MURL: DTRS test and acceptance requirements

VicTrack Telecommunications guideline

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Contents

1. Background

VicTrack is a statutory corporation, established under the *Rail Corporations Act 1996*, with an independent Board which oversees VicTrack's performance. Under the *Transport Integration Act 2010*, VicTrack's role is to support public transport and to support broader government priorities by operating commercially.

As a licensed telecommunications carrier with network infrastructure spanning the state, VicTrack provides a full suite of communications services to the transport sector. As the owners of Victoria's public transport assets, supporting network performance is VicTrack's core business.

Mobile phone coverage in the Melbourne Underground Rail Loop (MURL) was delivered by VicTrack in October 2015, which ended years of frustration for rail commuters travelling in the city loop. The project (Phase 1) was a successful joint effort between VicTrack and the mobile carriers led by Optus. The system used by the mobile carriers utilizes the passive infrastructure of the Distributed Antenna System (DAS) deployed for the Digital Train Radio System (DTRS).

The MURL DTRS DAS equipment consists of an ION-M Master Unit (MU) which is located with the GSM-R BTS and ION-M Remote Units (RU) which are located at the main equipment nodes in a star configuration. The ION-M MU and ION-M RU are connected by single mode fibre.

Tunnel coverage is provided by ION-M RU serving a radiating cable and log periodic tunnel antennas. The station platforms, concourses and operations office coverage is provided by a combination of BTS and ION-M RU serving a distributed antenna system which consist of indoor omni-directional and ceiling-mount directional antennas.

2. Purpose

The purpose of this document is to describe a comprehensive test plan to ensure that the co-location of mobile carriers or any upgrade works by the carriers in the MURL at any stage does not have an adverse impact on the operation of DTRS. The DTRS is a GSM-R system operating in the 1800 MHz band.

3. Acronyms, abbreviations and definitions

Term	Definition
3GPP	3rd Generation Partnership Project
ARFCN	Absolute Radio Frequency Channel Number
BCCH	Broadcast Control Channel
BSC	Base Station Controller
BTS	Base Transceiver Station
CDR	Call Drop Rate
CSSR	Call Setup Success Rate
DAS	Distributed Antenna System

Term	Definition
DTF	Distance-To-Fault
DTRS	Digital Train Radio System
EME	Electromagnetic Energy
GSM	Global System for Mobile Communications
GSM-R	Global System for Mobile Communications for Railways
HOSR	Handover Success Rate
KPI	Key Performance Indicator
MCF	Mobile Carriers Forum
MNC	Multi Network Combiner
MTM	Metro Trains Melbourne
MURL	Melbourne Underground Rail Loop
MU	Master Unit
OSS	Operations Support System
PIM	Passive Intermodulation
RU	Remote Unit
SCADA	Supervisory Control and Data Acquisition
TCH	Traffic Channel
UE	User Equipment

4. Test and acceptance requirements

The testing and acceptance requirements and detailed test procedures stated in this document have been derived in part from the reference documents in Section 12. While some test procedures have been performed in a certain way previously, VicTrack has now uplifted the requirements to be based on the latest industry standards, MCF 2018. VicTrack has also incorporated Nokia's DTRS test configuration into the procedures. Thus, all DTRS test and acceptance requirements shall be referred to this document.

The document is structured into three sections:

- DTRS functionality initial call testing upon work completion
- DTRS pre and post-test requirements
- Measured performance of the DAS which include the PIM test requirements.

5. DTRS functionality initial call testing

5.1. Test purpose

These test procedures are performed immediately after the completion of work activities to provide an indication if there is any adverse impact on the DTRS functionalities.

5.2. Test location

Initial call testing shall be performed at the nearest antennas or tunnel section for each MNC location.

5.3. Test equipment definition

Portable Walk Test - Test equipment setup when measuring outside the train driver's cabin (in-tunnel and station/platform coverage) – A portable radio utilising its internal antenna to measure Portable Radio coverage – Rx Level and Rx Quality.

5.3.1. Test criteria

Conduct 50 test calls at agreed locations to verify DTRS functionality. The DTRS target KPIs shall be met.

5.3.2. Test guidelines and deliverables

a. DTRS ION-M and DTRS base station equipment shall be in good working condition – free of any alarms.

b. Carriers ION-M system (existing and new both) and associated base station equipment shall be in good working condition – free of any alarms.

c. The test calls shall be initiated at one DAS segment per MNC at the platform area, right below the antenna with the following configuration:
   - Call duration 20 seconds
   - Wait time 5 seconds
   - Stationary call.

d. Test calls shall be performed on DTRS to verify normal functionality with existing and new carriers' technologies connected after the work has been completed.

e. Target success KPI is 99% Call Setup Success Rate as per the DTRS KPI.

f. Rollback if not meeting the KPI target shall be considered.

6. DTRS test requirements

The DTRS testing shall be performed prior to commencement of any works to capture the baseline performance. A set of initial call functionality testing procedures at the nearest antenna(s) or tunnel section as detailed in Section 4 shall be performed immediately after work completion. Once this is deemed successful and no rollback is required, a final post DTRS test shall be arranged immediately in the following few days to ensure that the DTRS performance is similar or better than the baseline.

