.3 Power Installations Test Report

5.3.1 For each Item described in the Inspection Test Plan the following will be reported:

i) A uniquely identified Visual Inspection Sheet for each asset installed, as defined in the Annex of this document.

ii) Date Visual Inspection Sheet Completed

iii) Date Internal Snagging Completed

iv) NOWRI Date

v) Date NOWRI Snagging Completed

5.3.2 An Electrical Installation Certificate will be produced for the entire station as described in Annex F.

5.3.3 Where Continuity Tests, Insulation Tests, etc. are performed the following information will be recorded for the equipment used for these tests:

i) Equipment Type

ii) Equipment Ref.

iii) Equipment Manufacturer

iv) Model Number

v) Serial Number

vi) Asset Tag

vii) Calibration Date/

6 Referenced Documents

Document Type	Document Name	Document Owner	Document Author	Revision /Date
Design Specification	TBA - TCP High Level Design			
Design Guide	TBA - Tunnel Radio Design Installation Assurance Guidelines and Process			

Document Type	Document Name	Document Owner	Document Author	Revision /Date
1-144:A1	Wireless Communications Systems (and appropriate referenced standards or their successors within Section 5.2 of that document relating to Human Factors & Ergonomics, EMC / Environment, Fire Materials, Performance, Legislative, Code of Best Practice)			A1/2007
1-145:A1	Wired Communication Systems (to the extent that this standard does not conflict with the ISO 11801:2017 family of standards for structured cabling or industry best practice. In particular, cable sheath colours for single mode fibre may be a colour other than yellow (but not orange, aqua or lime green) should this be required for fire resistance, Ultraviolet resistance or other reasons impacting operational life which is required to be a minimum of 20 years. In this event the cable sheath will be clearly marked at intervals not exceeding 2m with the cable type. The author of the standard is asked to note that OM1 and OM2 fibre with an orange sheath has been phased out in new installations to be replaced by OM3 and OM4 cable with Aqua sheath and OM5 with a Lime Green sheath and that the Engineering notice relating to sheath colours should be amended to avoid unnecessary cost to LU and long lead-times for suppliers not being able to use off the shelf cables, jumpers and patch leads.)			A1/2017

7 Annexes

7.1 Annex A VISUAL INSPECTION CHECK LIST FOR CABINET

Station Name: Kings Cross Location: ____

Type of Cabinet _____

ITEM #.	DESCRIPTION	YES	NO	N/A	COMMENT
1	CMS Installed correctly from Rotary switch to Cabinet (max 0.7m Flexible Conduit)				
2	Flexible Conduit correct grade (braided)				
3	Connections checked in Rotary Switch				
4	Additional 4mm earth run from rotary switch to cabinet earth point				
5	16mm Earth installed from Functional Earth Bar to Cabinet Main Earth Terminal				
6	Power Distribution Unit within Cabinet mounted correctly, and external earth lug bonded				
7	Cabinet cross bonded (door)				
8	Cabinet labelled with Danger 230volt				
9	Cabinet labelled showing Distribution Board/Rotary Switch location				
10	Access doors open Unhindered				
11	Cabinet fixed/mounted securely				
12	All components within cabinet are fixed securely.				
13	Cross Bonding within cabinet shall be verified with the manufacturer's installation data sheet.				
	ADDITIONAL COMMENTS:				
	INSPECTORS NAME:	**SIGNATURE:**			
	COMPANY:	**DATE:**			

7.2 Annex B VISUAL INSPECTION CHECK LIST FOR DISTRIBUTION BOARD

Station Name _____ location:

DB Ref: _____ Supply Details: Delete whichever not applicable

LUL	LEB
BR	DLR
TP&N	DP
	SP

Number of ways: _____ Delete whichever not applicable

Type of Board _____

ITEM #.	DESCRIPTION	YES	NO	N/A	COMMENT
1	Is the distribution board labelled externally?				
2	Is the description on circuit labels correct?				
3	Does the label correspond to the circuit fuse rating?				
4	Are labels fixed with nuts and bolts?				
5	Are all circuit labels identified with "Z" type Critchley markers?				
6	Are all neutral and earth cables connected to the correct ways?				
7	Are the cables installed in accordance with specification?				
8	Are cables terminated correctly?				
9	Are all cables correctly coloured?				
10	Are the cables neatly dressed in the board?				
11	Do doors operate and close securely?				
12	Is the board bonded correctly?				
13	Are all spare ways fitted with a blank fuse base?				
14	Are all fuse flashes and cable guards in place?				
15	Is there any sign of overheating or burning?				
16	Is the board fixed securely?				
17	Is there any water or dampness on the board?				
18	Is the board clean and dust free?				
19	Are there any sharp edges around the cable entry points?				
20	Is the board clean and dust free?				
21	Are there any sharp edges around the cable entry points?				
22	Is interlink between board, trunking, bus bar and fuse switch carried out correctly?				
	ADDITIONAL COMMENTS:				
	INSPECTORS NAME:	**SIGNATURE:**			
	COMPANY:	**DATE:**			

7.3 Annex C VISUAL INSPECTION CHECK LIST FOR COPPER AND FIBRE PERMANENT LINK CABLING

Location Ref:
DB Ref:
Station Name: Kings Cross Station **Circuit Ref:**

Item	DESCRIPTION	YES	NO	N/A	COMMENT
1	Are cables supported securely?				
2	Are the cable runs tidy?				
3	Are cable brackets fixed securely?				
4	Are cleats fixed securely and correctly spaced?				
5	Are cleats approved type?				
6	Is there enough protection when cables pass through wall, floor or ceiling?				
7	Are there any signs of sharp bending radius?				
8	Are cable glands and shrouds in place and secure?				
9	Are cables bonded?				
10	Are all cables labelled?				
11	Are there any exposed live parts?				
12	Are there any damaged cables?				
13	Are there any redundant cables?				
14	Are all services segregated?				
15	Is fire stopping present internally and externally at penetrations				

ADDITIONAL COMMENTS:	

INSPECTORS NAME:	**SIGNATURE:**
COMPANY:	**DATE:**

7.4 Annex D VISUAL INSPECTION CHECK LIST FOR EXISTING CMS

Station Name: **Location Ref:**

Item	DESCRIPTION	YES	NO	N/A	COMMENT
	Conduit				
1	Is the CMS run complete as per design requirements?				
2	Is the CMS installed as per design specifications?				
3	Does CMS segregation meet the requirements				
4	Is the CMS galvanised?				
5	Are there enough saddle fixings and are they correctly spaced?				
6	Are the saddles securely fixed?				
7	Have the appropriate conduit boxes been utilised?				
8	Are gaskets fitted to the BESA boxes?				
9	Are there any sharp edges or burrs?				
10	Are there any threads visible where BESA boxes are fitted?				
11	Are the lock nuts tight on the conduit runners?				
12	Are all unused holes blanked off?				
13	Are all the conduit connections tight?				
14	Is there any sign of damage?				
15	Are conduit runs bonded correctly?				
16	Are all the bonding positions secure and clean?				
17	Is there any sign of rust or galvanising?				
	Trunking/Tray				
18	Is the trunking/tray galvanised?				
19	Is trunking/tray fixing less than 1.2 metres?				
20	Is the trunking/tray run securely fixed?				
21	Is trunking/tray run clear of other services?				
22	Are there enough cable retainers in the trunking/tray run?				
23	Are all the bends and tees manufactured and not site fabricated?				
24	Are there any sharp edges or corners?				
25	Are all trunking/tray and bend lids, end caps fixed securely with screws?				
26	Do trunking/tray joints butt solidly?				
27	Are copper links fixed at every joint?				
28	Are trunking/tray runs bonded correctly?				
29	Are all services segregated in trunking?				
30	Are there cable supports on vertical cable run exceeding 5 metres?				
31	Are all unused holes and slots blanked off?				
32	Is there any sign of damage on trunking/tray runs?				
33	Is there any sign of rust or galvanising?				
34	Are trunking/tray runs free from dirt, dust or dampness?				

35	Is the trunking/tray secured with the correct fixings?				
36	Is the trunking/tray run complete?				
37	Are all sharp burrs removed from the trunking/tray?				
38	Is the trunking/tray over loaded?				
39	Are all cuts painted?				
40	Are all the trunking/tray connections tight?				
41	Is the trunking/ tray secured with the correct fixtures?				
42	Do "bends" and "tees" on trunking/trays provide enough radius?				
43	Are all joints butted together?				
44	Are all trunking/tray runs bonded?				
45	Are trunking/tray runs fixed securely				
46	Are trunking/tray runs overloaded?				

