Test Plan for Wireless Device Over-the-Air Performance

CTIA 01.51 Wireless Technology, Location Based Technologies

Version 8.0.1

April 2025

Use Instructions

All testing shall be performed in a CTIA Certification Authorized Test Lab and shall be initiated through one of the following methods:

1. By submitting a PTCRB or IoT Network Certified device certification request at https://certify.ptcrb.com/

2. By submitting an OTA Test Plan use request at https://certify.ctiacertification.org/

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Section 1 Introduction

1.1 Purpose

The purpose of this document is to define the CTIA Certification program test methodology for performing Receiver Performance measurements on wireless devices supporting Location Based Technologies.

This document is written in a normative context, but all or portions of the text may be considered normative or informative based on the certification body that incorporates this test plan.

1.2 Scope

This test plan defines general requirements for test systems, test conditions, equipment configurations, laboratory techniques, test methodologies, and evaluation criteria that must be met in order to ensure the accurate, repeatable, and uniform testing of wireless devices capable of supporting Location Based Technologies.

This test plan provides high level test procedures and basic test equipment configuration information but does not include detailed test instructions by which to execute certification testing. Such documentation and procedures must be presented by the CTIA Certification Authorized Test Lab (ATL) as part of the CTIA authorization process and subsequently employed and maintained by the ATL to remain authorized to perform Certification testing.

1.3 Acronyms and Definition

Table 1.3-1 contains specialized terms and acronyms are used throughout this document.

Table 1.3-1 Acronyms and Definitions

Acronym/Term	Definition
A-GALILEO	Assisted Galileo
A-GNSS	Assisted GNSS
A-GPS	Assisted GPS
AWGN	Additive White Gaussian Noise
BHHL	Beside Head and Hand Left Side (Head and Hand Phantom)
BHHR	Beside Head and Hand Right Side (Head and Hand Phantom)
C/N_0	Carrier to Noise
CNR	Linearized C/N_0
DL	Downlink
DUT	Device Under Test
EPS	Evolved Packet System
FR1	Frequency Range 1 (410 MHz – 7125 MHz)

Acronym/Term	Definition
GALILEO E1	Galileo E1 navigation signal with carrier frequency of 1575.420 MHz.
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPS L1	GPS L1 navigation signal with carrier frequency of 1575.420 MHz
GPS L5	GPS L5 navigation signal with carrier frequency of 1176.450 MHz.
HDOP	Horizontal Dilution Of Precision
HL	Hand Left (Hand Phantom Only)
HR	Hand Right (Hand Phantom Only)
ICD	Intermediate Channel Degradation
Informative	Optional testing/condition that is not part of certification testing
LPP	LTE Positioning Protocol
MBS	Metropolitan Beacon System
M-LMS	Multilateration Location and Monitoring Service
MS	Mobile Station
NHPIS	Near-Horizon Partial Isotropic Sensitivity
NMEA	National Marine Electronics Association
Normative	Mandatory aspect for certification testing
NR	New Radio
OMA	Open Mobile Alliance
OTA	Over-the-Air
PIG 3D C/N_0	Partial Isotropic GNSS 3D C/N_0
PIGS	Partial Isotropic GNSS Sensitivity
RB	Resource Block
RRC	Radio Resource Control
RRLP	Radio Resource LCS Protocol
RSS	Receive Signal Strength
SIB16	System Information Block 16: GPS

Acronym/Term	Definition
SIB8	System Information Block 8: CDMA Neighbour Cell
SUPL	Secure User Plane
SV	Satellite Vehicle
TIS	Total Isotropic Sensitivity
UE	User Equipment
UH 3D C/N_0	Upper Hemisphere 3D C/N_0
UHIS	Upper Hemisphere Isotropic Sensitivity
UL	Uplink
VoIP	Voice over Internet Protocol
VoLTE	Voice over LTE

1.4 Document References

Document Number, Document Name
[1] CTIA 01.90, *Informative Reference Material*
[2] CTIA 01.01, *Test Scope, Requirements, and Applicability*
[3] CTIA 01.71, *Positioning Guidelines*
[4] CTIA 01.20, *Test Methodology, SISO, Anechoic Chamber*
[5] CTIA 01.50, *Wireless Technology, 3GPP Radio Access Technologies*
[6] 3GPP TS 37.571-1, *User Equipment (UE) Conformance Specification for UE Positioning; Part 1: Conformance Test Specification*
[7] 3GPP TS 37.571-5, *User Equipment (UE) Conformance Specification for UE Positioning, Part 5: Test Scenarios and Assistance Data*
[8] 3GPP TS 34.108 V8.2.0 (2008-03), *Common Test Environments for User Equipment (UE); Conformance Testing*
[9] 3GPP TS 51.010-1 V8.3.0 (2009-09), *Mobile Station (MS) Conformance Specification; Part 1: Conformance specification*
[10] 3GPP TS 34.171 V7.1.0 (2008-03), *Terminal Conformance Specification; Assisted Global Positioning System (A-GPS); Frequency Division Duplex (FDD)*
[11] 3GPP TS 25.331 V8.2.0 (2008-04), *Radio Resource Control (RRC); Protocol Specification*

Document Number, Document Name
[12] 3GPP TS 44.031, *Location Services (LCS); Mobile Station (MS) - Serving Mobile Location Centre (SMLC) Radio Resource LCS Protocol (RRLP)*
[13] OMA-AD-SUPL-V2_0-20110527-C, *Candidate Version 2.0 (27 May 2011): Secure User Plane Location Architecture*
[14] 3GPP TS 36.355, *Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)*
[15] 3GPP TS 36.508, *Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); Common Test Environments for User Equipment (UE) Conformance Testing*
[16] 3GPP TS 38.521-3, *NR; User Equipment (UE) Conformance Specification; Radio Transmission and Reception; Part 3: Range 1 and Range 2 Interworking operation with other radios*
[17] 3GPP TS 38.508-1, *5GS; User Equipment (UE) Conformance Specification; Part 1: Common test environment*
[18] 3GPP TS 36.509, *Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); Special Conformance Testing Functions for User Equipment (UE)*
[19] OMA-TS-ULP-V2_0_3-20160524-A, UserPlane Location Protocol
[20] National Marine Electronics Association (NMEA) 0183 Version 4.10 November 2008
[21] CTIA 01.04, *Informative Reporting Tables*
[22] TS 37.355, *LTE Positioning Protocol (LPP)*

Section 2 A-GNSS

2.1 Test Procedure

The procedure identified herein has been based on industry standards used during DUT conformance testing. However, some modifications were made to reduce test time, to reduce the Over-the-Air test solution complexity, and to account for specific Over-the-Air testing needs. The specific modifications are described in the corresponding cellular radio mode test specifics in Section 2.5. It is assumed that the DUT will be tested per the conformance testing requirements defined by the industry standards. Therefore, any device that does not specifically meet the requirements of the industry standards would be identified during the conformance testing.

A-GNSS Receiver Sensitivity measurements shall be performed using test equipment that supports the relevant standards defined herein. Unless otherwise specified, the latest versions of the referenced 3GPP documents shall be used. The DUT's A-GNSS receiver sensitivity will be the minimum GNSS signal level that results in a passing result based on the relevant A-GNSS test parameters defined herein.

The test will determine the Total Isotropic Sensitivity (TIS), the Upper Hemisphere Isotropic Sensitivity (UHIS) (theta = 0 to 90 degrees) and the Partial Isotropic GNSS Sensitivity (PIGS) (theta = 0 to 120 degrees) of the GNSS receiver. The TIS test procedure based on receive signal strength specified in Section 2.4 will be used.

The test applies to both UE-based and UE-assisted A-GNSS devices. If both UE-based and UE-assisted A-GNSS are supported by a device, then both modes will be tested unless otherwise specified.

This test will consist of the following measurements:

- Radiated 3D C/N_0 pattern measurement
- Radiated A-GNSS sensitivity measurement
- Radiated A-GNSS intermediate channel degradation measurement

TIS, UHIS, and PIGS shall be fully measured as described in Section 2.2.1 and Section 2.3.1 and calculated pursuant to the document *CTIA 01.90* [1]. Test the DUT in all frequency bands and cellular radio modes where the DUT supports A-GNSS and as defined herein (for example, A-GNSS Over-the-Air performance would not be tested for GPRS since it is only defined for GSM). In all cases, the linearized C/N_0 values shall be used in the calculations.

For both the full TIS test and the A-GNSS intermediate channel degradation test, head with hand phantom and/or hand phantom testing shall be conducted based on device type, as specified in *CTIA 01.01* [2] Section 2.1.8. Refer to the *CTIA 01.71* [3] for head and hand testing guidance. Perform each test in all functional use configurations, and with the DUT antenna extended and retracted, as applicable.

A-GNSS OTA testing shall be performed with the device configured in its normal operating state with regards to the use of cellular diversity antennas.

When testing A-GNSS with different cellular radio modes used for assistance and with different operating bands, the Alternate Test Procedure for TIS Single Point Offset Test in *CTIA 01.20* [4] Section 4.4 may be used except that the position/polarization that is used shall be the same position/polarization determined for the A-GNSS sensitivity search. The Alternate Test Procedure for TIS Single Point Offset Test cannot be used when a different physical radiator, or different aperture tuning of the antenna is used between the reference cellular protocol/band and with the protocol/band being evaluated.