6.1. DTRS signal level and quality

6.1.1. Test location

DTRS signal level and quality in the MURL shall be measured in the tunnel and in all associated station areas. In-tunnel testing shall be conducted in a consistent manner for baseline and post testing, either via a revenue train in driver's cabin or a hi-rail vehicle. The tunnel loops and the underground stations are:

- City Circle Loop/Clifton Hill Loop (Upper Platform)
- Caulfield Loop (Upper Platform)
- Northern Loop (Lower Platform)
- Burnley Loop (Lower Platform)
- Flagstaff Station
- Melbourne Central Station
- Parliament Station

6.1.2. Test equipment definition

a. In-cab portable internal - a portable radio/handset inside the train driver's cabin utilising the internal antenna to measure radio coverage - Rx Level and Rx Quality. Due to in-cab penetration loss, the antenna has to be located at a same location for both baseline and post implementation tests. If connection to the external antenna is available, this method is preferred.

b. Portable walk test - test equipment setup when measuring outside the train driver's cabin (in-tunnel and station/platform coverage) - A portable radio utilising its internal antenna to measure Portable Radio coverage - Rx Level and Rx Quality.

6.1.3. DTRS target signal level and quality criteria

a. For 98% of readings in both the Up and Down direction for the Burnley, Northern and Caulfield loops and the Down direction for the Clifton Hill loop, in-tunnel DTRS target signal level requirements are:
   - RxLevFull ≥ -95dBm when measured with In-Cab Portable Internal test method, signal level must not be lower than -95dBm for a consecutive distance greater than 15 metres
   - RxLevFull ≥ -95dBm when measured with Portable walk-test method, signal level must not be lower than -95dBm for a consecutive distance greater than 15 metres.

b. In-tunnel DTRS target signal quality requirement is RxQual ≤ 3.5 in 98% of readings in both the Up and Down direction for the Burnley, Northern and Caulfield loops and the Down direction for the Clifton Hill loop.

c. Station/Platform DTRS target signal level is RxLevFull ≥ -95dBm when measured as a Portable Walk Test, in 98% of readings in all associated station areas which are external to the tunnels and are served by the DTRS DAS.

d. Station/Platform DTRS target signal quality is RxQual ≤ 3.5 in 98% of readings in all associated station areas which are outside external to the tunnels and are served by the DTRS DAS.

6.1.4. Test guidelines and deliverables

a. The following deliverables are required from the In-tunnel DTRS data collection:
   - RxLevFull and RxQualFull of server 'snail trail' of in-train tests overlaid on top of tunnel maps (with drop call events marked on plot)
   - Serving cell (cell BCCH) 'snail trail' of in-train tests overlaid on top of tunnel maps (with drop call events marked on plot)
   - A report showing the percentage of tunnel loop meeting required levels.

b. The following deliverables are required from the Station/Platform DTRS data collection:
   - RxLevFull and RxQualFull of server 'snail trail' of walk-tests overlaid on station/platform floor plans (with drop call events marked on plot)
   - Serving cell (cell BCCH) 'snail trail' of walk tests overlaid on station/platform floor-plans (with drop call events marked on plot)
   - A report showing the percentage of Station/Platform floor plans meeting required levels.

c. Equipment to be used for the coverage testing are the NEMO test phones and antenna kit:
   - Call measurements will be recorded by manually plotting location points onto the NEMO test equipment
   - There will be no pre-processing of call data during measurement. Data binning feature will be switched off.

d. The test equipment shall work in conjunction with a data post-processing software which will produce separate reports for in-train (tunnel) tests and station/platform tests:
   - reports showing the percentage of the tunnel length and station/platform floor meeting the required levels, to be incorporated into a KPI report document
   - 'snail trail' of the in-train test overlaid on top of the tunnel loop layout and walk-test overlaid on top of a station/platform floor plan
   - statistical reports showing the percentage of the tunnel and station/platform meeting required levels.

e. The 'snail trail' plots shall be provided for all tunnel loops below:
   - Burnley Loop (both directions – Up & Down)
   - Northern Loop (both directions – Up & Down)
   - Caulfield Loop (both directions – Up & Down)
   - Clifton Hill Loop (Down[1] direction only).

f. To ensure that the DTRS signal levels are consistent during the measurement, Downlink Power Control on the DTRS BTS is required to be disabled throughout the measurement activity.

g. MTM shall provide the DTRS SIM cards required for testing.

h. In-cab portable testing shall be conducted in a revenue train service or a hi-rail vehicle. Testing to be conducted using similar train model during baseline and post testing for consistent data

[1] Upon consultation with MTM, measurements for Clifton Hill are only for the Down direction

measurements. The handset must be located in the same location when testing is done in other train cabs to maintain setup consistency.

i. Portable walk testing in station areas must include station platforms, escalators, station concourses and station office spaces, where a walk test route will be pre-defined and agreed by both VicTrack and MTM.

j. The starting point of the train test is where portal roof begins and the testing shall end where the portal roof ends.

k. All portals shall be tested according to the peak/off-peak timetable.

l. MTM shall provide the updated DTRS BCCH/TCH frequency plan in the MURL to ensure that the correct frequencies are measured. This includes macro DTRS cells which provide MURL coverage inside some of the MURL portals. The current MURL channel allocation is provided in Appendix D.