ADDITIONAL COMMENTS:	
INSPECTORS NAME:	**SIGNATURE:**
COMPANY:	**DATE:**

7.5 Annex E VISUAL INSPECTION CHECK LIST FOR Rotary Switch, JB and Earth Bar

Station Name: Kings Cross **Location Ref:**

Item	DESCRIPTION	YES	NO	N/A	COMMENT
	Rotary Switch				
1	Is Rotary Switch secure to wall/building fabric				
2	Final connections tight and secure				
3	Correct Labelling				
4	CMS correctly Interfaced into switch				
5	SWA Glanced correctly				
6	Rotary Switch cross bonded to Asset with separate dedicated earth cable				
7	Is Rotary Switch level				
8	Height and orientation acceptable				
9	Location and position accessible				
	Earth Bar				
1	Is Earth Bar secure to wall/building fabric				
2	Final connections tight and secure				
3	Earth Bar connected to associated Assets				
4	Earth Bar correctly labelled				
5	Is Earth Bar level				
6	Height and orientation acceptable				
7	Location and position accessible				
	Junction Box				
1	Is Junction Box secure to wall/building fabric				
2	Final connections tight and secure				
3	Junction Box connected to associated Assets				
4	Junction Box correctly labelled				
5	Is Junction Box level				
6	Height and orientation acceptable				
7	Location and position accessible				

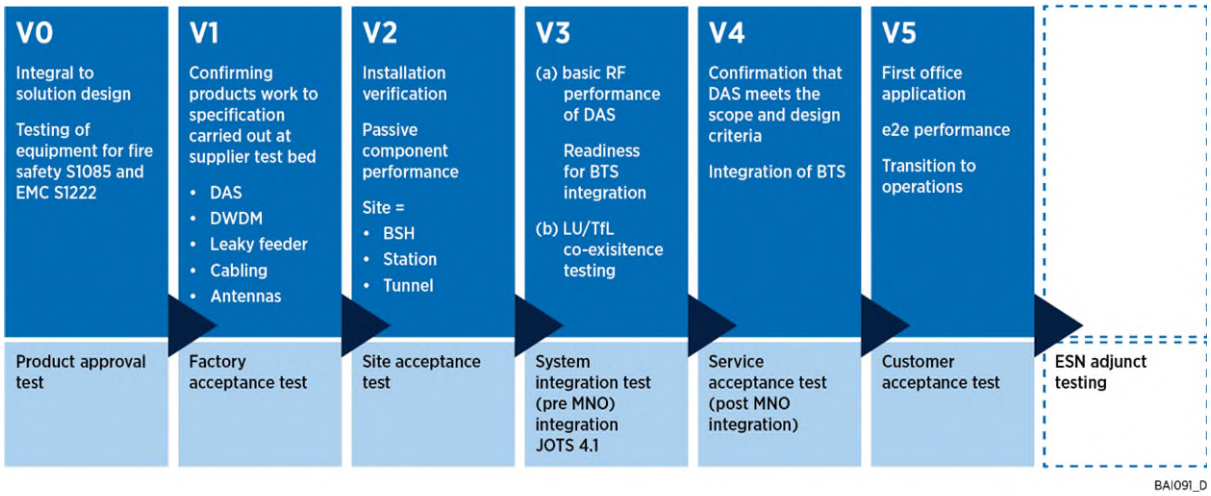
ADDITIONAL COMMENTS:	
INSPECTORS NAME:	**SIGNATURE:**
COMPANY:	**DATE:**

PART C – CMS/ESN TUNNEL

CONTENTS

1 Introduction

The purpose of the document is to describe the test environment, tools, processes, test cases, inputs and outputs, across all applicable stages of the Concessionaire's V-Stage verification model (as described in Annex 2 (Outline Test Strategy) to this Schedule 6.2), for the technical subsystems in the appropriate Service Lines of the TCP project.



2 Scope of testing

The scope of this document is CMS and ESN / Tunnel.

Sequence	CMS and ESN Service Line	
1	BSH testing	
2	Station testing	
3	Tunnel testing	←this document

3 Testing dates/schedule

To be confirmed at final Test Plan Template submission.

4 Test plan manager

To be confirmed at final Test Plan Template submission.

5 Test environment

Individual environments pertaining to FAT, SAT and further stages of the V-stages will be described in the appropriate sections of the document. To be confirmed at final Test Plan Template submission.

The tunnel system for CMS and ESN consists of the following main components:

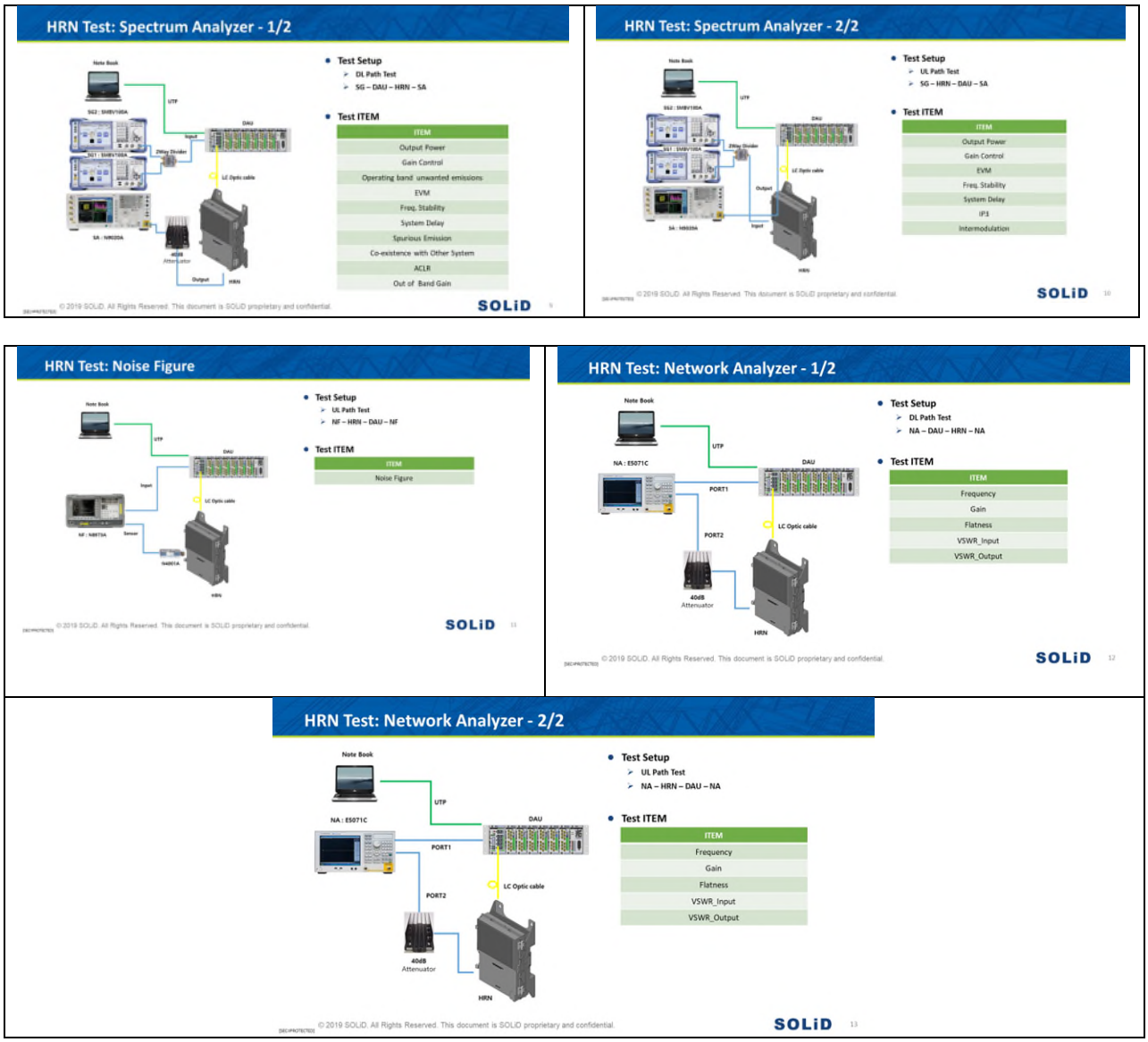
Entity	Test
High Power Radio Node (HRN) -End of tunnel -Mid tunnel (HRN, sHRN)	FAT. Commissioning tests
Optical fibre (96c)	FAT. Installation verification.
Radiating Cable	FAT. Installation verification.
Jumper Cable	Installation / visual check
Connectors	Installation / visual check
Tappers/directional couplers	Installation / visual check
DC blocks	Installation / visual check
Attenuators	Installation / visual check
Connectors	Installation / visual check
Splitters	Installation / visual check
Combiners	Installation / visual check
Power systems	Installation / electrical tests.

6 Test Stage V0 - Product approval

Product approval / materials compliance process for all key components is covered in Part B (CMS and ESN Station) to this Annex 3 (Outline Test Plan Templates) to Schedule 6.2. Additional tunnel passive based components such as the radiating cable and 96-core optical fibre are also subject to product approval certification.

7 Test Stage V1 - Factory Acceptance Test (FAT)

High Power Radio Nodes (HRN) will be Factory Acceptance Tested by SOLiD.
High Power (HPR) testing scheme is shown below:



Optical Fibre for CMS and ESN is based on the 96-core cable run throughout the tunnels by TfL.

Radiating Cable will be Factory Acceptance tested. A typical FAT schedule for Radiating Cable is shown below:

RFS GmbH QM	**Test Specification/Report Factory Acceptance Test**	Pxxxxx-A 11.09.2019

Cable Type: **RAYA158-50CPR** Art.-No.: 166xxx
Customer: **xxx**
Order No.: Xxx
Cable No.: Xxx Length: xx m
Drum No.: xxx

No.	Characteristic	Requirements Spec.	Unit	Result	Procedure / Remarks
1.	**Dimensions**				
1.1	Inner Conductor Inner Diameter	15,1 – 15,7	mm		
1.2	Inner Conductor Outer Diameter	17,3 – 17,9	mm		
1.3	Core Diameter (Foam)	42,5 – 44,1	mm		P-B034-*
1.4	Outer Conductor Outer Diameter	43,4 – 45,0	mm		
1.5	Sheath Diameter	47,2 – 49,2	mm		
2.	**Electrical Characteristics**				
2.1	High Voltage Test (DC, 1 min, 14 kV)	no breakdown			P-B004-*
2.2	Characteristic Impedance	50 ± 2	Ω		P-B026-*
2.3	Relative Velocity of Propagation	91	%		P-B026-* Nominal Value
2.4	Capacitance	72	pF/m		P-B033-* Nominal Value
2.5	Insulation Resistance	>10	GΩ*km		P-B025-*
2.6	DC-Resistance Inner Conductor	1,62	Ω/km		P-B024-* Nominal Value
2.7	DC-Resistance Outer Conductor	1,47	Ω/km		P-B024-* Nominal Value
2.8	Reflection Factor (VSWR)				P-B028-*
	698 – 960 MHz	≤ 25 (1,67)	%		
	1710 – 1880 MHz	≤ 25 (1,67)	%		
	1920 – 2170 MHz	≤ 25 (1,67)	%		
	2200 – 2700 MHz	≤ 25 (1,67)	%		