2.2 Radiated 3D C/N_0 Pattern Measurement

2.2.1 General

Devices supporting UE-assisted A-GNSS can perform this section, however devices supporting UE-based A-GNSS only may not be able to perform this section. If a device supports both methods, then the radiated 3D C/N_0 pattern measurement may be limited to UE-assisted A-GNSS. The 3D C/N_0 pattern will then be used for determining the radiated GNSS performance for both UE-assisted and UE-based A-GNSS. If a device only supports UE-based A-GNSS then the C/N_0 data shall be stored in the DUT's internal memory in the format specified in *CTIA 01.20* [4] Section 4.7.4. Another alternative for a device which only supports UE-based A-GNSS, is to enable UE-assisted A-GNSS or some other test mode to perform the radiated 3D C/N_0 pattern measurement. If used, the test mode shall allow for the exceptions in the device firmware for UE-based tests as specified in the cellular radio mode test specifics in Section 2.5.

The pattern data shall be determined by averaging Carrier-to-Noise (C/N_0) measurement of all visible GNSS satellites for each measurement at each point on the sphere. Data points shall be captured at 30-degree intervals. The GNSS satellite simulator shall provide the number of satellites specified herein and each satellite vehicle shall be at the same power.

All C/N_0 measurements shall be done with the GNSS engine in a tracking mode or by using individual UE-assisted measurements. Orthogonal linear polarizations will be measured. For one measurement report, the reported satellite C/N_0 values shall be averaged. If it is necessary to obtain more measurements to reduce uncertainty, repeat the measurement requests at the same position and polarization and independently average the reported satellite C/N_0 values for each measurement report.

After a sufficient number of measurement requests have been made, average the average results that were obtained for each measurement request. Sufficient averaging shall be completed to ensure that the uncertainty is less than the value included in the uncertainty budget. The C/N_0 pattern measurements shall be performed with highest priority supported cellular radio mode in Table 2.2.1-1 using a low TX power to conserve battery power and to minimize self-interference. The transmit power shall be guaranteed to be 10 dB or more below the maximum TX power.

Table 2.2.1-1 Priority List for Cellular Radio Modes

Priority	Cellular Radio Modes
1st	NR FR1 SA
2nd	NR FR1 EN-DC
3rd	LTE
4th	UMTS
5th	GSM

In case of wrist-worn devices where it may be necessary to increase the A-GNSS signal level during the Radiated 3D C/N0 Pattern Measurement, signal level may be increased by up to 5 dB. Care should be taken to avoid compression of the receiver as mentioned in *CTIA 01.20* [4] Section 4.7.2.

The C/N_0 pattern data shall be linearized per the linearization method specified in *CTIA 01.20* [4] Section 4.7.2. In case of wrist-worn devices, the dynamic range for the linearization shall be reduced so C/N_0 measurements shall be made at a maximum of 1 dB steps from the peak C/N_0 measurement to at least 5 dB below the peak C/N_0 measurement. Any data points in the pattern where no measurement was obtained shall use a replacement value that is at least 20 dB below the lowest C/N_0 measurement.

Note that when the Alternate Test Procedure for TIS Single Point Offset Test can be and is used for A-GNSS testing, the 3D C/N_0 patterns do not need to be measured and the linearization step does not need to be applied for other applicable operating bands and cellular radio modes.

2.2.2 A-GPS L1

The radiated 3D C/N_0 pattern measurement shall be performed for A-GPS L1 (Assisted Global Positioning System). The GPS satellite simulator shall implement the GPS L1 scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GPS L1 test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

2.2.3 A-GPS L5

The radiated 3D C/N_0 pattern measurement shall be performed for A-GPS L5. The GPS satellite simulator shall implement the GPS L5 scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GPS L5 test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

The reported metric shall be average 3D C/N_0 for the L1 satellites and the average 3D C/N_0 for the L5 satellites. Both sets of 3D C/N_0 pattern data shall be linearized prior to calculating the average 3D C/N_0. The set of 3D C/N_0 pattern data for the L1 satellites used to the calculate average 3D C/N_0 will come from a previous measurement of the A-GPS L1 and not from the A-GPS L5 measurement. Average 3D C/N_0 is calculated in the same way as TRP, except C/N_0 pattern data is used instead of EIRP pattern data. Higher values of average 3D C/N_0 represent better OTA performance, similar to TRP. UH 3D C/N_0 is similar to UHIS in that that same portion of the pattern is used to calculate both metrics. Partial Integrated GPS 3D C/N_0 (PIG 3D C/N_0) is similar to PIGS in that that same portion of the pattern is used to calculate both metrics.

For the A-GPS L5 radiated 3D C/N_0 pattern measurement, it is necessary to compensate the GPS L1 power level to achieve similar C/N_0 on the GPS L1 and GPS L5 satellites, which is caused by the difference in antenna gain between GPS L1 and GPS L5 frequencies. For each point on the 3D C/N_0 pattern measurement, the power level of the GPS L1 and GPS L5 satellites shall be initially set to deliver -130 dBm to an isotropic radiator. After the C/N_0 for the GPS L1 and GPS L5 satellites have been measured, the GPS L1 signal power shall be adjusted (if needed) to achieve a C/N_0 within 3 dB of the C/N_0 measured for the GPS L5 satellites. The GPS L1 power level estimate is based on the average C/N_0 measurements made on the GPS L1 satellite vehicles. The GPS L5 C/N_0 averaging method shall be the same C/N_0 averaging method used to estimate the GPS L1 power level.

2.2.4 A-GALILEO E1

The radiated 3D C/N_0 pattern measurement does not have to be performed for A-GALILEO E1. Further evaluation of A-GALILEO E1 performance will utilize the A-GPS L1 radiated 3D C/N_0 pattern measurement as determined in Section 2.2.2.

2.2.5 A-GALILEO E5A

The full radiated 3D C/N_0 pattern measurement does not have to be performed for A-GALILEO E5A. Instead, a Single Point Offset Test as described *CTIA 01.20* [4] section 3.2 can be used. A C/N_0 measurement can be performed at the position/polarization where the peak GPS L5 C/N_0 value was obtained in the upper hemisphere. By calculating the offset between this measured C/N_0 value and measured GPS L5 C/N_0 value, the full radiated 3D C/N_0 pattern of A-GALILEO E5A can be calculated. In order to reduce uncertainty, at least 10 measurements shall be performed at the same position and polarization, and independently averaged the reported satellite C/N_0 values for each measurement reported. The GNSS satellite simulator shall implement the GALILEO E5A scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GALILEO E5A test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

The reported metric shall be average 3D C/N_0 for the GPS L1 satellites and the average 3D C/N_0 for the GALILEO E5A satellites. Both sets of 3D C/N_0 pattern data shall be linearized prior to calculating the average 3D C/N_0. The set of 3D C/N_0 pattern data for the L1 satellites used to the calculate average 3D C/N_0 will come from a previous measurement of the A-GPS L1 and not from the A-GALILEO E5A measurement. Average 3D C/N_0 is calculated in the same way as TRP, except C/N_0 pattern data is used instead of EIRP pattern data. Higher values of average 3D C/N_0 represent better OTA performance, similar to TRP. UH 3D C/N_0 is similar to UHIS in that that same portion of the pattern is used to calculate both metrics. Partial Integrated GPS 3D C/N_0 (PIG 3D C/N_0) is similar to PIGS in that that same portion of the pattern is used to calculate both metrics.

Similar to A-GPS L5 radiated 3D C/N_0 pattern measurement, for the A-GALILEO E5A measurement, it is necessary to compensate the GPS L1/GALILEO E1 power level to achieve similar C/N_0 on the GPS L1/GALILEO E1 and GALILEO E5A satellites, which is caused by the difference in antenna gain between GPS L1/GALILEO E1 and GALILEO E5A frequencies. For each point on the 3D C/N_0 pattern measurement, the power level of the GPS L1/GALILEO E1 and GALILEO E5A satellites shall be initially set to deliver -130 dBm to an isotropic radiator. After the C/N_0 for the GPS L1/GALILEO E1 and GALILEO E5A satellites have been measured, the GPS L1/GALILEO E1 signal power shall be adjusted (if needed) to achieve a C/N_0 within 3 dB of the C/N_0 measured for the GALILEO E5A satellites. The GPS L1/ GALILEO E1 power level estimate is based on the average C/N_0 measurements made on the GPS L1 satellite vehicles. The GALILEO E5A C/N_0 averaging method shall be the same C/N_0 averaging method used to estimate the GPS L1 power level.

2.3 Radiated A-GNSS Sensitivity Measurement

2.3.1 General

The radiated A-GNSS sensitivity search shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere. The DUT's A-GNSS receiver sensitivity will be the minimum GNSS signal level that results in a passing result for the applicable A-GNSS Sensitivity test specified herein. The maximum A-GNSS sensitivity search step size shall be no more than 0.5 dB when the satellite vehicle power level is near the A-GNSS sensitivity level. The DUT shall be transmitting at maximum power at the declared A-GNSS sensitivity level. The transmit power settings for maximum power shall be as defined in the cellular radio mode test specifics in Section 2.5. In order to minimize test time, the DUT measurements may be performed on a single call as long as each DUT measurement report is the result of a separate request. The DUT is not required to be power cycled in between measurements. When operating in UE-assisted, MS-Assisted, or UE-Based mode, the A-GNSS information shall be cleared in between measurements regardless of technology and operating mode. Refer to *CTIA 01.20* [4] Section 6, and *CTIA 01.71* [3] Section 2 for test set-up illustrations.

The radiated sensitivity tests for a particular band/antenna configuration should be performed without disturbing the setup to minimize uncertainty in the sensitivity search. If the DUT will be disturbed during the test, a corresponding uncertainty component shall be included in the uncertainty budget.

The conducted A-GNSS sensitivity of the DUT shall also be measured at the antenna connector, if available. It is preferable that the DUT be the same as utilized for the TIS measurements. However, if the DUT does not readily support an antenna port for conducted measurements, a separate modified DUT may be provided for all conducted measurements. If no connector is available, the conducted sensitivity measurement is not required. Ideally, the sensitivity measurement will be performed with the same instrumentation in an equivalent configuration in order to minimize the measurement uncertainty involved. A different sensitivity measurement device may be used as long as any differences in absolute measurement accuracy are accounted for, either in corrections to the recorded sensitivity level or increased reported measurement uncertainty for the conducted measurement. Refer to *CTIA 01.20* [4] Section 6 for more information on conducted sensitivity measurements and cabling setups.