m. Test calls shall be conducted using the following configuration for all baseline and post implementation tests to ensure consistency in test measurements:

Table 1. DTRS Test Configuration

Test Equipment	Configuration
UE #1 - Idle Mode	• UE to be connected with NEMO Kit antenna (0 dB gain)
UE #2 - Long Call	• Continuous call duration of 1 hour • If call ends, reinitiate a new long call after call waiting period of 5 sec • UE to be connected with NEMO kit antenna (0 dB gain) • Number to be dialled is 0297789199[2]
UE #3 - Short Call	• Call Duration is 20 sec • Call Waiting is 5 sec • UE's internal mobile antenna • Number to be dialled is 0297789199
Scanner #1 - GSM Frequency Scanning	• Scanner antenna gain to be determined and normalized to 0 dB. • Range for frequency scanning (GSM 1800 ARFCN): 824 - 885 • Top N= 10 means top 10 ARFCNs to be monitored

a. MTM to confirm that the DTRS BTS equipment is in normal operation, free from equipment system/hardware alarms.

b. A representative from MTM shall be invited along with the walk test if required.

c. Measurements shall be taken in reference to tunnel markers/signages or tunnel structure references to achieve reliable location information within the tunnel from a moving vehicle.

d. Pre and post-tests shall be carried out at the same time, direction and platform areas to ensure consistency.

[2] External test number used by the VicTrack Maintenance team. If an internal number is required, VicTrack shall advise an alternate number.

6.2. DTRS main key performance indicators

The following test procedures are conducted to ensure that the co-location of mobile carriers or any upgrade works by the carriers in the MURL at any stage does not have an adverse impact on the performance of DTRS, which is vital for train operations in the MURL. The KPIs measured are Call Setup Success Rate (CSSR), Call Drop Rate (CDR) and Handover Success Rate (HOSR). These KPIs also align to the tests conducted by Nokia for MTM.

6.2.1. Test location

This test shall be conducted in-cab throughout the tunnel only, either via a clockwise run or anti-clockwise run consistently. This can be conducted in conjunction with Section 5.1. using the short calls test setup.

6.2.2. Test equipment definition

In-Cab Portable Internal – A portable radio/handset inside the train driver's cabin utilising the internal antenna to measure CSSR, CDR and HOSR. Due to in-cab penetration loss, the antenna has to be located at a same location for both baseline and post implementation tests. If connection to the external antenna is available, this method is preferred.

6.2.3. DTRS target CSSR, CDR and HOSR criteria

Table 2. DTRS Target KPIs

RAN KPI		KPI Target	Unit
Voice KPI	Call Setup Success Rate (CSSR)	99.00	%
	Handover Success Rate (HOSR)	99.50	%
	Call Drop Rate (CDR)	1.00	%

6.2.4. Test guidelines and deliverables

a. The KPI to be measured as successful call initiation is termed as Call Setup Success Rate (CSSR), which is categorised in the following formula below:

   CSSR = (Successful Call Setup/Call Attempts) x 100%

   – Call Attempt is defined as a call being initiated by the user in order to setup a voice call

   – Successful Call Setup is defined as a call attempt which has successfully established a GSM-R call connection.

b. The KPI to be measured as dropped calls is termed as Call Drop Rate (CDR), which is categorised in the following formula below:

   Call Drop Rate = (TCH Drop/Number of Terminated Calls) x 100%

   – Call Drop Rate indicates the number of terminated calls and the call drop rate from the view of the user

c. The KPI to be measured as successful call handover is termed as Handover Success Rate (HOSR) which is categorised in the following formula below:

   HOSR = (Total Handover Successes/Total Handover Attempts) x 100%

   – Handover Success Rate indicates the general mobility performance of the user

- Handover attempt is the process of transferring an ongoing call from one cell to another cell of better received level as the signal strength of the serving cell drops.

d. The following deliverables are required from the DTRS in-cab data collection:
   - A 'snail trail' of test calls shall be overlaid on top of tunnel map layout showing successful and unsuccessful call setup events on the plots
   - A corresponding serving cell (cell BCCH) 'snail trail' of the test calls shall be overlaid on top of the tunnel map layout
   - A report showing the CSSR, CDR and HOSR measurements for each tunnel loop.

e. Equipment to be used for the coverage testing are the NEMO test phones and antenna kit:
   - Call measurements shall be recorded by manually plotting location points onto the NEMO test equipment
   - There will be no pre-processing of call data during measurement. Data binning feature shall be switched off

f. The test equipment shall work in conjunction with a data post-processing software which will produce separate reports for in-train (tunnel) tests:
   - reports showing the percentage of the tunnel length meeting the required levels, to be incorporated into a KPI report document
   - 'snail trail' of the in-train test overlaid on top of the tunnel loop layout
   - statistical reports showing the percentage of the tunnel meeting required levels.

g. The 'snail trail' plots shall be provided for all tunnel loops below:
   - Burnley Loop (both directions – Up & Down)
   - Northern Loop (both directions – Up & Down)
   - Caulfield Loop (both directions – Up & Down)
   - Clifton Hill Loop (Down direction only).

h. To ensure that the DTRS signal levels are consistent during the measurement, Downlink Power Control on the DTRS BTS is required to be disabled throughout the measurement activity.

i. MTM shall provide the DTRS SIM cards required for testing.

j. In-cab portable testing shall be conducted in a revenue train service or a hi-rail vehicle. Testing to be conducted using similar train model during baseline and post testing for consistent data measurements. The handset must be located in the same location when testing is done in other train cabs to maintain setup consistency.

k. Measurements shall be taken in reference to tunnel markers/signages or tunnel structure references to achieve reliable location information within the tunnel from a moving vehicle.

l. Appendix A shows the 3GPP call flow reference for Mobile Originating Call.