2.9 Longitudinal Loss P-B313-*

700 MHz	≤ 1,84 + 5%	dB/100m	
780 MHz	≤ 1,96 + 5%	dB/100m	
800 MHz	≤ 1,99 + 5%	dB/100m	
820 MHz	≤ 2,02 + 5%	dB/100m	
900 MHz	≤ 2,15 + 5%	dB/100m	
960 MHz	≤ 2,26 + 5%	dB/100m	
1700 MHz	≤ 3,30 + 5%	dB/100m	
1800 MHz	≤ 3,49 + 5%	dB/100m	
1900 MHz	≤ 3,69 + 5%	dB/100m	
2000 MHz	≤ 3,85 + 5%	dB/100m	
2100 MHz	≤ 4,08 + 5%	dB/100m	
2200 MHz	≤ 4,26 + 5%	dB/100m	
2300 MHz	≤ 4,54 + 5%	dB/100m	
2500 MHz	≤ 5,23 + 5%	dB/100m	
2600 MHz	≤ 5,68 + 5%	dB/100m	
2700 MHz	≤ 6,62 + 5%	dB/100m	

2.10 Coupling Loss in dB (measured with an orthogonal orientated dipole antenna) P-B313-*

Reception probability	50%		95%		
700 MHz	≤ 74 + 5		≤ 79 + 5		
780 MHz	≤ 72 + 5		≤ 76 + 5		
800 MHz	≤ 72 + 5		≤ 76 + 5		[1])
820 MHz	≤ 72 + 5		≤ 76 + 5		
900 MHz	≤ 73 + 5		≤ 77 + 5		
960 MHz	≤ 71 + 5		≤ 76 + 5		
1700 MHz	≤ 66 + 5		≤ 72 + 5		
1800 MHz	≤ 67 + 5		≤ 74 + 5		
1900 MHz	≤ 67 + 5		≤ 73 + 5		
2000 MHz	≤ 64 + 5		≤ 71 + 5		
2100 MHz	≤ 64 + 5		≤ 70 + 5		
2200 MHz	≤ 64 + 5		≤ 70 + 5		
2300 MHz	≤ 62 + 5		≤ 68 + 5		
2500 MHz	≤ 61 + 5		≤ 67 + 5		
2600 MHz	≤ 60 + 5		≤ 65 + 5		
2700 MHz	≤ 59 + 5		≤ 66 + 5		

[1]) subject to LTE live network interferences, see chart

3.	**Marking**			
	Marking of cable			Visual inspection
4.	**Fire Tests**			
4.1	Flame test, IEC 60332-1			P-B035-*
4.2	Flame test, IEC 60332-3-24			P-B030-*
4.3	Smoke Emission, IEC 61034	Light Transmission ≥ 60%		P-B036-*

Report Date:11.09.2010	Inspected:	Witnessed by Customer:	Pass: YES / NO
Specification	Prepared:	Inspected:	Approved

Pxxxxxx-A_RAYA158-50CPR Page 3 / 3

For each FAT activity, there is supporting documentation from the radiating cable manufacturer. As an example, these will include test and measurement set-ups for:

- Conductor resistance
- Insulation Resistance
- Characteristic impedance and velocity ratio
- Capacitance

- Reflection Coefficient measured with a Vector Network Analyzer, frequency- and time-domain.

8 Test Stage V2: Site Acceptance Test (SAT)

8.1 Aim

The purpose of this stage is to verify the installation.

Key components of the tunnel system include:

- Radiating cable
- Connectors
- Power system
- Optical fibre connection to HRN/SHRN
- High-Power Radio Node (HRN) at tunnel portal
- Slim High-Power Radio Node (SHRN) mid-tunnel.

8.2 Electrical Installation

The following information should be tested/ recorded for new electrical connections:

i. Earth fault loop impedance
ii. Continuity of protective conductors
iii. Insulation resistance – between live conductors and between conductors and Earth
iv. Polarity
v. Verify phases and voltage drops
vi. Issuing of relevant NICIEC certificate

8.3 High Power Radio Node (HRN)

Thorough inspection that the HRN at / near tunnel portal meets the SOLiD Installation Guidelines and meets the site-specific Low-Level Installation Design.

8.4 Optical Fibre

The existing 96-core fibre will drop off optical connections at each station.
A 24-core fibre from the appropriate station cabinet to the HRN unit is required. This should be tested as per the CMS+ESN Station Test Plan template.

8.5 Radiating cable testing in-situ

8.5.1 Approach

The radiating cable system includes the leaky feeder, associated connectors, Tappers and DC blocks.

Testing will comprise of:

- Visual checks of cables.
  - Correctly fastened.
  - Distance from wall / reflective surface
  - Bend radius checks
  - RF slots have correct orientation
  - Checking for kinks, knocks
  - Measure lengths of cables and inter-cable distances
  - Installation of cable earthing in line with manufacturers recommendations

- Installation of DC blocks

- VSWR test of cable.
- Insertion Loss Measurement.
- PIM test of cable

This testing approach addresses those components of the TfL TCP solution required in tunnels, i.e. leaky feeder and associated connectors, mid tunnel radios and coaxial jumper cables, as described in the:

a) High Level Design
b) The Low-Level Design specification produced for each of the tunnel sections in scope.

8.5.2 Testing process

An industry standard cable test set will be employed (Anritsu or equivalent). The device will be calibrated at the start of every test shift.
Each contiguous length of Leakey Feeder and Coaxial Jumper Cable will be tested for:

a) Cable Loss
b) Cable Length
c) Distance to Fault
d) Return Loss

Each test will be carried out with at least one low band and one mid band for the following frequencies:
Low band
a) 800 MHz – 791 to 862 MHz start and stop frequencies respectively.
b) 900 MHz – 925 to 960 MHz
Mid band
c) 1800 MHz - 1710 to 1880 MHz start and stop frequencies respectively.
d) 2100 MHz - 1920 to 2170 MHz start and stop frequencies respectively.

Workflow will follow the steps listed below:

i. Cables and Fixings report for new tunnels sections received from Installation Team.
ii. Cable tester to be calibrated at the start of every shift once device temperature matches the environment.
iii. Each individual length of cable to be tested is assigned a unique identifier, according to a predefined syntax.
iv. A single Test schedule spreadsheet is maintained for each line with a tab for tunnel sections updated as each tunnel section completes Radio Design Assurance, and a tab per station detailing all tests to be performed at that station.
v. Test schedules are issued to test teams. The test teams determine the sequence of testing in conjunction with the installation teams, accounting for overlapping works, resource availability or environment-specific constraints.
vi. Measurements are taken during engineering hours. Minor issues are resolved and retested on the night and major issues reported back to installation team for remedial work, in which case retesting is planned.
vii. Local survey teams are instructed to either switch off their mobile devices or put them in flight-safe mode over the measurement window.
viii. Measurement files are downloaded from cable testers each morning and stored using IT solutions with adequate backup/resilience features. Measurement files are then emailed back to Installation Assurance Team.
ix. Collate raw measurement files for report.

8.5.3 Test Reporting

Measurement Report produced per tunnel section and per road.

The sequence of graphs in the report will follow the physical succession of measured cable runs, along travel direction, regardless of the start and end position of each measurement or date of capture.

A test report will be produced for each tunnel section in scope of TCP. Each contiguous length of cable within that tunnel section will have its own set of test results (measurement graphs with markers) embedded in the test report.

Further details of testing for power and optical feeds for the HRN and SHRNs will be provided when this document is up issued to final status.

8.5.4 Expected results

Leaky Feeder

The expected results and pass/fail criteria are described in the following table:

Test	Measurement Type	Expected Results and Pass/Fail Criteria
Cable Loss	Document	Predicted link budget loss +/- 10%
Distance to Fault - VSWR	Pass//Fail	≤1.4
Return Loss	Pass/Fail	>15dB
PIM test	Pass/Fail	Testing at a low and high band (800MHz, 2100MHz), transmitting 2x20W. Result <-151 dBc, +/- 5%

Optical Fibre Cable

Wavelength	Splice	Connector	Reflectance	Overall loss	Attenuation
1310 nm	<0.3dB	<0.75 dB	>-50dB	Optical budget +/- 5%	0.4dB/km
1550 nm	<0.3dB	<0.75 dB	>-50dB	Optical budget +/- 5%	0.25dB/km

9 Test Stage V3: System Integration (pre MNO)

Tunnels will have been walked, to ensure that the feeder is installed correctly and is working as expected.

Carrier Wave (CW) testing will be carried out. This confirms that the Tunnel HRN and associated radiating cable is fault free and verifies coverage dominance, as well as confirming fibre connectivity from the HRN.

CW will be injected using either equipment at the Base Station Hotel, if the BSH is ready, or alternatively equipment at the station site if the BSH is not yet fully commissioned. This can take the form of a signal generator or portable DAS headend on wheels.

CW testing will be carried out at mid-points in the 800MHz, 900MHz, 1800MHz and 2100MHz bands.

Before HRNs can be energised dialogue with the relevant TfL departments will be carried out to ensure compliance. The TfL Network Operations Centre (NOC) will be contact to confirm no interference with critical systems.

RSSI measurements will be taken along the length of the radiating cable within the tunnel at equidistant points and recorded at the correct location on the tunnel topology map.

The recorded CW measurements will be post processed and presented as a graphical snail trail map showing the equivalent RxLev, RSCP and RSRP levels.

10 Test Stage V4: Service acceptance (Post MNO BTS integration)

This testing is to validate the coverage and performance of live MNO coverage when integrated to the ADAS within public tunnel sections.

The most efficient way to test tunnel coverage is to use test equipment / test UEs on a train and carry out the coverage tests.

The tests will include the following:

Idle Mode drive tests: Using a scanner to capture all MNOs, frequency bands, serving and neighbour cells covering the following:

- 2G: RxLev/RxQual/Best Server
- 3G: RSCP/EcNo/Best Server
- 4G: RSRP/RSRP/Best Server
- DAS Zone overlap plots

The above will be presented as snail trail heatmaps on tunnel drawings and graphed results for each test conducted, producing a plot for each frequency & technology per MNO.