2.3.2 A-GPS L1

The radiated A-GPS L1 sensitivity measurement shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere. The GPS satellite simulator shall implement the GPS L1 scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GPS L1 test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

2.3.3 A-GPS L5

The radiated A-GPS L5 sensitivity measurement is not required.

2.3.4 A-GALILEO E1

The radiated A-GALILEO E1 sensitivity measurement shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere during the radiated 3D C/N_0 pattern measurement for A-GPS L1 for one operating band in highest priority supported cellular radio mode in Table 2.2.1-1 and in each usage mode (BHHR, BHHL, HR, and HL) using the Alternate Test Procedure for TIS Single Point Offset Test specified in *CTIA 01.20* [4] Section 4.4. However, the Alternate Test Procedure for TIS Single Point Offset Test cannot be used when a different physical radiator, or a different aperture tuning of the antenna is used between the reference cellular protocol/band and with the protocol/band being evaluated. In the case with dynamically tuned GNSS antennas as noted in Section 2.5, the A-GALILEO E1 sensitivity measurement as defined above shall be made in the same cellular radio mode and operating band as the full A-GPS L1 OTA sensitivity measurement and the alternative pass/fail test specified in the steps below shall not be used. The GALILEO E1 satellite simulator shall implement the GALILEO E1 scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GALILEO E1 test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

For all other operating bands within the same cellular radio mode and usage mode (BHHR, BHHL, HR, and HL), the following steps shall be performed.

1. Ensure that the chamber positioner(s) are positioned at the location & polarization where the peak C/N_0 value was obtained in the upper hemisphere during the radiated 3D C/N_0 pattern measurement for A-GPS L1. If the positioners have been moved since the A-GPS L1 OTA sensitivity measurement, perform the A-GPS sensitivity search immediately prior to the A-GALILEO E1 sensitivity search.
2. Note the downlink power level which corresponds to the DUT's peak radiated A-GPS L1 sensitivity as described in step 1 above, which will be referred to as $A\text{-}GPS\ L1\ EIS_{peak,reference\ band}$. Note the downlink power level which corresponds to the DUT's peak radiated A-GALILEO E1 sensitivity as described in step 1 above, which will be referred to as $A\text{-}GALILEO\ E1\ EIS_{peak,reference\ band}$.
3. Change to the test frequency associated with the next operating band for the cellular radio mode in use and adjust the A-GALILEO E1 signal level to the RF power level calculated by the following formula:

Equation 2.3-1

$$A\text{-}GALILEO\ E1\,Signal\ Level\ (\mathrm{dBm}) = A\text{-}GPS\ L1\,EIS_{\ peak,band\ under\ test}(\mathrm{dBm}) + A\text{-}GALILEO\ E1\,EIS_{\ peak,reference\ band}(\mathrm{dBm}) - A\text{-}GPS\ L1\,EIS_{\ peak,reference\ band}(\mathrm{dBm}) + 3(\mathrm{dB})$$

4. Perform the A-GALILEO E1 sensitivity procedure as defined in the cellular radio mode test specifics in Section 2.5 with the exception that pass/fail will be determined at only the A-GALILEO E1 signal level calculated in step 3.
5. Repeat steps 3 and 4 for each remaining operating band for the cellular radio mode in use.
6. Repeat steps 1 through 5 for each remaining cellular radio mode in the existing usage mode.
7. Repeat steps 1 through 6 for each remaining usage mode (BHHR, BHHL, HR, and HL) based on device type, as specified in *CTIA 01.01* [2] Section 2.1.8. Perform each test with the DUT antenna extended and retracted, as applicable.
8. Report the pass/fail status of each measurement taken in step 4 above.

2.3.5 A-GALILEO E5A

The radiated A-GALILEO E5A sensitivity measurement is not required.

2.4 Radiated A-GNSS Intermediate Channel Degradation Measurement

2.4.1 General

Devices supporting UE-assisted A-GNSS can perform this section, however devices supporting UE-based A-GNSS only may not be able to perform this section. If a device supports both methods, then the radiated A-GNSS intermediate channel degradation measurement will be limited to UE-assisted A-GNSS. In this case, the radiated A-GNSS intermediate channel degradation results will apply to both UE-assisted and UE-based A-GNSS. If a device only supports UE-based A-GNSS then the C/N_0 data shall be stored in the DUT's internal memory in the format specified in *CTIA 01.20* [4] Section 4.7.4. Another alternative for a device, which only supports UE-based A-GNSS, is to enable UE-assisted A-GNSS or some other test mode to perform the radiated A-GNSS intermediate channel degradation measurement. If used, the test mode shall allow for the exceptions in the device firmware for UE-based tests as specified in the cellular radio mode test specifics in Section 2.5.

In addition to performing the sensitivity scan at the middle channel, the difference in sensitivity of the GNSS receiver will be evaluated with the cellular transceiver active for all intermediate cellular channels. This difference in sensitivity will be determined by measuring the difference in the radiated C/N_0 at the mid-channel and the radiated C/N_0 result at each of the intermediate channels with the cellular transmitter active at maximum power. This test will be called the A-GNSS intermediate channel degradation test.

For this test, the radiated C/N_0 shall be measured at the position/polarization where the peak C/N_0 was obtained in the upper hemisphere.

The C/N_0 measurements for each band/antenna configuration should be performed without disturbing the setup to minimize uncertainty in A-GNSS intermediate channel degradation test. If the DUT will be disturbed during the test, a corresponding uncertainty component shall be included in the uncertainty budget.

The basic test sequence for performing this A-GNSS intermediate channel degradation test is as follows:

1. Set up the satellite simulator with the number of satellites specified for the radiated 3D C/N_0 pattern measurement at the same power. The GNSS satellite power and scenario shall be set according to the recommendations in the cellular radio mode test specifics in Section 2.5.
2. Enable a call using the appropriate cellular radio protocol.
3. Enable the GNSS engine.
4. Obtain a GNSS lock and start tracking.
5. Set the cellular radio channel to the middle channel and the transmit power level to maximum power as defined in the cellular radio mode test specifics in Section 2.5.
6. Transmit the C/N_0 of the visible GNSS satellites over the existing cellular radio link. Record the average C/N_0 of the visible GNSS satellites. If additional C/N_0 measurements are required to minimize uncertainty, the measurements should be made prior to moving to the next step. Calculate the average C/N_0 (or average over repeated measurements of averages) and linearize the result using the data from the earlier linearization process. If a multi-GNSS scenario is being used, the C/N_0 measurements associated with each GNSS shall be considered separately. In the case where the pattern data is being re-used, only the satellite C/N_0 measurements for the GNSS associated with the pattern data shall be used when determining the corrections necessary as part of the linearization process.
7. Change the cellular radio channel to a channel in the intermediate channel list for each appropriate cellular radio mode and operating band in *CTIA 01.50* [5], except for NR FR1 EN-DC. Radio channel combinations for NR FR1 EN-DC are listed in Section 2.5.6.2. It is up to the implementer to determine how to change channels.
8. Transmit the C/N_0 of the visible GNSS satellites over the existing cellular radio link. Record the average C/N_0 of the visible GNSS satellites. If additional C/N_0 measurements are required to minimize uncertainty, the measurements should be made prior to moving to the next step. Calculate the average C/N_0 (or average over repeated measurements of averages) and linearize the result using the data from the earlier linearization process. If a multi-GNSS scenario is being used, the C/N_0 measurements associated with each GNSS shall be considered separately. In the case where the pattern data is being re-used, only the satellite C/N_0 measurements for the GNSS associated with the pattern data shall be used when determining the corrections necessary as part of the linearization process.
9. Repeat steps 7 and 8 for each channel in the intermediate channel list for each appropriate cellular radio mode and operating band in *CTIA 01.50* [5] except for NR FR1 EN-DC. Radio channel combinations for NR FR1 EN-DC are listed in Section 2.5.6.2.
10. Repeat steps 5 through 9 for each cellular radio mode and operating band supported by the DUT.

Alternatively, the C/N_0 measurements defined above may be achieved by using the methodology defined for the radiated 3D C/N_0 pattern measurement defined in Section 2.2 except that transmit power level will be set to maximum power as defined in the cellular radio mode test specifics in Section 2.5.

The A-GNSS intermediate channel degradation is the difference between the linearized average C/N_0 (or average over repeated measurements of averages) with the transmitter at the mid-channel and the lowest linearized average C/N_0 (or average over repeated measurements of averages) with the transmitter at any intermediate channel (including the mid-channel). Therefore, the A-GNSS intermediate channel degradation will always be zero or greater. Report the A-GNSS intermediate channel degradation.

As specified above, the average Carrier-to-Noise (C/N_0) measurement of all visible GNSS satellites at each instance in time will be used. Sufficient averaging over time of C/N_0 measurements shall be completed to ensure that the uncertainty is less than the value specified in the lab's uncertainty budget.

$$A\text{-}GNSS_{ICD} = \text{A-GNSS degradation due to intermediate channel jamming}$$

$$CNR_{mid\text{-}channel} = \text{Linearized } C/N_0 \text{ with the mid-channel}$$

$$CNR_{\min IC} = \text{minimum linearized } C/N_0 \text{ across all intermediate cellular channels}$$

$$A\text{-}GNSS_{ICD} = CNR_{mid\text{-}channel} - CNR_{\min IC} \text{ (in dB)}$$

2.4.2 A-GPS L1

The radiated A-GPS L1 intermediate channel degradation measurement shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere. The GPS satellite simulator shall implement the GPS L1 scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GPS L1 test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

2.4.3 A-GPS L5

Note that a sensitivity scan is not performed at the mid-channel for A-GPS L5, unlike A-GPS L1.