6.3. Noise testing – onsite testing with spectrum analyser

These test procedures are to ensure that there is no adverse impact on DTRS noise level after the any mobile carrier upgrade on capacity or the introduction of additional technologies by the carriers. The test shall be performed during peak hour or simulated traffic load to capture the full impact of carriers

traffic on DTRS. If using the simulated traffic load method, carriers involvement respectively is required to change the parameters on their end.

6.3.1. Test location

This test shall be conducted at DTRS BTS and ION-M Master Unit locations at:

a. Parliament Station Plant Level (MNC-PS-P-1)

b. Flagstaff Station Plant Level (MNC-FS-P-1)

6.3.2. Test equipment definition

The equipment shall be set up in accordance with the appropriate tools and equipment. The spectrum analyzer shall be connected to laptop/computer loaded with the appropriate software to analyse the live data stream.

6.3.3. Test guidelines and deliverables

The following test procedures shall measure the possible downlink/uplink spurious emissions from the mobile carriers traffic load on the DTRS BTS during peak hour:

a. The noise testing shall be performed prior to commencement of any works to capture the baseline performance and again after all works have been completed.

b. The test shall be carried out during live peak hour (7.30am – 9am) to capture the actual full traffic load on carriers.

c. DTRS ION-M and DTRS base station equipment shall be in good working condition – free of any alarms.

d. Carriers ION-M system (both existing and new) and associated base station equipment shall be in good working condition – free of any alarms.

e. The spectrum analyser shall be connected to a coupling port located between the DTRS ION-M Master Unit and the DTRS base station. Coupling/probe ports are located on the BTS-Connect cards as shown in **Figure 1** below.

f. The spectrum analyser shall be set-up to scan from 1700 to 1890 MHz, and RBW to high. Logging shall be initiated for a period of 10 minutes before the start of test.

g. Spectrum trace measurement logs shall be collected for a minimum of 30 minutes.

h. Steps d to f are to be repeated for every coupling/probe port on every BTS-Connect card on all shelves, on both Flagstaff and Parliament station locations.

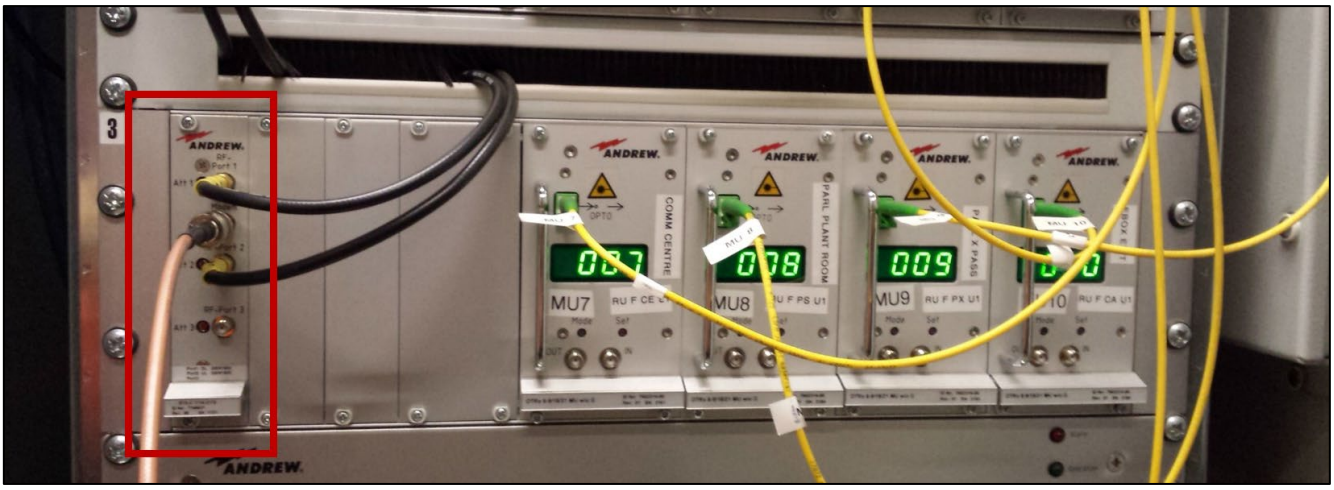


Figure 1. DTRS ION-M BTS-Connect Cards

Notes:

- Do not adjust the GSM-R BTS-Connect tuning screws as this will decommission the Remote Units connected to the Master Unit
- Do not remove the SMA jumpers connecting the GSM-R base station to the BTS-Connect card
- Always use SMA torque wrench to fasten/unfasten SMA connectors on the BTS-Connect card
- Do not touch or remove the Optical Patch Lead (in green) connecting the OTRX to the patch panel
- As a precaution, DTRS test calls shall be made prior to the start and after the completion of this test to verify that the DTRS system is operational.