Dedicated Mode drive test: Walk tests shall be repeated with a UE (User Equipment) in a call to ensure coverage and quality are sufficient to hold a call throughout the appropriate tunnels. The test also validates that the ADAS sectorisation is correct to ensure handover between neighbouring sectors as per the station sector plan.

- 2G: RxLev/RxQual/Serving cell
- 3G: RSCP/EcNo/ Serving cell
- 4G: RSRP/RSRP/ Serving cell

The test mobile shall not be locked to a band such that it is free to move between frequency layers freely.

The above will be presented as snail trail heatmaps on tunnel drawings and graphed results for each test conducted.

11 Test Stage V5: Customer acceptance

11.1 CMS requirements.

Subject to the arrangements with the individual MNOs, end-to-end performance testing may be carried out, with connection back to the MNO Core Network.

This includes:

Call tests:

- CSFB/VoLTE call test per DAS Zone

- Fast Reselection time to 4G

Data tests:
File transfer tests using the FTP protocol shall be undertaken to validate the performance of 3G and 4G data services:

3G FTP:
- Download (50MB file)
- Upload (20MB file)
- RTT Ping

4G FTP:
- Downloads (200 MB file)
- Upload (100 MB file)
- RTT Ping

The test shall use the Radio Opt: Traffic Monitor Plus mobile application.

Test Set Up
Idle Mode Tests
Idle mode tests will be undertaken using an RF scanner as shown below. The scanner will allow the tester to capture all MNOs spectrum bands that are radiating in the station.

Dedicated Mode tests

Dedicated mode testing will be undertaken using a backpack mounted test mobile setup shown below and controlled from a tablet computer.

The test backpack contains a number of test mobiles, capable of measuring and recording signal level and quality, as well as other network KPIs. Sufficient test mobiles will be provided to ensure that all MNOs can be tested in one walk tests.

Tunnel Drive Test Methodology:

All tunnel drive tests shall be conducted following the methodology set out in JOTS using the following rules to ensure sufficient data is captured to present an accurate representation of coverage and performance.

Each test shall be conducted sat at a mid-point of the carriage, and repeated at the front, middle and rear of the train.

Coverage and call tests shall be conducted starting at the end station of the line, or at the preceding station of the route prior to where the line enters the underground tunnel. The test will run continuously to the far end of the line or route to where it exits to above ground track, this will ensure that correct handover between the ADAS and the macro layer is confirmed.

Data markers will be inserted into the captured results at entrance and exit of each station platform to identify tunnel sections without the use of GPS positional data.
The testing will be conducted in both directions of travel along the line.

Pass Criteria:

The following levels shall be utilised for each of the tests conducted above:
Idle & Dedicated Mode Tests

2G	**Pass Criteria**
RxLev	>-95dBm
RxQual	>7
Best Server	As per sector plan
3G	
RSCP	>-105dBm
Ec/Io	>-13dB
Best Server	As per sector plan
DAS Zone overlap	+/- 5dB
4G	
RSRP	>-105dBm

RSRQ	>-13
Best Server	As per sector plan
DAS Zone overlap	+/-10dB

Test Output

Coverage and quality plots, shall be presented as heat map snail trails plotted on station floor plans, covering the area under test.

The plots shall be formatted using the following threshold levels and colour schemes:

GSM:

	RxLev (dBm)
	≥–55
	-55,-65
	-65,-75
	-75,-85
	-85,-95
	-95,-98
	-98,-101
	-101,-103
	-103,-106
	<-112

	RxQual
	1,3
	-4
	5
	6
	7

UMTS:

	RSCP (dBm)
	≥–55
	-55,-65
	-65,-77
	-77,-87
	-87,-97
	-97,-100
	-100,-106
	-106,-109
	-109,-112
	<-112

	Ec/Io (dB)
	>-4
	-4,-8
	-8,-10
	-10,-13
	<-13

LTE:

	RSRP (dBm)
	≥–65
	-65,-80
	-80,-95
	-95,-105
	-105,-110
	-110,-113
	-113,-116
	-116,-118
	-118,-121
	<-11

	RSRQ (dB)
	-4, MAX
	-7,-4
	-10,-7
	-13,-10
	MIN, -13

	SNR (dB)
	->20
	14,20
	6,14
	-0,6
	<0

Full log files are to be made available in all cases, to be used in cases where further/deeper analysis becomes necessary. These must be either Nemo or TEMS, or a CSV export containing specific agreed data fields, accompanied by a Geo-Located Tab File for the floor plan.

Log file naming convention should follow this format: *Operator_Technology_State_Location_Date_Time*

12 Test Stage - ESN adjunct testing

12.1 First-on-Air scenario

The TfL ESN High Level Design document calls for a first on air scenario (First Office Application or FOA) agreed between TfL and ESN Coverage Supplier in order to validate performance and processes.

Aim of first on air trial is to test in real deployment all defined criteria and procedures, evaluate their feasibility and transfer to Operations and Service Management.

Key in this activity is to provide stakeholders with confidence around the system. For ESN, this would include:

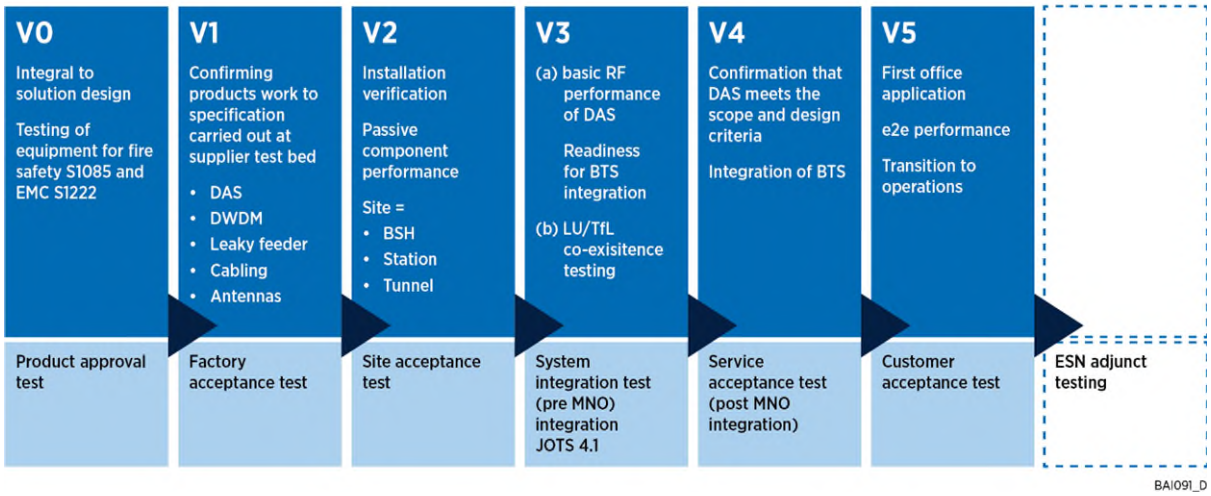
- ESN Coverage Supplier
- TfL
- Home office
- User community
  - Police
  - British Transport Police
  - Fire
  - Ambulance services

PART D – EIP

CONTENTS

1 Introduction

The purpose of the document is to describe the test environment, tools, processes, test cases, inputs and outputs, across all applicable stages of the Concessionaire's V-Stage verification model (as described in Annex 2 (Outline Test Strategy) to this Schedule 6.2), for the technical subsystems in the appropriate Service Lines of the TCP project.



2 Scope of testing

The scope of this document is ESN Service Line / Emergency Intervention Point (EIP).

Sequence	ESN Service Line	
1	BSH testing	
2	Station testing	
3	Tunnel testing	
4	EIP	←this document

3 Testing dates/schedule

To be confirmed at final Test Plan Template submission.

4 Test plan manager

To be confirmed at final Test Plan Template submission.

5 EIP definition

In the ESN Service Line scope there are a number of Emergency Intervention Point (EIPs), known as ESN Annex 3 locations within the TCP contract. These require ESN only coverage.

Type	Number
Tunnel related. These comprise non-public entrance ways, spaces and equipment rooms throughout the tunnel network.	31
Station related. These consist of disused stations, some with street level entrances, walkways and platforms.	4
Total	35

Figure 1 is a high-level map showing EIP locations:

Figure 1 EIP locations

6 EIP design aspects

Where coverage is required for an EIP, a bespoke RF design will be created. Preference will be given to using the existing ADAS passive infrastructure rather than allocating new active equipment for an EIP that will see minimal ESN traffic throughout its life. For example, a tunnel EIP could be covered by running leaky feeder up the staircase coupled from the trackside ESN leaky feeder, thereby removing the need for additional HRNs, fibre, and backed up power dedicated solely for the EIP.

The Concessionaire will provide ESN coverage on 800 MHz where appropriate, providing coverage using a small passive DAS comprising leaky feeders and antennas to cover a long staircase or shaft. Utilising 800 MHz would require less infrastructure than 1800 MHz to achieve the same level of coverage and performance. In addition, utilising 800 MHz back of house could require less infrastructure overall which lessens the impact on the TfL estate.

Each ESN Annex 3 location will be surveyed, as part of the Detailed Design process, when the corresponding station or tunnel is designed to assess the best coverage solution for each Annex 3 locations. Coverage leakage will be controlled and tested in the same manner as CMS to ensure that it does not introduce interference to the MNOs' macro layer

7 Test Stages

The tests for an EIP will follow the Concessionaire's V-Stage process.

7.1 Stage V0 – Product Approval

Product approval / materials compliance process for all key components is required as a pre-requisite.

7.2 Test Stage V1 - Factory Acceptance Test (FAT)

FAT will be carried out for the SOLiD DAS system. Interoperability results with the ADVA DWDM will be provided. Witness testing of the radiating cable and optical fibre products will also be carried out.

7.3 Test Stage V2: Site Acceptance Test (SAT)

The purpose of this stage is to verify the installation of the key components of the site.

7.4 Test Stage V3: System Integration (pre ESN Coverage Supplier BTS)

Carrier Wave (CW) testing will be carried out before BTS integration at the BSH.