The radiated A-GPS L5 intermediate channel degradation measurement shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere. The GPS satellite simulator shall implement the GPS L5 scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GPS L5 test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

For the peak position/polarization of the 3D C/N_0 pattern measurement, the power level of the GPS L1 and GPS L5 satellites shall be initially set to deliver -130 dBm to an isotropic radiator. After the C/N_0 for the GPS L1 and GPS L5 satellites have been measured, the GPS L1 signal power shall be adjusted (if needed) to achieve a C/N_0 within 3 dB of the C/N_0 measured for the GPS L5 satellites. The GPS L1 power level estimate is based on the average C/N_0 measurements made on the GPS L1 satellite vehicles. The GPS L5 C/N_0 averaging method shall be the same C/N_0 averaging method used to estimate the GPS L1 power level.

2.4.4 A-GALILEO E1

The radiated A-GALILEO E1 intermediate channel degradation measurement shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere during the radiated 3D C/N_0 pattern measurement for A-GPS L1. The GNSS satellite simulator shall implement the multi-GNSS (A-GPS L1 and A-GALILEO E1) scenario as defined in the cellular radio mode test specifics in Section 2.5. The multi-GNSS test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5. Since a multi-GNSS scenario is being used, the C/N_0 measurements associated with each GNSS shall be considered separately (A-GALILEO E1 SVs need to be averaged separately from A-GPS L1 SVs). Since the pattern data is being re-used from GPS L1, only the satellite C/N_0 measurements for GPS L1 shall be used when determining the corrections necessary as part of the linearization process. The same offset determined by the linearization process shall be used to linearize the A-GALILEO E1 results. The final A-GALILEO E1 ICD result shall only include the measurements made on the A-GALILEO E1 satellite vehicles.

2.4.5 A-GALILEO E5A

The radiated A- GALILEO E5A intermediate channel degradation measurement shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere. The GNSS satellite simulator shall implement the GALILEO E5A scenarios as defined in the cellular radio mode test specifics in Section 2.5. The A-GALILEO E5A test parameters shall be as defined in the cellular radio mode test specifics in Section 2.5.

For the peak position/polarization of the 3D C/N_0 pattern measurement, the power level of the GPS L1/GALILEO E1 and GALILEO E5A satellites shall be initially set to deliver -130 dBm to an isotropic radiator. After the C/N_0 for the GPS L1/GALILEO E1 and GALILEO E5A satellites have been measured, the GPS L1/GALILEO E1 signal power shall be adjusted (if needed) to achieve a C/N_0 within 3 dB of the C/N_0 measured for the GALILEO E5A satellites. The GPS L1/GALILEO E1 power level estimate is based on the average C/N_0 measurements made on the GPS L1/GALILEO E1 satellite vehicles. The GALILEO E5A C/N_0 averaging method shall be the same C/N_0 averaging method used to estimate the GPS L1/GALILEO E1 power level.

2.5 Cellular Radio Mode Test Specifics

2.5.1 A-GNSS Scenarios and Test Parameters

A-GNSS radiated 3D C/N_0 pattern measurement, receiver sensitivity measurement and intermediate channel degradation measurement shall be performed using test equipment that supports the relevant portions of 3GPP documents as specified in Table 2.5.1-1. Unless otherwise specified, the latest versions of the referenced 3GPP documents shall be used.

For the A-GNSS radiated 3D C/N_0 pattern measurement, receiver sensitivity measurement and intermediate channel degradation measurement, the GNSS satellite simulator shall implement GNSS scenario as specified in Table 2.5.1-1 for each cellular radio mode, GNSS service and measurement type. The scenario shall be reset before the initial satellites become not visible and shall be executed as required in the corresponding test specifications defined in Table 2.5.1-1 for each cellular radio, GNSS service and measurement type, with the exception that random errors shall not be applied to the UE locations and the alternating locations requirement shall not be implemented. The reference signal power level for all satellites shall be -130 dBm for GPS L1 and GALILEO E1. Early delivery of Acquisition Assistance Data and Reference Time Data may be provided to the DUT.

Table 2.5.1-1 A-GNSS Scenarios

Cellular Radio Mode	GNSS Service	GNSS Scenario	Measurement	Scenario Execution
GSM	GPS L1	3GPP TS 34.108, Version 8.2.0 [8] Section 10.1.2.1 GPS L1 Scenario #1	Pattern/ICD	3GPP TS 51.010-1, Version 8.3.0 [9] Section 70.11.6
			Receiver Sensitivity	3GPP TS 51.010-1, Version 8.3.0 [9] Section 70.11.5.1
UMTS	GPS L1	3GPP TS 34.108, Version 8.2.0 [8] Section 10.1.2.1 GPS L1 Scenario #1	Pattern/ICD	3GPP TS 34.171, Version 7.1.0 [10] Section 5.3
			Receiver Sensitivity	3GPP TS 34.171, Version 7.1.0 [10] Section 5.2.1

Cellular Radio Mode	GNSS Service	GNSS Scenario	Measurement	Scenario Execution
LTE	GPS L1	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 7 Sub-test case number 1	Pattern/ICD	3GPP TS 37.571-1 [6] Section 7.2, Sub-Test Number 1
			Receiver Sensitivity	3GPP TS 37.571-1 [6] Section 7.1.1, Sub-Test Number 1
	GPS L5	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 7 Sub-test case number 4	Pattern/ICD	3GPP TS 37.571-1 [6] Section 7.2, Sub-Test Number 4
	GALILEO E1	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 7 Sub-test case number 8[1]	ICD	3GPP TS 37.571-1 [6] Section 7.2, Sub-Test Number 8[1]
			Receiver Sensitivity	3GPP TS 37.571-1 [6] Section 7.1.1, Sub-Test Number 8[1]
	GALILEO E5A	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 7 Sub-test case number 8[2]	Pattern/ICD	3GPP TS 37.571-1 [6] Section 7.2, Sub-Test Number 8[2]
LTE Category M1 (Informative)	GPS L1	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 7 Sub-test case number 1	Pattern/ICD	3GPP TS 37.571-1 [6] Section 7.2, Sub-Test Number 1
			Receiver Sensitivity	3GPP TS 37.571-1 [6] Section 7.1.1, Sub-Test Number 1
NR FR1 EN-DC	GPS L1	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 1	Pattern/ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 1
			Receiver Sensitivity	3GPP TS 37.571-1 [6] Section 13.2.1, Sub-Test Number 1
	GPS L5	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 4	Pattern/ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 4

Cellular Radio Mode	GNSS Service	GNSS Scenario	Measurement	Scenario Execution
	GALILEO E1	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 8[1]	ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 8[1]
			Receiver Sensitivity	3GPP TS 37.571-1 [6] Section 13.2.1, Sub-Test Number 8[1]
	GALILEO E5A	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 8[2]	Pattern/ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 8[2]
NR FR1 SA	GPS L1	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 1	Pattern/ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 1
			Receiver Sensitivity	3GPP TS 37.571-1 [6] Section 13.2.1, Sub-Test Number 1
	GPS L5	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 4	Pattern/ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 4
	GALILEO E1	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 8[1]	ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 8[1]
			Receiver Sensitivity	3GPP TS 37.571-1 [6] Section 13.2.1, Sub-Test Number 8[1]
	GALILEO E5A	3GPP TS 37.571-5 [7] Section 6.2.1.2.1 for 3GPP TS 37.571-1 [6] subclause 13 Sub-test case number 8[2]	Pattern/ICD	3GPP TS 37.571-1 [6] Section 13.3, Sub-Test Number 8[2]

Note 1: for Galileo E1, the satellite simulator shall generate only GPS L1 and Galileo E1 signals for all the simulated satellites.

Note 2: for Galileo E5A, the satellite simulator shall generate GPS L1, GPS L5, Galileo E1 and Galileo E5A signals for all the simulated satellites,

The A-GNSS radiated receiver sensitivity measurements shall be performed for each cellular radio mode and GNSS service using the test parameters in Table 2.5.1-2 which are based on test specifications in

Table 2.5.1-1 except for the modifications herein. For GSM and UMTS, the test scenario basically determines the A-GNSS sensitivity in acquisition mode with assistance using the control plane.

Table 2.5.1-2 A-GNSS Test Parameters

Cellular Radio Mode	GNSS Service	Number of Satellites	HDOP Range	GPS L1 Time Assistance	Phone Response Time	Acceptable Response Time to Network	Success Rate	Position Accuracy	Propagation Conditions
GSM	GPS L1	8	1.1 to 1.6	Coarse, ± 1.8 s	16 s	20.3 s	95 successful fixes with the necessary accuracy out of 100 attempts (95%) **For wrist-worn devices [1]:** 24 successful fixes with the necessary accuracy out of 25 attempts (96%)	101.3 m	AWGN
UMTS	GPS L1	8	1.1 to 1.6	Coarse, ± 1.8 s	20 s				
LTE	GPS L1	8	1.1 to 1.6	Coarse, ± 2.0 s	20 s for LPP 16 s for RRLP				
	GALILEO E1	6	1.4 to 2.1	Coarse, ± 2.0 s	20 s for LPP 16 s for RRLP				
LTE Category M1 (Informative)	GPS L1	8	1.1 to 1.6	Coarse, ± 2.0 s	20 s for LPP 16 s for RRLP				
NR FR1 EN-DC	GPS L1	8	1.1 to 1.6	Coarse, ± 2.0 s	20 s for LPP 16 s for RRLP				
	GALILEO E1	6	1.4 to 2.1	Coarse, ± 2.0 s	20 s for LPP 16 s for RRLP				
NR FR1 SA	GPS L1	8	1.1 to 1.6	Coarse, ± 2.0 s	20 s for LPP				
	GALILEO E1	6	1.4 to 2.1	Coarse, ± 2.0 s	20 s for LPP				

Note 1: While no explicit measurement uncertainty is assigned to the confidence associated with the pass/fail criteria of any sensitivity measurement, the measurement uncertainty associated with the pass/fail criteria of 24 successful fixes out of 25 fix attempts is greater than the measurement uncertainty associated with the standard A-GNSS pass/fail criteria of 95 successful fixes out of 100 fix attempts.