6.4. Noise floor measurements – performance monitoring

To support the results from on-site noise testing in Section 5.3. Idle Traffic Channel data is required from the GSM-R Nokia OSS.

6.4.1. Test guidelines and deliverables

a. All performance counters related to the Idle Traffic Channel measurements must be activated in the OSS/BSC/BTS levels.

b. A measurement period of 14 days before and after the activity is required as a minimum to provide a pre and post installation comparison.

c. As an alternative, to avoid any special events that might occur during that period, a statistical comparison can be taken from the same period the previous year if the data is available.

d. MTM shall confirm that the DTRS BTS is in normal operation, free from equipment system/hardware alarms.

e. MTM shall provide the raw data measurements for post-processing as required.

f. The Idle Traffic Channel measurements shall be presented as follows:

- An averaged percentage distribution of the occurrence of Idle TCH Interference bands (1-5) over the required period. Band 1 represents an environment without interference and Band 5 represents high interference
- Individual statistics for the two DTRS BTS in the MURL.

7. Measured performance of the DAS

7.1. Passive intermodulation testing

Passive intermodulation (PIM) is one of the most important measurements that needs to be undertaken on Distributed Antenna Systems (DAS). Its importance stems from the fact that PIM can significantly inhibit the ability of a DAS to operate at KPI levels established by VicTrack or the Carriers who are currently operating in the MURL.

The main causes of PIM are:

- Poor quality components
- Poor workmanship
- Inappropriate placement of antennas.

7.1.1. Test location

This test is to be conducted at all MNC locations within MURL.

7.1.2. Test equipment definition

a. The PIM Tester for this test procedure shall be capable of PIM measurements in both Low and High bands.

b. The PIM Master equipment shall be calibrated and validated; this includes all adapters and cables to be connected.

c. Features required in the PIM tester include the following:
   - Filter units of at least 1 low band and 1 high band (Band 3 1800MHz in high band is required)
   - PIM vs. Time, Swept PIM, Noise Floor, Distance-to-PIM
   - Accuracy of < 0.5m for PIM Distance to Fault (DTF) measurement
   - Able to capture at least the 3rd, 5th and 7th order intermodulation products
   - Test power of 20dBm to 46dBm (Two CW tones, 0.1 dBm steps)
   - Capable of capturing Residual PIM at –125 dBm typical (2 x 43 dBm test tones).

7.1.3. Test criteria

a. A baseline PIM shall be performed prior to any upgrade or introduction of new technologies. Any deficiencies against the baseline records shall be highlighted to VicTrack for further action.

b. If required, the deficiency identified shall be remedied and confirmed by a retest of PIM.

c. The DAS must conform to standards for frequencies in BOTH Low Band and High Band[3]. The corresponding 3GPP bands are as follows:
   - Low Band = Band 5, 8 or 28
   - High Band = Band 1, 3 or 7.

d. DTRS operates in Band 3, it is preferred that high band PIM testing is conducted in Band 3. Low band PIM can be conducted either in Band 5, 8 or 28.

e. The test parameters in the following table shall be assessed against the Pass/Fail criteria specified:

Table 3. Test Criteria for PIM Testing

Test parameter	Pass/Fail Criteria	Remarks
At MNC Input - PIM LB	≤ -140dBc	The third-order passive intermodulation performance must meet ≤ -140 dBc with 2 x 43 dBm carriers.
At MNC Input - PIM HB	≤ -140dBc	The third-order passive intermodulation performance must meet ≤ -140 dBc with 2 x 43 dBm carriers.
At MNC Output - PIM LB[4]	≤ -140dBc	The third-order passive intermodulation performance of each passive DAS segment shall be ≤ -140 dBc with 2 x 43 dBm carriers.
At MNC Output - PIM HB	≤ -140dBc	The third-order passive intermodulation performance of each passive DAS segment shall be ≤ -140 dBc with 2 x 43 dBm carriers.

7.1.4. Test guidelines and deliverables

a. During testing it is imperative that all connectors of both test equipment and antenna system are kept clean at all times as the introduction of foreign material to connector or feeder termination will result in additional PIM issues.

b. At the MNC Input – Baseline:
   - Disconnect one of the input ports that will be impacted by the work activity.
   - All active equipment connected to the other input ports of the MNC shall be locked/shut down to prevent any intermodulation to the system.
   - PIM testing criteria shall meet the specifications stated in Table 4 for both Low and High bands.
   - If the PIM measurements do not meet the criteria, the specific passive DAS segment that failed shall be identified.
   - In this case, distance-to-PIM test shall be performed to locate the fault.
   - For segments that exceed the maximum distance for meaningful PIM measurement results, it is recommended to disconnect that DAS segment and replace with low-IM loads. An overview of the MURL DAS is provided in Appendix E.