CW will be injected using either equipment at the Base Station Hotel, if the BSH is ready, or alternatively equipment at the station site if the BSH is not yet fully commissioned. This can take the form of a signal generator or portable DAS headend on wheels.

7.5 Test Stage V4: Service acceptance (Post ESN Coverage Supplier BTS)

This testing is to validate the coverage and performance of live ESN coverage when integrated to the ADAS within non-public sections.

7.6 Test Stage V5: Customer acceptance and adjunct testing

7.6.1 First-on-Air scenario

The TfL ESN High Level Design document calls for a first on air scenario (First Office Application or FOA) agreed between TfL and the ESN Coverage Supplier in order to validate acceptance procedure.

Aim of first on air trial is to test in real deployment all defined criteria and procedures, evaluate their feasibility and transfer to Operations and Service Management.

Key in this activity is to provide stakeholders with confidence around the system. For ESN, this would include:

- ESN Coverage Supplier
- TfL
- Home office
- User community
  - Police
  - British Transport Police
  - Fire
  - Ambulance services

8 Testing plan template approach

8.1 EIP test plan

A specific EIP test plan will be created, based on the specific Outline Test Plan Template below. Additional tests required by the ESN programme for the key stakeholders will be captured during the creation of those plans.

8.2 Tunnel related EIPs

For detailed testing methods, please refer to the Outline Test Plan Template for ESN Tunnels.

8.3 Station related EIPs

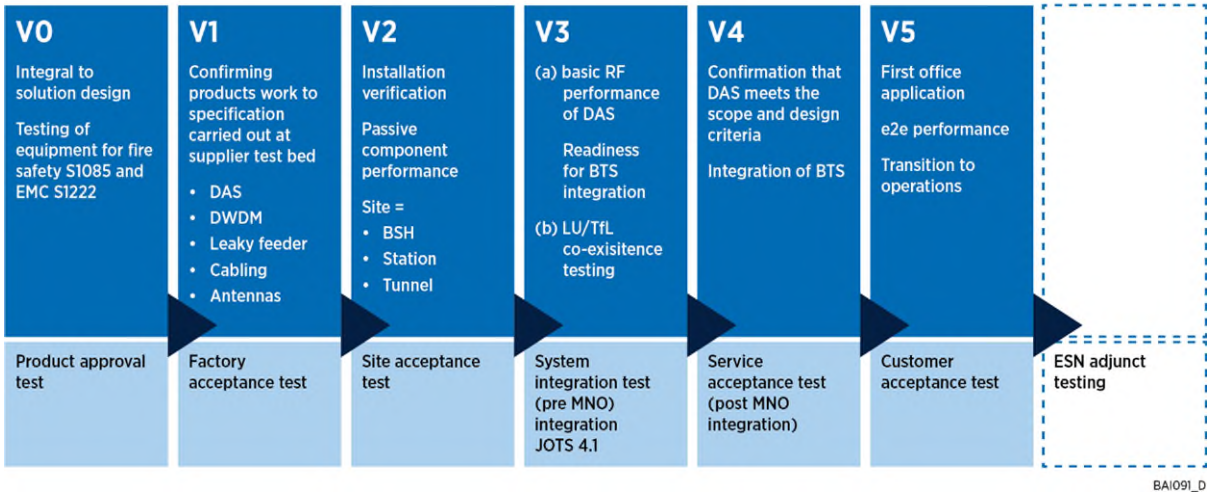
For detailed testing methods, please refer to the Outline Test Plan Template for ESN Stations.

PART E – PoP

CONTENTS

1 Introduction

The purpose of the document is to describe the test environment, tools, processes, test cases, inputs and outputs, across all applicable stages of the Concessionaire's V-Stage verification model (as described in Annex 2 (Outline Test Strategy) to this Schedule 6.2), for the technical subsystems in the appropriate Service Lines of the TCP project.



2 Scope of testing

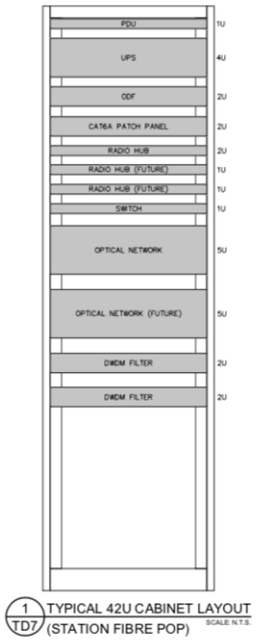
The scope of this document is Fibre Services / PoP (Point of Presence).

To provide fibre connectivity, streetscape connections and services to public assets, stations will be enabled to act as a PoP. A 42U Station PoP cabinet will reside in the station on at street level, or alternatively external to the station in a street cabinet, depending on space available within the station. The PoP consists of a high-density Fibre Optic Splice Enclosure (FOSE) which will be used to connect fibre from the Concessionaire's core fibre network to a demarcation point. From there the optical connectivity can be exposed.

From the FOSE, fibre will be patched to the PoP rack and then spliced through as dark fibre back to the Base Station Hotel or in the future via active ethernet aggregation switches.

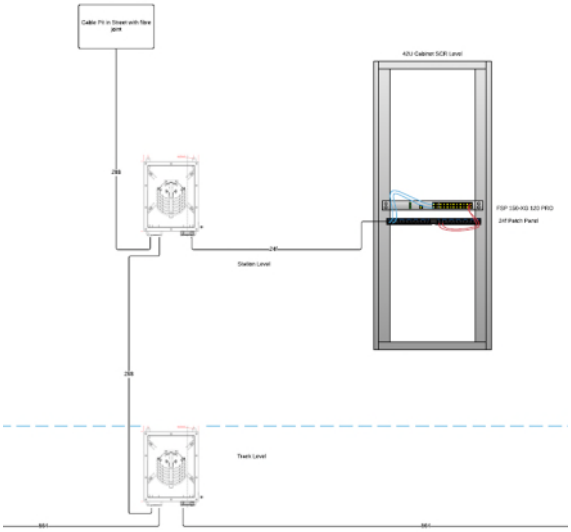
The exact constitution of the fibre link will vary, station by station. The reference design calls for a 288 spur from the PoP to the commercial 864 fibre network.

A fully populated PoP is shown below.



1 TD7 TYPICAL 42U CABINET LAYOUT (STATION FIBRE POP) SCALE N.T.S.

For the purposes of testing, a basic variant will be verified, as the requirement and demand for customer connectivity will be market led. The basic PoP structure is shown below.



3 Testing dates / Schedule

To be confirmed at final Test Plan Template submission.

4 Test plan manager

To be confirmed at final Test Plan Template submission.

5 Test environment

Individual environments pertaining to FAT, SAT and further stages of the V-stages will be described in the appropriate sections of the document. To be confirmed at final Test Plan Template submission.

Entity	Passive Test	Active Test
Optical fibre	X	
Fibre Optic Splice Enclosure	X	
DWDM / Ethernet		X
Power system and UPS		X

The foundation of the PoP testing will focus on essential connectivity using the passive components. Future additional testing utilising active equipment will be dependent on market demand.

6 Testing stages

The testing of the basic PoP entity will focus on V2 – Site Acceptance.

Entity	V-STAGE	Description
Optical fibre and FOSE	V0 Product Approval	Optical cables to undergo Materials Testing, as per CMS Station Test Plan
	V1 Factory Acceptance Test	Optical fibre will be FAT tested at manufacturers' HQ
	V2 Site Acceptance	**Basic PoP installed with bearer connectivity.**
	V3 System Integration	Required when Active component needed
	V4 Service Acceptance Test	Required when 1st customer connected
	V5 Customer Acceptance	Subject to contract with customer

7 Site acceptance – stage V2

The purpose of this stage is to verify the installation of the PoP and verify its integrity as a fibre demarcation point.

Test equipment will be a calibrated Optical Time Domain Reflectometer (OTDR) and Insertion Loss Measurement test set.

- Visual checks of cables.
  - Correctly fastened.
- Optical fibre tests:
  - The Concessionaire will ensure that all contractor personnel engaged in installation, handling and testing of the fibre optic cable and connectors are certified and trained.
  - Bi-directional OTDR test of cable at 1310nm and 1550nm (raw data and PDF report), from BSH to PoP.
  - Bi-directional Insertion Loss Measurement (ILM) trades at 1310nm and 1550nm (raw data and PDF)
  - Full traces of the link in both directions: A-B, B-A.
  - Data will be compiled in a standardised characterisation sheet. Location A and B to be recorded, including room, rack location, patch panel ID and fibre position.

PART F – WI-FI

CONTENTS

1 Introduction

The purpose of the document is to describe the test environment, tools, processes, test cases, inputs and outputs, across all applicable stages of the Concessionaire's V-Stage verification model (as described in Annex 2 (Outline Test Strategy) to this Schedule 6.2), for the technical subsystems in the appropriate Service Lines of the TCP project. This is shown below in Figure 1.

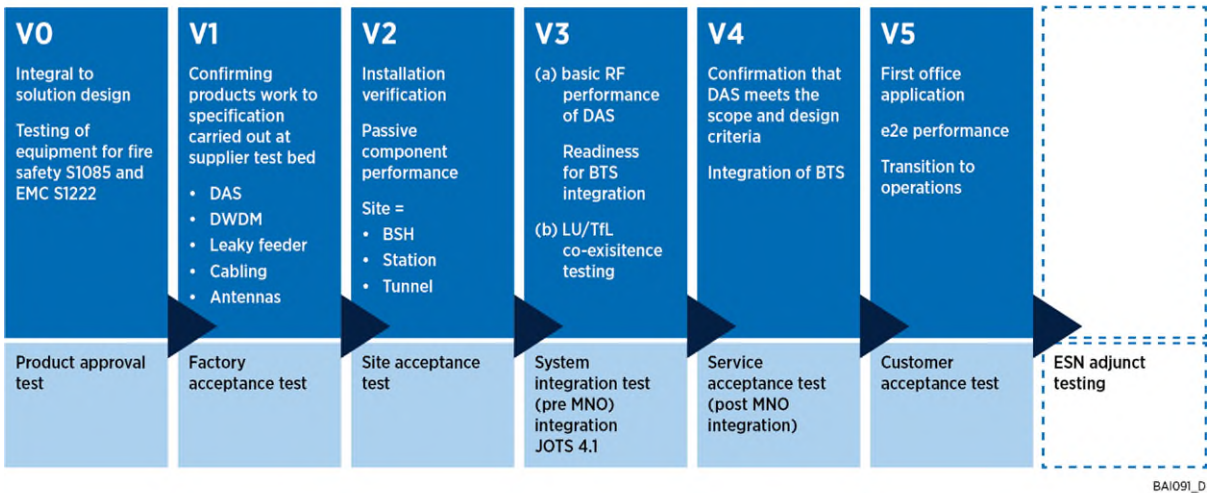


Figure 2 6-stage verification model

2 Solution

The Concessionaire will provide Public Wi-Fi, with two variants:

a) MNO access as today. Seamlessly connect, via EAP-SIM, end customers mobile devices onto the Public Wi-Fi network and ensure security is maintained.

b) A new open access Public Wi-Fi.
Users will gain access via Captive Portal intercept or online OSU (Hotspot 2.0) registration process. This will utilise current TfL user experience. Access is free of charge. Options for users to see an Interstitial page (message or advert) will be available on the platform.