As the A-GALILEO E1 radiated receiver sensitivity measurements are based on a multi-GNSS sub-test, the GALILEO E1 signal power levels need particular treatment compared to the GPS L1 signal power levels. Therefore, the reference signal power level for all GALILEO E1 satellite power levels shall be equal to the power level of the weaker GPS L1 satellites so that there are no GALILEO E1 satellites which are transmitted at a higher signal level. During this test, the GPS L1 satellite power levels are set such that there will be one satellite, which transmits 5 dB higher than the other GPS L1 satellites. The reported A-GALILEO E1 sensitivity level will be based on the power of the weaker satellites.

Note that the satellite power levels for the sensitivity test are such that there will be one satellite that transmits 5dB higher than the other satellites. The reported sensitivity level will be based on the power of the weaker satellites. The 1 dB test tolerance or test parameter relaxation for the absolute GNSS signal level shall not be used in reporting the sensitivity measurement results. The above clarification means that passing the requirements of test specification for different radio mode and GNSS as modified in Table 2.5.1-2 above, at signal levels -141 dBm and -146 dBm will lead to a sensitivity level report of -146 dBm, rather than -147 dBm. For Control Plane testing, the GNSS engine shall be cold started for every location attempt.

2.5.2 UMTS

2.5.2.1 A-GNSS Testing for UMTS: General

Table 2.5.2.1-1 specifies the mid-channel test channels for UMTS and the settings to be used when transmitting at the maximum UE output power.

Table 2.5.2.1-1 Maximum TX Power Settings and Mid-Channel Test Channels for UMTS

Band	Power Setting	Test Channel
UMTS 850	All “up power” commands	TX: 4183, RX: 4408
UMTS 1900	All “up power” commands	TX: 9400, RX: 9800
UMTS 2100/1700	All “up power” commands	TX: 1413, RX: 1638

For the tests that do not operate at maximum UE output power such as the radiated 3D C/N_0 pattern measurement, it is up to the implementer to set the UE transmit power such that the requirement specified can be met.

The radiated A-GNSS intermediate channel degradation measurements shall be made at the intermediate channels defined in *CTIA 01.50* [5] Section 3.1.2.1.

A Voice Call or Supplemental Service Call shall be used for the wireless connection. The supplemental service call shall be in accordance with the defined 3GPP standards and shall support a circuit switched connection for normal device operation (3GPP test mode and/or data loopback calls are not allowed).

For a device which only supports UE-based A-GNSS and utilizes the test mode identified in Section 2.2.1 and 2.4.1, the test mode shall allow for the following exceptions in the device firmware for UE-based tests:

- Measurement Report Message (RRC): As referenced in *TS 25.331* [11] v8.2 Section 10.3.7.99, both “UE Positioning position estimate info” and “UE positioning GPS L1 measured results” IEs shall be included.

GPS L1 assistance using control plane will be used for all A-GPS L1 TIS testing for UMTS.

2.5.3 GSM

2.5.3.1 A-GNSS Testing for GSM: General

Table 2.5.3.1-1 specifies the mid-channel test channels for GSM and the settings to be used when transmitting at the maximum UE output power.

Table 2.5.3.1-1 Maximum TX Power Settings and Mid-Channel Test Channels for GSM

Protocol/Band	Power Setting	Test Channel
GSM 850	Select PCL from *CTIA 01.50* [5], Table 2.1.1-1	190
GSM 1900	Select PCL from *CTIA 01.50* [5], Table 2.1.1-2	661

For the tests that do not operate at maximum UE output power such as the radiated 3D C/N_0 pattern measurement, it is up to the implementer to set the UE transmit power such that the requirement specified can be met.

The radiated A-GNSS intermediate channel degradation measurements shall be made at the intermediate channels defined in *CTIA 01.50* [5] Section 2.1.2.1.

A Voice Call or Supplemental Service Call shall be used for the wireless connection. The supplemental service call shall be in accordance with the defined 3GPP standards and shall support a circuit switched connection for normal device operation (3GPP test mode and/or data loopback calls are not allowed).

For a device which only supports UE-based A-GNSS and utilizes the test mode identified in Section 2.2.1 and 2.4.1 the test mode shall allow for the following exceptions in the device firmware for UE-based tests:

- Measure Position Response Message (RRLP): As referenced in *TS 44.031* [12] Section 4.2, both “locationInfo” and “gps-MeasureInfo” IEs shall be included.

GPS L1 assistance using control plane will be used for all A-GPS L1 TIS Testing for GSM.

2.5.4 LTE Single Carrier

2.5.4.1 LTE A-GNSS Testing: General

A-GNSS testing for LTE Devices will use either User Plane or Control Plane Positioning procedures. The use of User Plane positioning procedures is a deviation from A-GNSS for WCDMA/GSM device testing which used Control Plane positioning procedures.

When utilizing User Plane Positioning procedures, A-GNSS for LTE devices will be tested using the Open Mobile Alliance (OMA) Secure User Plane (SUPL) 2.0 protocol defined in *OMA-AD-SUPL-V2_0-20110527-C* [13]. RRLP or LPP can be used as the underlying positioning protocol for SUPL 2.0 over the LTE default bearer.

When utilizing User Plane Positioning procedures, the test applies to LTE devices supporting either RRLP or LPP positioning protocol. The test requires that the device support SUPL 2.0 as the User Plane protocol. If the device supports both RRLP and LPP positioning protocols, either one of these could be used during the test. When utilizing User Plane Positioning procedures, the test only applies to UE-assisted A-GNSS procedures. UE-based A-GNSS testing is not required.

When utilizing Control Plane Positioning procedures, A-GNSS for LTE devices will be tested using the LPP positioning protocol necessary for testing the Control Plane based tests in *3GPP TS 37.571-1* [6] over the LTE default bearer. When utilizing Control Plane Positioning procedures, the test applies to both UE-based and UE-assisted A-GNSS devices. If both UE-based and UE-assisted A-GNSS is supported by a device, then both modes will be tested.

The same positioning procedures and positioning protocol shall be used for the reference mode testing (A-GPS L1) and the additional GNSS mode testing (A-GALILEO E1, etc.).

Table 4.1.2-1 in *CTIA 01.50* [5] specifies the mid-channel test channels and UL and DL allocations for LTE except where specified herein. For LTE Band 13 and Band 14, the device shall be tested with the channel and UL RB allocation as defined in Table 2.5.4.1-1.

Table 2.5.4.1-1 Test Channel Settings for LTE Band 13 and Band 14

Band	Channel Bandwidth (MHz)	RX Channel	RX Frequency (MHz) [center of RX channel bandwidth]	UL RB Allocation	DL RB Allocation
13	10	5230	751	12 RB with RBstart=0	50 RB with RBstart=0
14	10	5330	763	15 RB with RBstart=35	50 RB with RBstart=0

For Band 12, testing is only required on either the low or mid channel in Band 12, and the test channel shall be selected by the manufacturer. The selection should be made with input from the target operators. In the absence of operator input, then the mid channel should be used. When the low channel is used, the A-GPS L1 and A-GPS L5 intermediate channel degradation tests are required for the remaining channels in *CTIA 01.50* [5] Section 4.1.2.1. If testing is done for both low and mid channels, then the A-GPS L1 and A-GPS L5 intermediate channel degradation test is only required for the remaining channels in *CTIA 01.50* [5] Section 4.1.2.1.

For the tests that operate at maximum output power, the UE transmit power shall be set to the maximum by sending continuous uplink power control “up” commands in every uplink scheduling information to the UE and allowing at least 200ms for the UE to reach its maximum level. As the 3GPP reference does not make any mention of p-Max, nor is p-Max included in the default message content defined in 3GPP TS 36.508 [15], p-Max shall not be signaled during attach procedures or during measurements.

For the tests that do not operate at maximum output power such as the radiated 3D C/N_0 pattern measurement, it is up to the implementer to utilize UE power control such that the requirement specified can be met.

The radiated A-GNSS intermediate channel degradation measurements shall be made at the intermediate channels defined in *CTIA 01.50* [5] Section 4.1.2.1*.*

The default EPS bearer shall be used for the wireless connection to establish the SUPL 2.0 or Control Plane session.

For a device which only supports UE-based A-GNSS and utilizes the test mode identified in Section 2.2.1 and 2.4.1 the test mode shall allow for the following exceptions in the device firmware for UE-based tests:

- Provide Location Information (LPP): In the A-GNSS-ProvideLocationInformation IE of the LPP Provide Location Information message as referenced in *TS 36.355* [14] Section 6.5.2.5, both “gnss-SignalMeasurementInformation” and “gnss-LocationInformation” shall be included.

The A-GNSS radiated receiver sensitivity measurements will be performed for the LTE bands, using the mid-channel test channel numbers, and the allocations specified in Table 4.1.2-1 in *CTIA 01.50* [5] with the following exceptions. For LTE Band 13 and Band 14, the device shall be tested with the UL allocations as defined in Table 2.5.4.1-2 for each band.