[3] Referenced from Section 3.15.2 MCF 2018 Design Specification

[4] For typical fault-finding PIM specifications

c. At the MNC Input – Post Test:
   - All active equipment connected to the other input ports of the MNC shall be locked/shut down to prevent any intermodulation to the system.
   - All DAS segments that have passed the PIM criteria shall be connected to the MNC outputs. Passive DAS segments that have failed the PIM test during baseline testing shall be removed and terminated with low-IM cable loads.
   - Cable loads connected to unused output ports must meet the -140 dBc specification.
   - If there are any newly introduced passive components, PIM shall be retested from that point for every leg to ensure that the component added does not introduce PIM to the system.
   - PIM testing criteria shall meet the specifications stated in Table 4 for both Low and High bands.

d. The third-order passive intermodulation (PIM) performance for each individual component shall conform to the specification below for both Low and High bands[5]:
   - Splitters and Couplers: =< -150 dBc, with 2x 43dBm carriers
   - Low power (<5W) 50 Ω terminations: =< -140 dBc, with 2x 33dBm carriers
   - High power (>=5W) 50 Ω terminations: =< -150 dBc, with 2x 43dBm carriers.

e. The following PIM Remediation steps shall be performed if included in the scope specified:
   - If the PIM power level of a DAS segment is higher than the allowable limit, work outwards from the MNC and eliminate any components, connectors, etc. which do not meet the PIM specification.
   - The DAS antennas are not connected during this phase. Terminate cables, splitter outputs etc. with low-IM cable loads and measure as close to the antennas as possible.
   - If the cables and non-radiating components are tested to be within specification and the PIM power of the segment is still over the limit, try and identify any faulty antennas by connecting one antenna at a time.
   - Determine whether it is an antenna or its location which is causing the high IM level (e.g. by dropping the antenna below the ceiling and re-measuring).
   - Terminate the outputs of the MNC with low-IM cable loads and measure the PIM performance at a spare input. The other input ports should be terminated with their normal equipment.
   - Initiate the PIM testing and this must fall within the specifications of the MNC.

7.2. Return loss and distance to fault

Before testing for PIM, it is best practice to ensure that line sweeping has been performed so that the insertion loss and return loss data are at acceptable levels. These results ensure that the PIM test signals actually reach all components at the correct signal level, and therefore offer the most accurate indication of true PIM performance. If the PIM test equipment is capable of Return Loss and DTF measurements simultaneously, this can be performed simultaneously.

[5] As referenced in Section 3.18.3, MCF 2018 DAS Specification

7.2.1. Test location

This test is to be conducted at all MNC locations within MURL.

7.2.2. Test equipment definition

The test equipment shall be capable of the following features:

- Measurements of Return Loss, VSWR, Cable Loss, Distance-to-Fault (DTF), Phase
- Frequency range: 2 MHz to 3 GHz
- Sweep Speed: 1 ms/data point typical
- Easy on-site calibration.

7.2.3. Test criteria

The test parameters in the following table shall be assessed against the Pass/Fail criteria specified:

Table 4. Test Criteria for Return Loss and Distance to Fault

Service/Element	Pass/Fail Criteria	Remarks
Return Loss Test-LB	> 16 dB	Return loss of each passive DAS segment connecting to an MNC shall be greater than 16dB over the operating bands
Return Loss Test-HB	> 16 dB	Return loss of each passive DAS segment connecting to an MNC shall be greater than 16dB over the operating bands
Distance to Fault-LB	> 30 dB	Reflected power at each discontinuity shall be at least 30dB lower than the signal level
Distance to Fault-HB	> 30 dB	Reflected power at each discontinuity shall be at least 30dB lower than the signal level

Locations that do not fulfil the specifications as per Table 5 shall be at least similar or better than the last baseline results in the MURL DAS Performance Verification Results in Appendix B.

7.2.4. Test guidelines and deliverables

The return loss of each passive DAS segment connecting to a multi-network combiner shall be ≥ 16 dB over the operating frequency bands as indicated in Section 6.1.3. Where a DAS segment is comprised of multiple branches connecting to a DAS segment, the connection points to the branch must each also individually comply with the above performance requirement.

8. Reference documents

This guideline should be read and applied in conjunction with the following documents:

Ref	Document ID	Document Title	Version	Author
A		M1412 MURL DTRS Test Procedures		Optus
B		MURL DTRS Test Specifications	2.4	Optus
C	**TS-ST 037**	Distributed Antenna System (DAS) Specification	1.0	VicTrack
D	**MCF 2018**	DAS Design Specification		MCF
E		Nokia Annual Drive Test Reports		Nokia

9. Document review and approval

Delegation	Name	Position	Version	Date
Owner	Jignesh Vekaria	Customer Relationship Manager, Solution Design	1.0	18 Oct 2019
Reviewers	Sahar Badamchi	Network Operations Engineer		03 Jul 2019
	Peter Vanek	Wireless Field Support Officer		03 Jul 2019
Endorsers	Jignesh Vekaria	Customer Relationship Manager, Solution Design		03 Sep 2019
	John Berti	Manager, Standards and Specifications		03 Sep 2019
	Bruno Del Vecchio	Manager, Wireless Services		03 Sep 2019
	Brett Aimers	Acting Manager, System Optimisation and Planning		03 Sep 2019
Approvers	Lesley Lindsay	Group Manager, Customer Service and Delivery	1.0	18 Oct 2019
	Sam Musso	Acting Group Manager, Operations / Chief Engineer	1.0	03 Sep 2019