3 Scope of testing

This test plan template comprises activities across:

- Public Wi-Fi
- Authentication Service
- Content Filtering Service
- Internet service

4 Testing dates/schedule

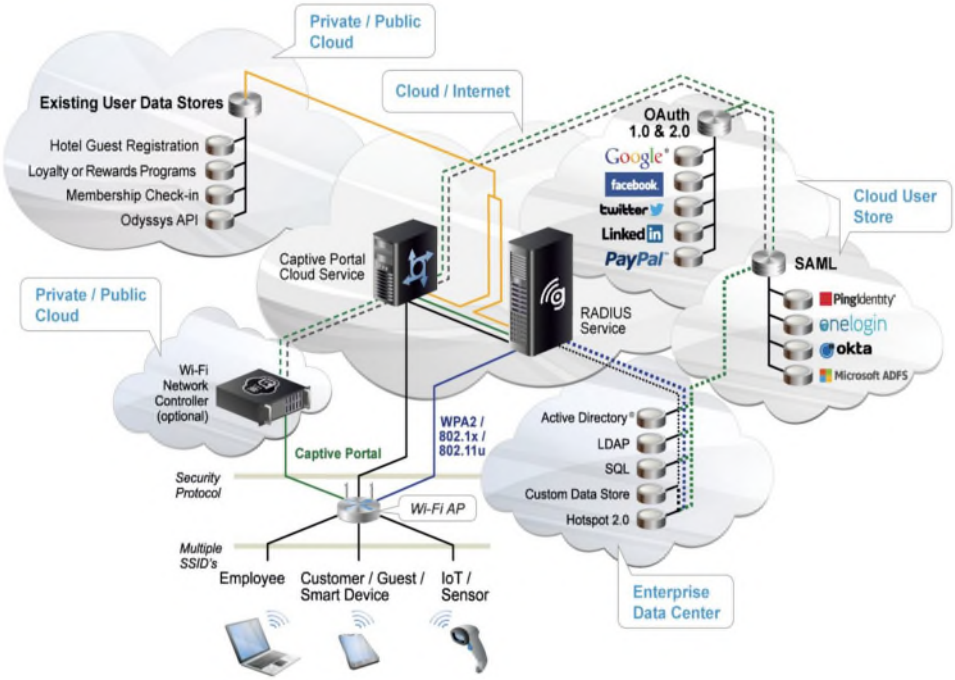
To be confirmed at final Test Plan Template submission.

5 Public Wi-Fi test plan

The Concessionaire shall deliver a public Wi-Fi Customer Product which shall be available direct to End Users (the "Open Access Customer Product").

The product shall not require each End User to have any agreement with a third-party supplier in order to gain access to the Wi-Fi in the Public Wi-Fi Services Locations. Access can either be by anonymous login or a registration managed by the Concessionaire.

The diagram below shows the system under test:



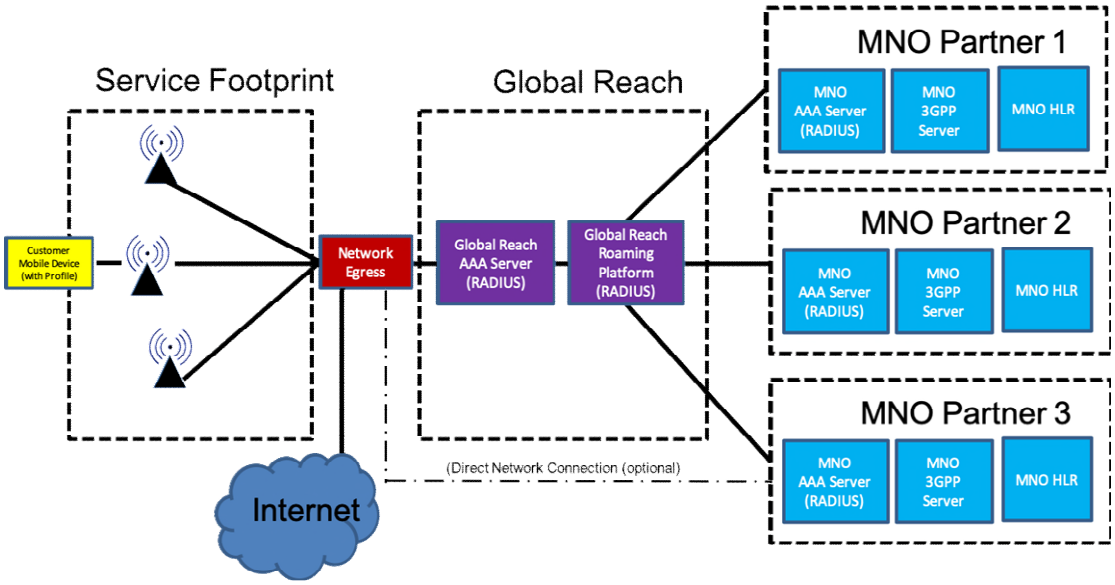
6 Authentication service test plan

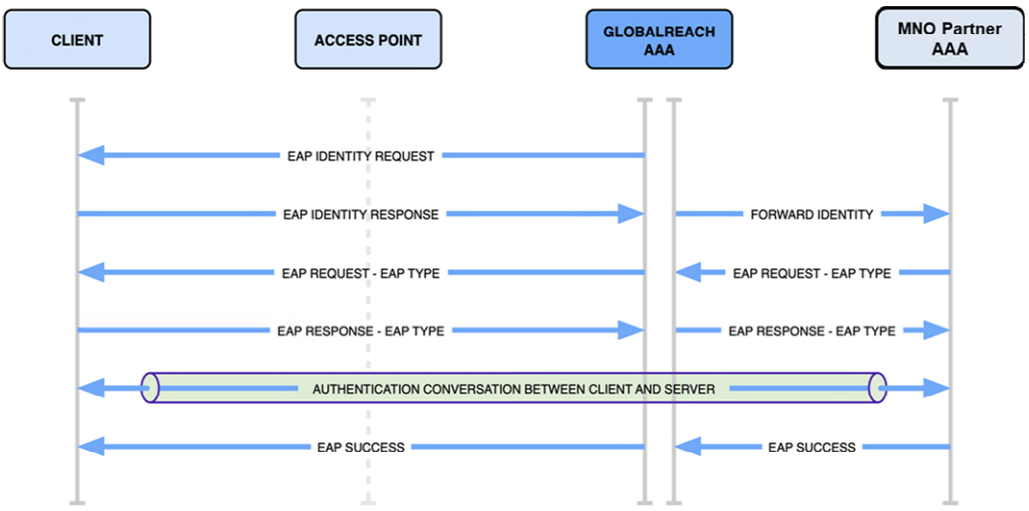
For the design and build of the Authentication Service the Concessionaire shall use: the TfL defined user experience design; and the TfL provided front-end UI code and UI assets.

The Concessionaire shall update the user interface at TfL's request, which shall be requested no more than four (4) times per Contract Year.

The Authentication Service uses EAP-SIM.

The user flow below details the authentication exchanges between the various devices, appliances and protocols when authenticating mobile SIM based devices against MNO providers using the Global Reach AAA platform.





Test sequence for Authentication/Registration

i. Record hardware, software, firmware on all entities – device, access points, AAA servers.
ii. Confirmation that client device associates with Access Point.
iii. Check the device types register with the network and has a valid IP address.
iv. Utilise Wireshark protocol analyser, or equivalent, to check 802.1X protocol flows.
v. Check RADIUS server databases. Check authentication logs on server.
vi. E2E verification with MNO(s)

7 Content filtering test plan

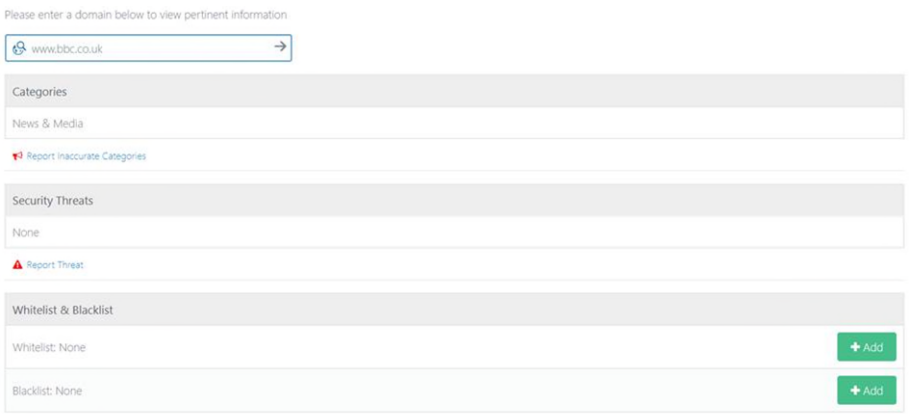
The design requirements stipulate that the Concessionaire shall filter unsuitable content in accordance with the codes of practice (as amended) issued in accordance with the Digital Economy Act 2017.