Table 2.5.4.1-2 A-GNSS Radiated Receiver Sensitivity Test Channel Settings for LTE Band 13 and Band 14

Band	Channel Bandwidth (MHz)	RX Channel	RX Frequency (MHz) [center of RX channel bandwidth]	UL RB Allocation	DL RB Allocation
13	10	5230	751	12 RB with RBstart=38	50 RB with RBstart=0
	10	5230	751	1 RB with RBstart=49	50 RB with RBstart=0
14	10	5330	763	12 RB with RBstart=0	50 RB with RBstart=0
	10	5330	763	1 RB with RBstart=0	50 RB with RBstart=0

Network operators or UE manufacturers may request additional testing with alternate UL RB allocations. In such cases, the additional data can be included and marked as supplemental in the test report.

Early delivery of Acquisition Assistance Data and Reference Time Data may be provided to the DUT and the SUPL 2.0 or Control Plane Positioning session shall be used over the wireless data connection.

2.5.5 LTE Category M1 (Informative)

2.5.5.1 LTE Category M1 A-GNSS Testing: General

A-GNSS testing for LTE Category M1 Devices will use either User Plane or Control Plane Positioning procedures. The use of User Plane positioning procedures is a deviation from A-GNSS for WCDMA/GSM device testing which used Control Plane positioning procedures.

When utilizing User Plane Positioning procedures, A-GNSS for LTE Category M1 devices will be tested using the Open Mobile Alliance (OMA) Secure User Plane (SUPL) 2.0 protocol defined in *OMA-AD-SUPL-V2_0-20110527-C* [13]. RRLP or LPP can be used as the underlying positioning protocol for SUPL 2.0 over the LTE default bearer.

When utilizing User Plane Positioning procedures, the test applies to LTE Category M1 devices supporting either RRLP or LPP positioning protocol. The test requires that the device support SUPL 2.0 as the User Plane protocol. If the device supports both RRLP and LPP positioning protocols, either one of these could be used during the test. When utilizing User Plane Positioning procedures, the test only applies to UE-assisted A-GNSS procedures. UE-based A-GNSS testing is not required.

When utilizing Control Plane Positioning procedures, A-GNSS for LTE Category M1 devices will be tested using the LPP positioning protocol necessary for testing the Control Plane based tests in *3GPP TS 37.571-1* [6] over the LTE default bearer. When utilizing Control Plane Positioning procedures, the test applies to both UE-based and UE-assisted A-GNSS devices. If both UE-based and UE-assisted A-GNSS is supported by a device, then both modes will be tested.

The same positioning procedures and positioning protocol shall be used for the reference mode testing (A-GPS L1) and the additional GNSS mode testing (A-GALILEO E1, etc.).

Table 4.5.2-1 in *CTIA 01.50* [5] specifies the mid-channel test channels and UL and DL allocations for LTE Category M1 except where specified herein.

For the tests that operate at maximum output power, the UE transmit power shall be set to the maximum by sending continuous uplink power control “up” commands in every uplink scheduling information to the UE and allowing at least 200ms for the UE to reach its maximum level. As the 3GPP reference does not make any mention of p-Max, nor is p-Max included in the default message content defined in *3GPP TS 36.508* [15], p-Max shall not be signaled during attach procedures or during measurements.

For the tests that do not operate at maximum output power such as the radiated 3D C/N_0 pattern measurement, it is up to the implementer to utilize UE power control such that the requirement specified can be met.

The default EPS bearer shall be used for the wireless connection to establish the SUPL 2.0 or Control Plane session.

For a device which only supports UE-based A-GNSS and utilizes the test mode identified in Section 2.2.1 and 2.4.1 the test mode shall allow for the following exceptions in the device firmware for UE-based tests:

- Provide Location Information (LPP): In the A-GNSS-ProvideLocationInformation IE of the LPP Provide Location Information message as referenced in *TS 36.355* [14] Section 6.5.2.5, both “gnss-SignalMeasurementInformation” and “gnss-LocationInformation” shall be included.

The A-GNSS radiated receiver sensitivity measurements will be performed for the LTE Category M1 bands, using the mid-channel test channel numbers, and the allocations specified in Table 4.5.2-1 in *CTIA 01.50* [5] with the following exceptions. For LTE Category M1 Band 13, the device shall be tested with the UL RB allocations in Table 2.5.5.1-1.

Table 2.5.5.1-1 A-GNSS Radiated Receiver Sensitivity Test Channel Settings for LTE Band 13

Band	Channel Bandwidth (MHz)	RX Channel	RX Frequency (MHz) [center of RX channel bandwidth]	UL RB Allocation	DL RB Allocation
13	10	5230	751	6 RB with RBstart=43	4 RB with RBstart=31
	10	5230	751	1 RB with RBstart=48	4 RB with RBstart=31

Early delivery of Acquisition Assistance Data and Reference Time Data may be provided to the DUT and the SUPL 2.0 or Control Plane Positioning session shall be used over the wireless data connection.

2.5.6 NR FR1 EN-DC (1 LTE carrier with 1 NR carrier)

2.5.6.1 NR FR1 EN-DC A-GNSS Testing: General

A-GNSS testing for NR FR1 EN-DC devices will use either User Plane or Control Plane Positioning procedures.

When utilizing User Plane Positioning procedures, A-GNSS for NR FR1 EN-DC devices will be tested using the Open Mobile Alliance (OMA) Secure User Plane (SUPL) 2.0 protocol defined in *OMA-AD-SUPL-V2_0-20110527-C* [13]. RRLP or LPP can be used as the underlying positioning protocol for SUPL 2.0 over the EN-DC default bearer.

When utilizing User Plane Positioning procedures, the test applies to NR FR1 EN-DC devices supporting either RRLP or LPP positioning protocol. The test requires that the devices support SUPL 2.0 as the User Plane protocol. If the device supports both RRLP and LPP positioning protocols, either one of these could be used during the test. When utilizing User Plane Positioning procedures, the test only applies to UE-assisted A-GNSS procedures. UE-based A-GNSS testing is not required.

When utilizing Control Plane Positioning procedures, A-GNSS for EN-DC devices will be tested using the LPP positioning protocol necessary for testing the Control Plane based tests in *3GPP TS 37.571-1* [6] over the EN-DC default bearer. When utilizing Control Plane Positioning procedures, the test applies to both UE-based and UE-assisted A-GNSS devices. If both UE-based and UE-assisted A-GNSS is supported by a device, then both modes will be tested.

The same positioning procedures and positioning protocol shall be used for the reference mode testing (A-GPS L1) and the additional GNSS mode testing (A-GALILEO E1, etc.).

Table 5.1.2.2.1-1 in *CTIA 01.50* [5] specifies the mid-channel test channels for first test (NR maximum power) and second test (NR-LTE balanced power), both including UL and DL allocations, for NR FR1 EN-DC device with the following exceptions. For NR FR1 EN-DC band combinations with identified IMD generated on the A-GNSS band, the device shall be tested with UL and DL allocations as specified in Table 2.5.6.1-1.

Table 2.5.6.1-1 Test Channel Settings for Second Test (NR-LTE Balanced Power) for NR FR1 EN-DC with Identified IMD Generated on the A-GPS L1 and A-GALILEO E1 band

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_2A_n66A	N/A	1	2	MCG / PCC	10	15	Yes[1]	850	6 RB with RBstart=22	50 RB with RBstart=0	425000	6@25	52@0
			n66	SCG / PCC	10	15							
DC_2A_n77A	R1	1	2	MCG / PCC	10	15	Yes[1]	650	6 RB with RBstart=0	50 RB with RBstart=0	664666	3@45	52@0
			n77 (R1)	SCG / PCC	20	30							
DC_2A_n77A	R2	1	2	MCG / PCC	10	15	Yes[1]	946	6 RB with RBstart=22	50 RB with RBstart=0	630668	3@24	51@0
			n77 (R2)	SCG / PCC	20	30							
DC_2A_n78A	N/A	1	2	MCG / PCC	10	15	Yes[1]	900	6 RB with RBstart=22	50 RB with RBstart=0	630334	3@25	51@0
			n78	SCG / PCC	20	30							
DC_7A_n78A	N/A	1	7	MCG / PCC	20	15	No	3100	6 RB with RBstart=47	100 RB with RBstart=0	633000	3@25	51@0
			n78	SCG / PCC	20	30							
DC_13A_n77A	R1	1	13	MCG / PCC	10	15	No	5230	6 RB with RBstart=21	50 RB with RBstart=0	661500	3@20	51@0
			n77 (R1)	SCG / PCC	20	30							
DC_66A_n2A	N/A	1	66	MCG / PCC	10	15	Yes[1]	66611	6 RB with RBstart=22	50 RB with RBstart=0	392000	6@23	52@0
			n2	SCG / PCC	10	15							
DC_66A_n77A	R1	1	66	MCG / PCC	10	15	Yes[1]	66954	6 RB with RBstart=22	50 RB with RBstart=0	647334	3@24	52@0
			n77 (R1)	SCG / PCC	20	30							
DC_66A_n77A	R2	1	66	MCG / PCC	10	15	Yes[1]	66486	6 RB with RBstart=0	50 RB with RBstart=0	636000	3@48	51@0
			n77 (R2)	SCG / PCC	20	30		67086	6 RB with RBstart=40	50 RB with RBstart=0	630688	3@10	51@0

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_66A_n78A	N/A	1	66	MCG / PCC	10	15	No	67086	6 RB with RBstart=22	50 RB with RBstart=0	623334	3@25	51@0
			n78	SCG / PCC	20	30							
Note 1: Single UL allowed due to potential emission issues, not self-interference.													