10. Document history

Version	Amendment description	Author	Date
1.0	Initial version for publication, including updates from peer review	Jaclyn Tan, Senior Design Engineer – RAN	30 Aug 2019

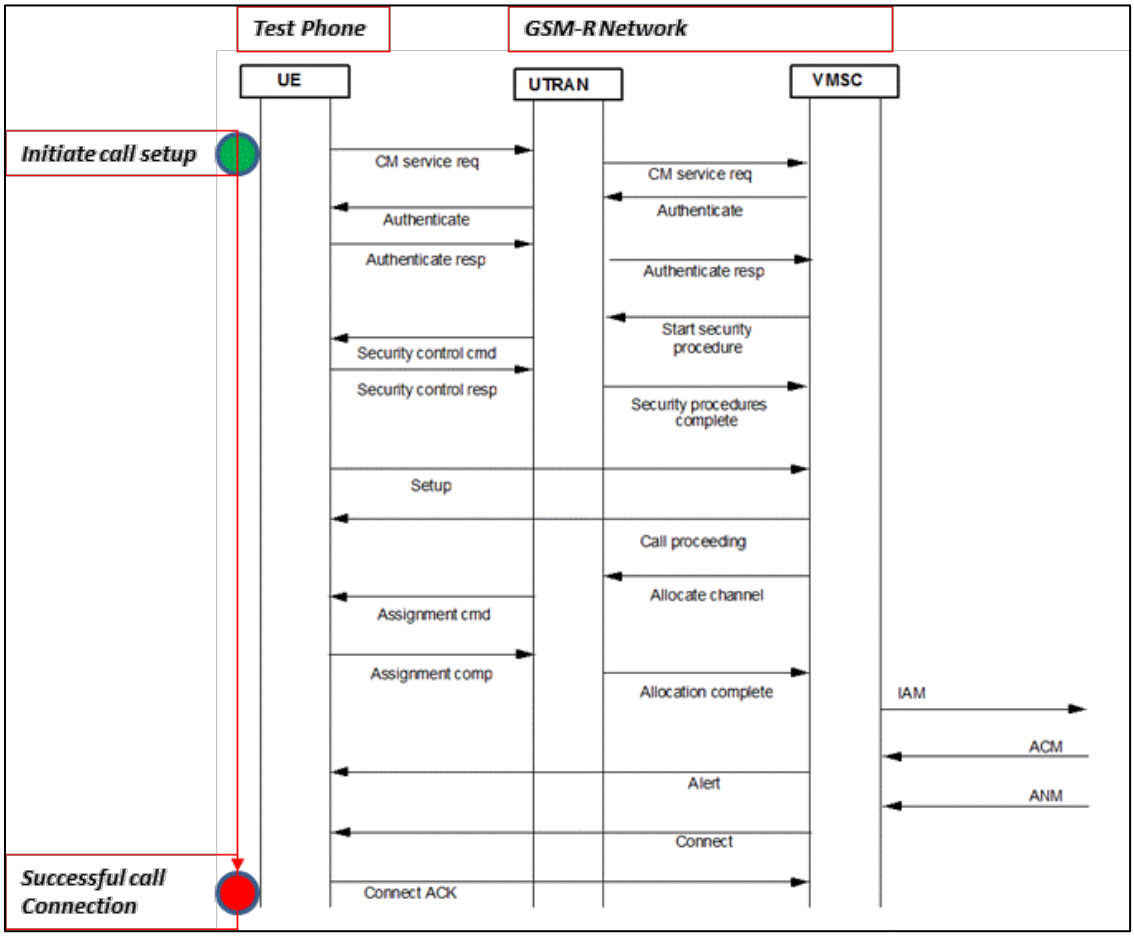
11. Review period

This procedure will be reviewed at least every one (1) years by the Document Owner, or amended as appropriate.

The content of this document is uncontrolled when printed. The current version of this document is available on The Loop.