Content filtering is provided by linking to third party blank-and-whitelists, explicitly blocking access to a controlled list of domains agreed with TfL, and display a branded page explaining why this domain is blocked.

In the dashboard designed by the Concessionaire's Wi-Fi Subcontractor is a tool providing a Domain Look Up (DUL) service. The DUL tool is central for two activities:

i) Seeing how the service classifies a domain
ii) One-click reporting of inaccurate categories and threats.
Once a specific domain name is entered, the DUL tool will find the classification of that domain, as well as any threat categories that may be associated. It will also check the domain against policies to see if it is in any of the whitelist/blacklist repositories.

1.



The Concessionaire's Wi-Fi Subcontractor aggregates and analyses a vast amount of public malicious/non-malicious web site datasets to provide the most accurate threat insights.

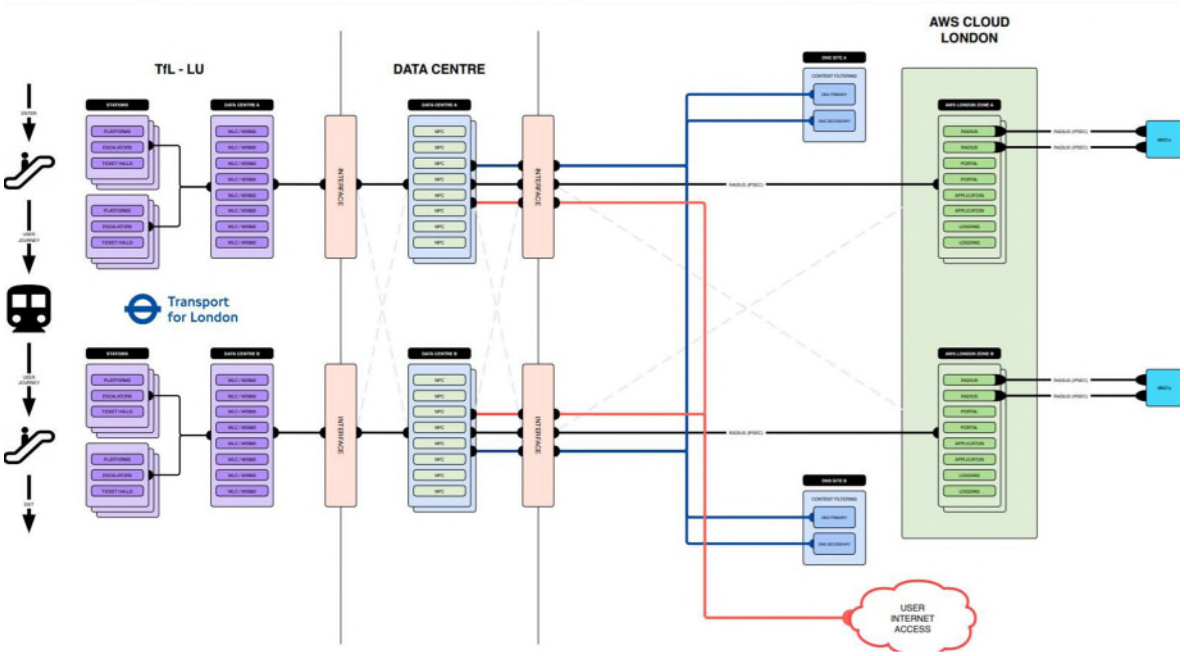
8 Internet service test plan

The Concessionaire shall ensure that the Open Access Customer Product shall provide End Users with Internet access once they have been authenticated in accordance with the Authentication Service (the "Internet Service").

2. Test plan to be developed will include:

- Test review with ISP
  - Assessing ISP core network and routing policy
  - Assessing CDN relationships and how connections to content providers work
- Test plans
  - Physical layer: transmission link, BER
  - Logical layer: IP ranges, DNS, routing tables, border gateway
- Lining up links
  - Physically
  - Logically
  - Cut over
- Post connection performance monitoring

9 Supporting material



3.

The attached draft plan outlines the overall testing approach by Global Reach, our Wi-Fi authentication partner for the overall domain.

TfL WiFi

Requirement for Functionality Testing of Migration & Build of Public WiFi Services (template)

02/09/2019

global reach
Your WiFi, Your Way.

3 Contents

4 Introduction

4.1 Purpose

This document is a high level presentation of the test approach to be undertaken in relation to the TfL SOW Migration & Authentication Schedule 1 & SOW query string Schedule 3. This document will be used as a reference by Global Reach to develop a Test Plan with details of test activities resourcing and schedules.

After reading this document, the reader will have a good understanding of:

- The objectives of software testing
- Test activities in different stages of the project lifecycle
- The different test levels and test types
- Entry and exit criteria including reporting
- Requirement Driven Testing (RDT) approach
- Creating and maintaining test artefacts
- Key testing processes and procedures

This Test Strategy will underpin all subsequent testing activities and as such is presented for Tom Thorogood for sign off as approval of the proposed approach. Formal approval will enable more detailed test planning and management to begin in earnest.

4.2 Project Overview

The project will be to build new Tfl Public WiFi UX service to the GRT Odyssys platform. This will involve setting up the new UX onto a new Radius instance and database. Once tested the TFL NPCs will be pointed to the new Radius where the new UX will be presented to Users onsite. As agreed all Users will be treated as "new" following migration to new Odyssys platform.

GRT shall create a Query String after the User has connected to the public WI-FI. Query strings to be generated by GRT from information User types into the landing page. This will provide the User details, allowing TFL to add or update the Users details in the TFL customer database each time a User connects to the public Wi-Fi.

The three areas of Global Reach testing will include:-

1. Back end Functionality (HTML/CSS/device detection/user string push to TFL)

   Global Reach will test the central components of the service, for authentication, data capture and hosting the Landing Pages.

2. Capacity and load testing

   Global Reach will load test and produce a report which will analyse timings.

3. UX (layout, content, language translations, redirection for TFL home page etc)

GRT will perform full functional testing of the UX to verify it performs as described in the SOW Migration & Authentication Schedule 1. Global Reach will test the new registration service per Site per portal to verify that the service performs as expected. This will include, that the UX is working as expected. TFL will perform tests of the service from each Site

UAT of UX and the validation of query string should be done by TFL

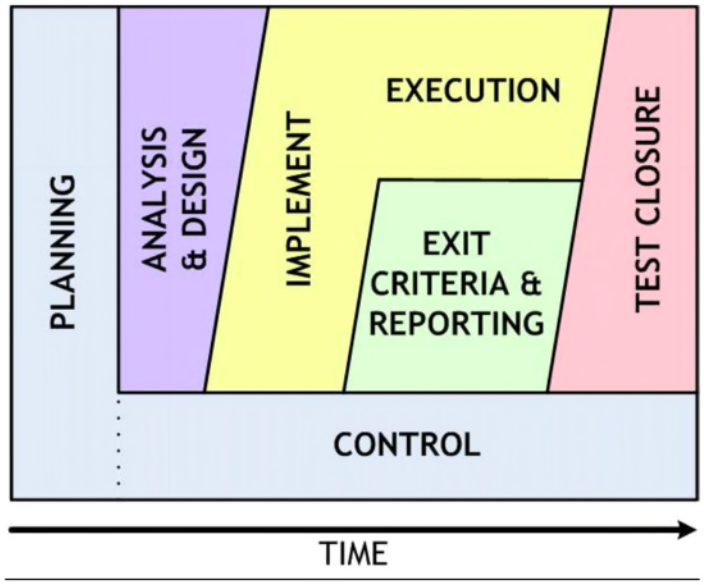
4.3 Testing objectives

The testing objects are to validate and verify that the system functionality works within the specified requirements and provides the required functionality to both TfL and their End customers.

Testing will provide confidence for business owner that the solution meet business needs.

4.4 Test Process[1]

The following diagram shows the high level test management activities throughout the Software Development Life cycle. These activities are shown in their logical order but might be repeated due to scope or resource changes.



With the exception of the 'Test Closure' phase and 'Planning' phase, all other phases in this diagram should be implemented for each level of testing. Details of test types will be explained in latter section.

During the Implement / Execution window the TfL business owners and/or TfL business users are required to participate in the testing process

To ensure the delivery items are in line with business objectives and requirements, the following key documents are to be approved by Tom Thorogood (if possible before writing test cases):

1. Test Strategy (this document)
2. Business requirement documentation (within SOW Ref 01 & 02)
3. Acceptance criteria (within SOW Ref 01 & 02)

5 Test levels and test types

This section describes the relationship between different test levels and test types which are to be included for different development phases.

5.1 Test levels

Test levels are used to split testing phase into logical phases and set clear boundaries for each level of testing. In most 3-tier applications there are 3 different levels of testing to focus on:

- Component testing
- System testing
- And User Acceptance Testing (UAT)

Component testing relates to the testing of individual software components built specifically to meet the requirements as per SOW Ref 01 & SOW Ref 02

System testing is looking at the behaviour of the whole Global reach platform for given scenarios. This is usually applying business processes in an environment that mirrors production as closely as possible.

Finally, the business owner is responsible for completing the UAT to establish confidence in the system. The business owner might choose to create test cases independently or use existing test cases. The frequency and extent of UAT varies for different projects.

5.2 Test types

Test type is about applying the appropriate type of testing method to verify specific business requirements. For example, usability and compatibility testing is required for public facing portal and User Experience.

Test Types	Component Testing	System Testing	UAT
Static test	Yes		
Functional test	Yes	Yes	Yes
Non-functional test		Yes	Yes
Security test			Yes
Negative test	Yes	Yes	
Regression test			

Table 1 - Test levels and test types

6 Pass/fail criteria

Test Scripts will be developed as a part of every test case. The test scripts will contain test steps, expected results, pass criteria and fail criteria.

Broadly speaking, deviation from what is written in a functional / technical specification will be considered a defect. A defect might not always result in failure.