For the tests that operate at maximum output power, the FR1 EN-DC system simulator and DUT shall be configured per *3GPP TS 38.521-3* [16], Section 6.2B.1 (UE Maximum Output Power for EN-DC) using the default settings specified in *3GPP TS 38.521-3* [16] and *3GPP TS 38.508-1* [17] as applicable, with the following exceptions for corresponding test case:

1. First test (NR maximum power) - the test procedure in section 6.2B.1 of *3GPP TS 38.521-3* [16] shall be used to set the UE output power but the device is set to transmit maximum output power at NR while the LTE output power shall be minimized (i.e. less than or equal to 10 dBm) to keep the link up and send LPP control plane positioning procedure. This scenario is applicable to the mid-channel test channels in Table 5.1.2.2.1-1 in *CTIA 01.50* [5].
2. Second test (NR-LTE balanced power) - the test procedure in section 6.2B.1 of *3GPP TS 38.521-3* [16] shall be used to set the UE output power so the device transmits both LTE and NR simultaneously at maximum output power. This scenario is applicable to the mid-channel test channels in Table 5.1.2.2.1-1 in *CTIA 01.50* [5] with exceptions for NR FR1 EN-DC band combinations with IMD. For those band combinations, the non mid-channel test channels are specified in Table 2.5.6.1-1. If the device supports only single UL for the EN-DC configuration allowed single UL (i.e. the device doesn't support dual transmission on those EN-DC configuration), it is not necessary to run this EN-DC configuration for second test.

For the tests that do not operate at maximum output power such as the radiated 3D C/N_0 pattern measurement, it is up to the implementer to utilize UE power control such that the requirement specified can be met.

For the second test with NR-LTE balanced power, the device shall run full radiated sensitivity search for all the NR FR1 EN-DC band combinations specified in table 2.5.6.1-1 for A-GPS L1, and A-GALILEO E1 when supported. For all other NR FR1 EN-DC band combinations, instead of running the full radiated sensivitiy search, the alternative pass/fail test specified in the steps below for A-GPS L1, and A-GALILEO E1 when supported shall be used:

1. Ensure that the chamber positioner(s) are positioned at the location & polarization where the peak C/N_0 value was obtained in the upper hemisphere during the radiated 3D C/N_0 pattern measurement for A-GPS L1
2. For testing A-GPS L1 at NR FR1 EN-DC band *bx_ny*, set the A-GPS L1 signal level as below:

Equation 2.5-1

$$A\text{-}GPS\ L1\,Signal\ Level\ _{bx\_ny(second\ test)}(\mathrm{dBm}) = A\text{-}GPS\ L1\,EIS\ _{bx\_ny(first\ test)}(\mathrm{dBm}) + 3(\mathrm{dB})$$

Or

Equation 2.5-2

$$A\text{-}GPS\ L1\,Signal\ Level\ _{bx\_ny(second\ test)}(\mathrm{dBm}) = A\text{-}GPS\ L1\,EIS\ _{ny}(\mathrm{dBm}) + 3(\mathrm{dB})$$

3. Perform the A-GPS L1 sensitivity procedure as defined in the cellular radio mode test specifics in Section 0 with the exception that pass/fail will be determined at only the A-GPS L1 signal level calculated in step 2.
4. For testing A-GALILEO E1 at NR FR1 EN-DC band *bx_ny*, set the A- GALILEO E1 signal level as below:

Equation 2.5-3

$$A\text{-}GALILEO\ E1\,Signal\ Level_{\,bx\_ny}(\mathrm{dBm}) = A\text{-}GALILEO\ \ E1\,EIS_{\,highest\ cellular\ mode\ reference\ band}(\mathrm{dBm}) + 3(\mathrm{dB})$$

5. Perform the A-GALILEO E1 sensitivity procedure as defined in the cellular radio mode test specifics in Section 0 with the exception that pass/fail will be determined at only the A-GALILEO E1 signal level calculated in step 4.
6. Repeat steps 2 to 5 for each remaining operating band for the cellular radio mode in use.
7. Report the pass/fail status of each measurement taken in step 3 for A-GPS L1 and step 5 for A-GALILEO E1 above.

Similar to radiated sensitivity, the radiated A-GNSS intermediate channel degradation measurements have two tests. The first test is with maximum NR power and LTE power minimal. The second test is with both NR and LTE at maximum power. The tests shall be made at the intermediate channels defined in Table 2.5.6.2-1 for the first test. For the second test, measurements shall be made at the intermediate channels defined in Table 2.5.6.2-2 for the second test A-GPS L1 and A-Galileo E1, and in Table 2.5.6.2-3 for A-GPS L5.

The default EPS bearer shall be used for the wireless connection to establish the SUPL 2.0 or Control Plane session.

For a device which only supports UE-based A-GNSS and utilizes the test mode identified in Section 2.2.1 and Section 2.4.1, the test mode shall allow for the following exceptions in the device firmware for UE-based tests:

- Provide Location Information (LPP): In the A-GNSS-ProvideLocationInformation IE of the LPP Provide Location Information message as referenced in *TS 36.355* [14] Section 6.5.2.5, both “gnss-SignalMeasurementInformation” and “gnss-LocationInformation” shall be included.

The A-GNSS radiated receiver sensitivity measurements will be performed for the EN-DC bands, using the mid-channel test channel numbers for the NR FR1 band, and the allocations specified in Table 5.1.2.2.1-1 in *CTIA 01.50* [5] and Table 2.5.6.1-1, depending on the test case.

Early delivery of Acquisition Assistance Data and Reference Time Data may be provided to the DUT and the SUPL 2.0 or Control Plane Positioning session shall be used over the wireless data connection.

2.5.6.2 NR FR1 EN-DC A-GNSS Testing: Intermediate Channel List

The intermediate channel list in Table 2.5.6.2-1, Table 2.5.6.2-2 and Table 2.5.6.2-3 shall be used for NR FR1 EN-DC A-GNSS.

Table 2.5.6.2-1 NR FR1 EN-DC Intermediate Channel Measurements Table for First Test (NR Maximum Power)

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_2A_n5A	N/A	1	2	MCG / PCC	10	15	No	900	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		900	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								900	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_2A_n66A	N/A	1	2	MCG / PCC	10	15	Yes[1]	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_2A_n71A	N/A	1	2	MCG / PCC	10	15	No	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n71	SCG / PCC	10	15							
DC_2A_n77A	R1	1	2	MCG / PCC	10	15	Yes[1]	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_2A_n77A	R2	1	2	MCG / PCC	10	15	Yes[1]	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							
DC_2A_n78A	N/A	1	2	MCG / PCC	10	15	Yes[1]	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
			n78	SCG / PCC	20	30							
DC_5A_n66A	N/A	1	5	MCG / PCC	10	15	Yes[1]	2525	25 RB with RBstart=25	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_5A_n78A	N/A	1	5	MCG / PCC	10	15	No	2525	25 RB with RBstart=25	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_7A_n78A	N/A	1	7	MCG / PCC	20	15	No	3100	75 RB with RBstart=25	100 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_12A_n66A	N/A	1	12	MCG / PCC	5	15	No	5095	20 RB with RBstart=5	25 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_13A_n2A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n2	SCG / PCC	10	15							
DC_13A_n5A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		5230	15 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								5230	15 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_13A_n66A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_13A_n77A	R1	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_13A_n77A	R2	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							
DC_48A_n5A	N/A	1	48	MCG / PCC	10	15	Yes[1]	55990	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		55990	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								55990	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_66A_n2A	N/A	1	66	MCG / PCC	10	15	Yes[1]	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n2	SCG / PCC	10	15							
DC_66A_n5A	N/A	1	66	MCG / PCC	10	15	Yes[1]	66786	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		66786	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								66786	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_66A_n71A	N/A	1	66	MCG / PCC	10	15	No	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n71	SCG / PCC	10	15							
DC_66A_n77A	R1	1	66	MCG / PCC	10	15	Yes[1]	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_66A_n77A	R2	1	66	MCG / PCC	10	15	Yes[1]	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							
DC_66A_n78A	N/A	2	66	MCG / PCC	10	15	No	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_(n)71AA	N/A	1	71	MCG / PCC	10	15	No	68736	25 RB with RBstart=0	50 RB with RBstart=0	124400	25@0	52@0
			n71	SCG / PCC	10	15		68786	25 RB with RBstart=0	50 RB with RBstart=0	129400	25@0	52@0

Note 1: Single UL allowed due to potential emission issues, not self-interference. If the device supports only single UL for single UL allowed EN-DC configuration, it needs to run in single UL mode

Note 2: If the device supports multiple EN-DC configurations with same NR band, it is not necessary to repeat for multiple EN-DC configurations

Table 2.5.6.2-2 A-GPS L1 and A-GALILEO E1 with NR FR1 EN-DC Intermediate Channel Measurements Table for Second Test (NR-LTE Balanced Power)

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_2A_n5A	N/A	1	2	MCG / PCC	10	15	No	900	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		900	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								900	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_2A_n66A	N/A	1	2	MCG / PCC	10	15	Yes[1]	1150	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_2A_n71A	N/A	1	2	MCG / PCC	10	15	No	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n71	SCG / PCC	10	15							
DC_2A_n77A	R1	1	2	MCG / PCC	10	15	Yes[1]	650	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_2A_n77A	R2	1	2	MCG / PCC	10	15	Yes[1]	1150	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							
DC_2A_n78A	N/A	1	2	MCG / PCC	10	15	Yes[1]	1150	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_5A_n66A	N/A	1	5	MCG / PCC	10	15	Yes[1]	2525	25 RB with RBstart=25	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_5A_n78A	N/A	1	5	MCG / PCC	10	15	No	2525	25 RB with RBstart=25	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_7A_n78A	N/A	1	7	MCG / PCC	20	15	No	3350	75 RB with RBstart=25	100 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_12A_n66A	N/A	1	12	MCG / PCC	5	15	No	5095	20 RB with RBstart=5	25 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_13A_n2A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n2	SCG / PCC	10	15							
DC_13A_n5A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		5230	15 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								5230	15 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_13A_n66A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_13A_n77A	R1	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_13A_n77A	R2	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							
DC_48A_n5A	N/A	1	48	MCG / PCC	10	15	Yes[1]	55990	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		55990	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								55990	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_66A_n2A	N/A	1	66	MCG / PCC	10	15	Yes[1]	66611	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n2	SCG / PCC	10	15							
DC_66A_n5A	N/A	1	66	MCG / PCC	10	15	Yes[1]	66786	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		66786	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								66786	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_66A_n71A	N/A	1	66	MCG / PCC	10	15	No	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n71	SCG / PCC	10	15							
DC_66A_n77A	R1	1	66	MCG / PCC	10	15	Yes[1]	67086	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_66A_n77A	R2	1	66	MCG / PCC	10	15	Yes[1]	66486	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30		67086					
DC_66A_n78A	N/A	1	66	MCG / PCC	10	15	No	67086	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_(n)71AA	N/A	1	71	MCG / PCC	10	15	No	68736	25 RB with RBstart=0	50 RB with RBstart=0	124400	25@0	52@0
			n71	SCG / PCC	10	15		68786	25 RB with RBstart=0	50 RB with RBstart=0	129400	25@0	52@0