Appendix A – 3GPP Call Initiation/CSSR Call Flow

Mobile Originating Call Flow *(Reference to 3GPP TS32.407)*

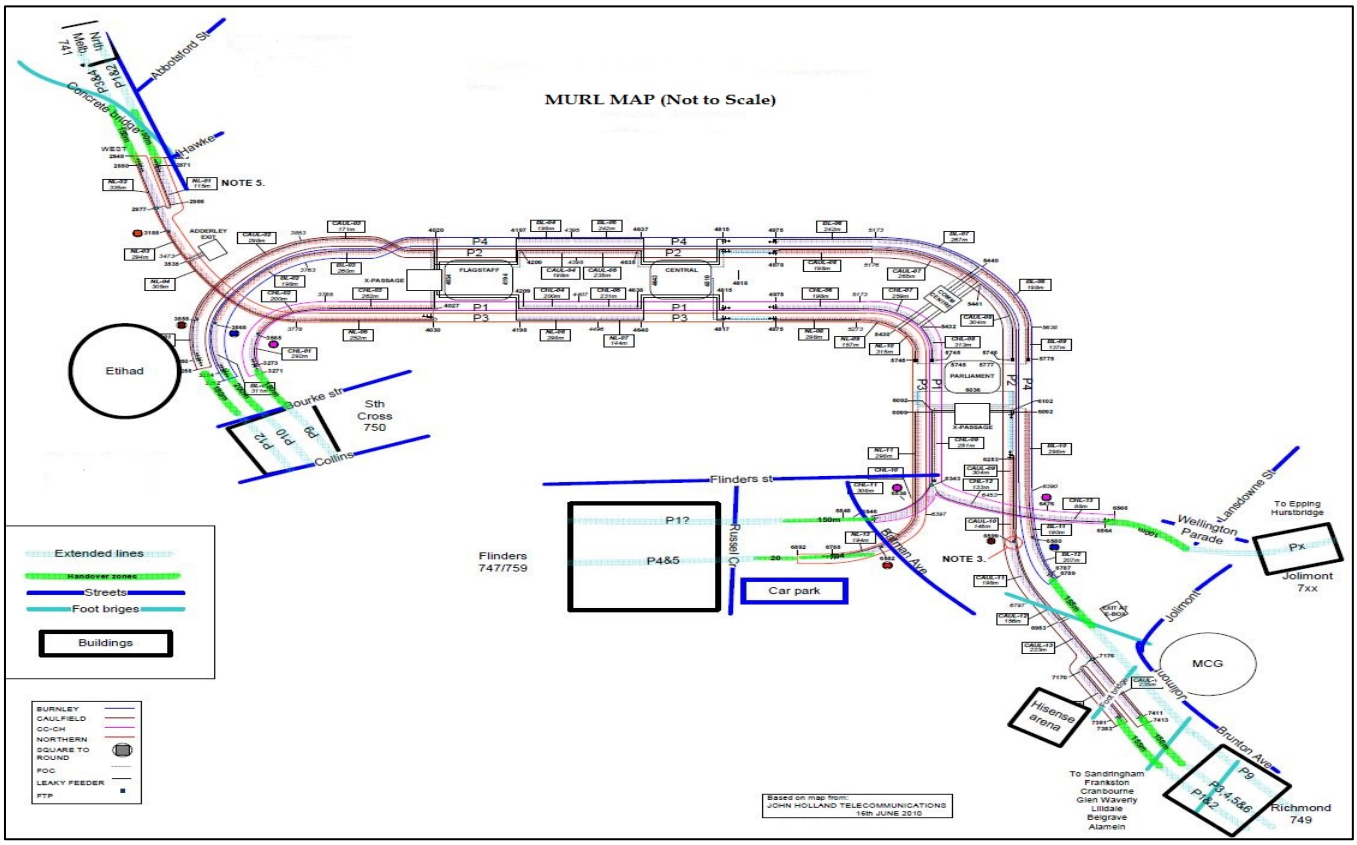


Appendix B – Baseline MURL DAS performance verification results

To be provided separately:

i. MURL DAS Performance Verification Report Rev 2.1
ii. DAS Performance verification test results for MNC-FS-P-1 located in Flagstaff Station Plant Room
iii. DAS Performance verification test results for MNC-FS-L-3 located in Flagstaff Station Riser
iv. DAS Performance verification test results for MNC-FS-L-2 located in Flagstaff Station Riser
v. DAS Performance verification test results for MNC-FS-L-1 located in Flagstaff Station Riser
vi. DAS Performance verification test results for MNC-PS-P-1 located in Parliament North Plant
vii. DAS Performance verification test results for MNC-PS-L-2 located in Parliament Station Riser
viii. DAS Performance verification test results for MNC-PS-L-1 located in Parliament Station Riser
ix. DAS Performance verification test results for MNC-CC-U-1 located in Commonwealth Shaft
x. DAS Performance verification test results for MNC-CC-U-2 located in Commonwealth Shaft
xi. DAS Performance verification test results for MNC-MS-P1 located in Melbourne Central

Appendix C – MURL map



Appendix D – MURL Channel Allocation

Channel Allocation for SB008 Flagstaff and SB009 Parliament

CELL	Site ID	BTSM	CELL ID	BCCH	TCH	NCC	BCC
SB008A	SB008	8	10081	885	883	0	0
SB009A	SB009	9	10091	881	879	0	0

Channel Usage for Outdoor DTRS Cells

BCCH																						
853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876
1778.4	1778.6	1778.8	1779.0	1779.2	1779.4	1779.6	1779.8	1780.0	1780.2	1780.4	1780.6	1780.8	1781.0	1781.2	1781.4	1781.6	1781.8	1782.0	1782.2	1782.4	1782.6	1782.8	1783.0
1873.4	1873.6	1873.8	1874.0	1874.2	1874.4	1874.6	1874.8	1875.0	1875.2	1875.4	1875.6	1875.8	1876.0	1876.2	1876.4	1876.6	1876.8	1877.0	1877.2	1877.4	1877.6	1877.8	1878.0

TCH															
837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852
1775.2	1775.4	1775.6	1775.8	1776.0	1776.2	1776.4	1776.6	1776.8	1777.0	1777.2	1777.4	1777.6	1777.8	1778.0	1778.2
1870.2	1870.4	1870.6	1870.8	1871.0	1871.2	1871.4	1871.6	1871.8	1872.0	1872.2	1872.4	1872.6	1872.8	1873.0	1873.2

Appendix E – MURL DAS overview