Where a defect is identified, a defect record will be raised for each deviation between the test result and the expected result recorded in the test scripts, which are in turn based on the relevant functional / technical specification.

If the incident is investigated and found not to be an error, the defect will be assigned back to the owner for closure.

If the incident is found to be a genuine error, it will be prioritised based on input from the relevant developers and testers. If discussion on the incident priority cannot reach agreement it will be escalated to the Test Manager and Project Manager(s) for a decision.

6.1 Entry Criteria

The following conditions are preferred before any testing can begin:

- Global Reach should have no P1 defects open from integration testing to meet entry criteria
- Global Reach should have no open P2 defects open from integration testing
- Global Reach should have no more than 5 Global Reach owned P3 defects open from integration testing
- Business requirement/SOW documentation is signed off by business owner
- Segments of development code are unit tested before released to the test environment
- Test artefacts are up to date and prioritised according to risk based analysis
- Test environment must be ready and accessible
- Actions for outstanding issues are finalised and assigned to the correct area
- Technical resources have been allocated and are available for support

6.2 Exit Criteria

These are the minimum acceptable conditions before promoting the SBR solution to a live production environment:

- There are no outstanding P1 Defects
- There are no outstanding P2 Defects
- There are no more than 5 outstanding P3 Defects
- All Test Cases with a high and medium priority have been successfully executed
- Approval to proceed to production environment received fro TfL
- During the course of the testing, certain tests (and by extension certain pieces of functionality) may not be tested due to project's constraint. If tests cannot be executed, approval will be sought from the Test Manager and Project Manager(s) and this will be recorded, as well as the reasons why, in the appropriate test report

7 Project Conditions

7.1 Assumptions

The following assumptions have been made in preparing this test strategy:

- The test environment will be available at the start of the testing period
- Technical resources will be available to provide support for the resolution of project issues/defects
- All business requirements will be finalised, documented and incorporated into the documents which form the test base prior to the start of testing

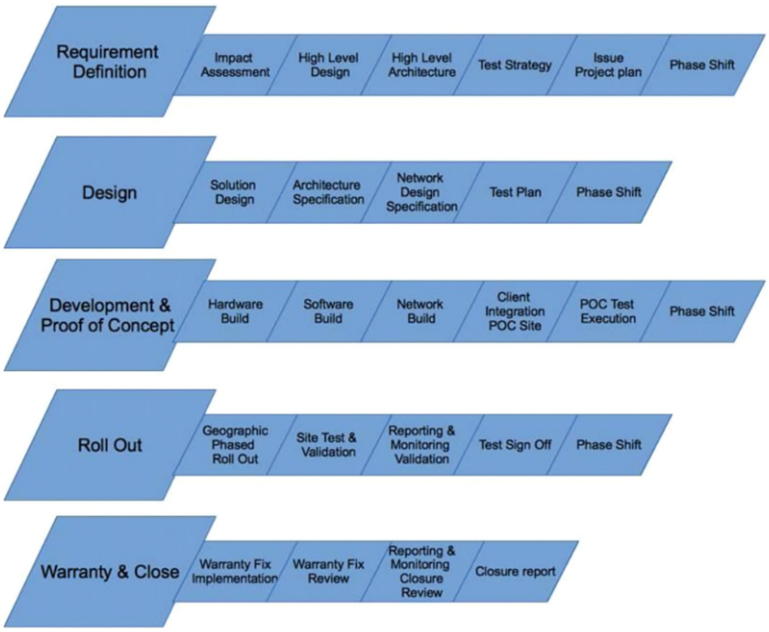
7.2 Constraints

The ability for the test team to deliver appropriate test coverage is contingent upon the following factors. Where additional constraints to successful testing are identified i.e. Response to testing defects will be within 12 hours for P2 and P3 issues, they will be formally documented and managed by Global Reach as part of the testing project management process

- There are no significant changes in priorities that require redeployment of resources
- The project scope remains relatively stable
- The test team is notified promptly of any changes in project scope so that impacts on testing can be properly assessed
- Development work is progressed and delivered within timeframes that enable full and detailed testing to take place
- The test team must be notified as soon as possible of any delays, potential or actual, in the project implementation so that resource allocation can be assessed

8 Proposed testing approach

8.1 Requirement Driven Testing



- Business Analyst
- Developers
- Tester
- Business users

8.2 Risk assessment

A testing risk assessment is used to prioritise test cases based on the following criteria:

1. the priority classification of business requirements to select which test cases to execute
2. the likelihood of code changes or new functionality affecting existing functionality

Once priorities have been assigned to test cases, test resources can be allocated and managed to ensure that they are deployed to the areas of most importance

8.3 Test iterations and deadlines

Test iterations will follow development iterations and key project milestones. The test plan will prioritise testing and include dates.

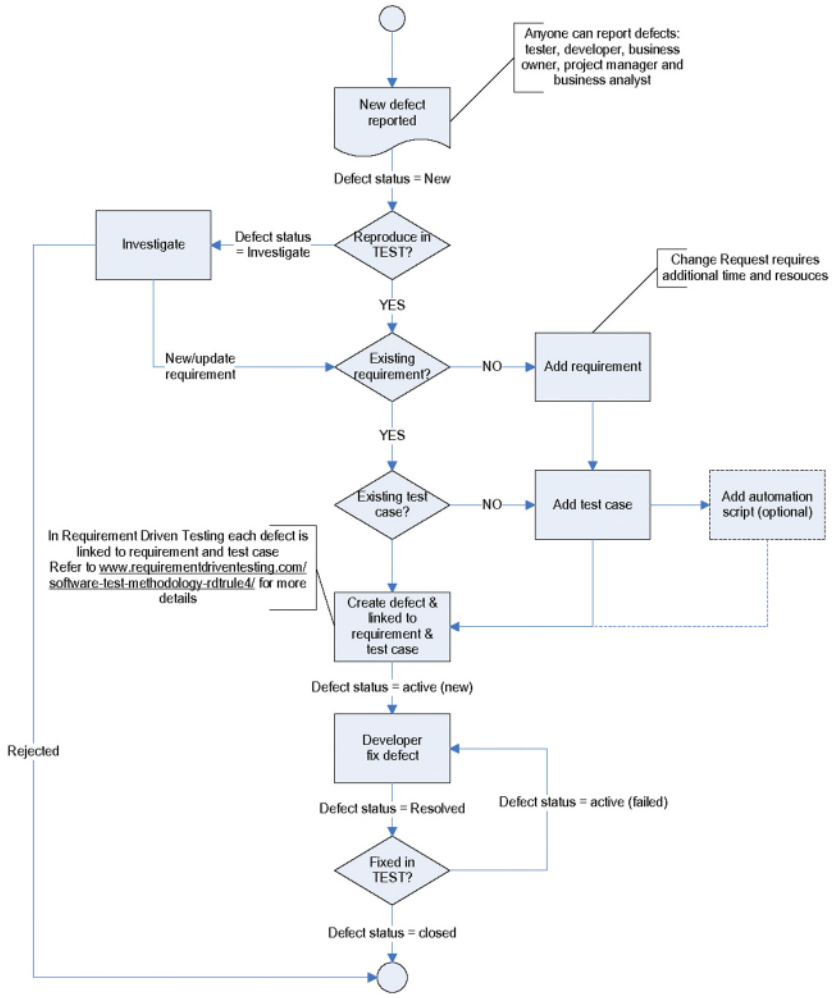
8.4 Defect Management

The detection, management and resolution of defects will be properly recorded and will be progressed using Google Docs – Global Reach UX testing Defect Log_Phase 2. All defects must be assessed to determine a severity level as described in the table below.

Severity	Severity Description
P1	The defect is service impacting and renders the TfL service unavailable or unusable by the customer
P2	Major system component unusable and prevents the user from utilising key parts of the service
P3	Incorrect or incomplete presentation of information ie. Portal content, language options, device language detection, font's images or page navigation post authentication

Table 2 - Defect Severity

The following diagram shows defect management workflow for different stages:



8.5 Test Environment

Testing will be performed utilising the existing live infrastructure in a mirrored environment within Global Reach office utilising a hidden SSID's accessed by the testing team. The Global Reach cloud architecture will provide the UX, authentication and user access to the Internet post authentication.

8.6 Managing Test Environment

The Global Reach Delivery Team will manage the Global Reach Solution elements of the test environment.

Global Reach will liaise with the appropriate infrastructure team/network teams named below for fault resolution diagnosed as originating from 3rd party or TfL owned architecture

- TfL project team for local hardware and network connectivity issues and network restrictions
- TfL project team for Home page presentation issues

8.7 Release management

Release Management of Defect fixes will be co-ordinated with the TfL project manager and TfL test team to meet the following requirements.

- All outage releases will be scheduled where possible for non-working hours unless an alternate window is agreed
- Defects to be included in a release are to be agreed in advance between TfL and Global Reach to facilitate inclusion in revised test schedules
- A Release schedule will be agreed and published prior to the release to the Global Reach test Team in a timely manner.
- All defects will be retested by the TfL test teams to confirm resolution within 2 working days of the Defect Release

8.8 Testing risks and mitigation

The following Risks should be noted for the testing schedule

ID	Risk	Mitigation
R01	Device availability for testing.	All commercially available devices with up to date software should be utilised by TfL in the execution of the test cases
R02		
R03		
R04		

8.9 Test reports and sign off procedure

Testing reports will be produced on the schedules detailed below

- Defect log will be published continuously via Google docs for all parties.
- The TfL Test Case document is to be maintained continuously via Goggle Docs
- A weekly summary report will be produced by Global Reach project manager
- Project calls between both parties to confirm sign off and acceptance to proceed to next step

Sign Off procedure will be based upon the defect release notifications from Global Reach and conclusion of test cases completed by TfL.

8.10 Staff Resources

Global Reach will provide support resources as detailed below

- Project Manager
- Senior Software Engineer
- .NET Software Engineer
- SQL DB Engineer
- RADIUS and NPC Engineer
- Escalation path to senior team

TfL will provide testing resources as detailed below

TfL to provide suitable skilled staff to cover UAT testing in all areas.