Note 1: Single UL allowed due to potential emission issues, not self-interference. If the device supports only single UL for single UL allowed EN-DC configuration, it needs to run in single UL mode

Table 2.5.6.2-3 A-GPS L5 with NR FR1 EN-DC Intermediate Channel Measurements Table for Second Test (NR-LTE Balanced Power)

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_2A_n5A	N/A	1	2	MCG / PCC	10	15	No	900	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		900	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								900	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_2A_n66A	N/A	1	2	MCG / PCC	10	15	Yes[1]	669	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_2A_n71A	N/A	1	2	MCG / PCC	10	15	No	1045	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n71	SCG / PCC	10	15							
DC_2A_n77A	R1	1	2	MCG / PCC	10	15	Yes[1]	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_2A_n77A	R2	1	2	MCG / PCC	10	15	Yes[1]	1150	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_2A_n78A	N/A	2	2	MCG / PCC	10	15	Yes[1]	900	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_5A_n66A	N/A	1	5	MCG / PCC	10	15	Yes[1]	2525	25 RB with RBstart=25	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_5A_n78A	N/A	2	5	MCG / PCC	10	15	No	2450	25 RB with RBstart=25	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_7A_n78A	N/A	2	7	MCG / PCC	20	15	No	2850	75 RB with RBstart=25	100 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_12A_n66A	N/A	1	12	MCG / PCC	5	15	No	5095	20 RB with RBstart=5	25 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_13A_n2A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n2	SCG / PCC	10	15							
DC_13A_n5A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
			n5	SCG / PCC	10	15		5230	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								5230	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_13A_n66A	N/A	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n66	SCG / PCC	10	15							
DC_13A_n77A	R1	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_13A_n77A	R2	1	13	MCG / PCC	10	15	Yes[1]	5230	15 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							
DC_48A_n5A	N/A	1	48	MCG / PCC	10	15	Yes[1]	56690	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		56690	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								56690	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_66A_n2A	N/A	1	66	MCG / PCC	10	15	Yes[1]	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n2	SCG / PCC	10	15							

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
DC_66A_n5A	N/A	1	66	MCG / PCC	10	15	Yes[1]	66786	50 RB with RBstart=0	50 RB with RBstart=0	174800	25@27	52@0
			n5	SCG / PCC	10	15		66786	50 RB with RBstart=0	50 RB with RBstart=0	176300	25@27	52@0
								66786	50 RB with RBstart=0	50 RB with RBstart=0	177800	25@27	52@0
DC_66A_n71A	N/A	1	66	MCG / PCC	10	15	No	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n71	SCG / PCC	10	15							
DC_66A_n77A	R1	1	66	MCG / PCC	10	15	Yes[1]	66486	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R1)	SCG / PCC	20	30							
DC_66A_n77A	R2	1	66	MCG / PCC	10	15	Yes[1]	66486	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n77 (R2)	SCG / PCC	20	30							
DC_66A_n78A	N/A	2	66	MCG / PCC	10	15	No	66786	50 RB with RBstart=0	50 RB with RBstart=0	NR channels and RB allocations refer to *CTIA 01.50* [5] Section 5.1.1.2.1		
			n78	SCG / PCC	20	30							
DC_(n)71AA	N/A	1	71	MCG / PCC	10	15	No	68736	25 RB with RBstart=0	50 RB with RBstart=0	124400	25@0	52@0
			n71	SCG / PCC	10	15		68786	25 RB with RBstart=0	50 RB with RBstart=0	129400	25@0	52@0

3GPP Config. Identifier	n77 Range ID	Var.	Band	CG / CC	CC BW (MHz)	SCS (kHz)	Single UL allowed	LTE DL Channel	LTE UL RB Allocation	LTE DL RB Allocation	NR DL Channel	NR UL RB Allocation	NR DL RB Allocation
Note 1: Single UL allowed due to potential emission issues, not self-interference. If the device supports only single UL for single UL allowed EN-DC configuration, it needs to run in single UL mode													

2.5.7 NR FR1 SA Single Carrier

2.5.7.1 NR FR1 SA A-GNSS Testing: General

A-GNSS testing for NR FR1 SA devices will use either User Plane or Control Plane Positioning procedures.

When utilizing User Plane Positioning procedures, A-GNSS for NR FR1 SA devices will be tested using the Open Mobile Alliance (OMA) Secure User Plane (SUPL) 2.0 protocol defined in *OMA-AD-SUPL-V2_0-20110527-C* [13] LPP can be used as the underlying positioning protocol for SUPL 2.0 over the NR default bearer.

When utilizing User Plane Positioning procedures, the test applies to NR FR1 SA devices supporting LPP positioning protocol. The test requires that the devices support SUPL 2.0 as the User Plane protocol. When utilizing User Plane Positioning procedures, the test only applies to UE-assisted A-GNSS procedures. UE-based A-GNSS testing is not required.

When utilizing Control Plane Positioning procedures, A-GNSS for SA devices will be tested using the LPP positioning protocol necessary for testing the Control Plane based tests in *3GPP TS 37.571-1* [6] over the SA default bearer. When utilizing Control Plane Positioning procedures, the test applies to both UE-based and UE-assisted A-GNSS devices. If both UE-based and UE-assisted A-GNSS is supported by a device, then both modes will be tested.

The same positioning procedures and positioning protocol shall be used for the reference mode testing (A-GPS L1) and the additional GNSS mode testing (A-GALILEO E1, etc.).

The device shall be tested at the mid-channels specified in Table 5.1.1.2-1 in *CTIA 01.50* [5] using the UL and DL allocations for NR FR1 SA except where specified herein. For NR band n14, the device shall be tested with the channel and UL RB allocation as defined in Table 2.5.7.1-1.

Table 2.5.7.1-1 Test Channel Settings for n14

3GPP Config. Identifier	CC BW (MHz)	SCS (kHz)	NR DL Channel	RX Frequency (MHz) [center of RX channel bandwidth]	NR UL RB Allocation	NR DL RB Allocation
14	10	15	152600	763	20@32	52@0

For band n77 in the USA, the mid-channel of n77(R1) shall be used as the mid-channel test channel. For band n77 in Canada, the mid-channel of n77(R3) shall be used as the mid-channel test channel.

For the tests that operate at maximum output power, the UE transmit power shall be set to the maximum by sending continuous uplink power control "up" commands in every uplink scheduling information to the UE and allowing at least 200ms for the UE to reach its maximum level. As the 3GPP reference does not make any mention of p-Max, nor is p-Max included in the default message content defined in *3GPP TS 38.508-1* [17], p-Max shall not be signaled during attach procedures or during measurements.

For the tests that do not operate at maximum output power such as the radiated 3D C/N_0 pattern measurement, it is up to the implementer to utilize UE power control such that the requirement specified can be met.

The radiated A-GNSS intermediate channel degradation measurements shall be made at the intermediate channels defined in *CTIA 01.50* [5] Section 5.1.1.2.1 and all reference channels for each band.

The default EPS bearer shall be used for the wireless connection to establish the SUPL 2.0 or Control Plane session.

For a device which only supports UE-based A-GNSS and utilizes the test mode identified in Section 2.2.1 and 2.4.1 the test mode shall allow for the following exceptions in the device firmware for UE-based tests:

- Provide Location Information (LPP): In the A-GNSS-ProvideLocationInformation IE of the LPP Provide Location Information message as referenced in *TS 37.355* [22] Section 6.5.2.5, both “gnss-SignalMeasurementInformation” and “gnss-LocationInformation” shall be included.

The A-GNSS radiated receiver sensitivity measurements will be performed for the NR bands, using the mid-channel test channel numbers, and the allocations specified in Table 5.1.1.2-1 in *CTIA 01.50* [5] with the following exceptions. For NR band n14, the device shall be tested with an UL RB allocation as defined in Table 2.5.7.1-2.

Table 2.5.7.1-2 A-GNSS Radiated Receiver Sensitivity Test Channel Settings for NR band n14

3GPP Config. Identifier	CC BW (MHz)	SCS (kHz)	NR DL Channel	RX Frequency (MHz) [center of RX channel bandwidth]	NR UL RB Allocation	NR DL RB Allocation
14	10	15	152600	763	12@0	52@0
			152600	763	1@2	52@0

Early delivery of Acquisition Assistance Data and Reference Time Data may be provided to the DUT and the SUPL 2.0 or Control Plane Positioning session shall be used over the wireless data connection.

2.5.8 LTE and LTE Category M1 A-GNSS Testing: With SIB8 or SIB16 support (Informative)

This section specifies the test procedures to support LTE and LTE Category M1 A-GNSS testing with SIB8 or SIB16. The use of "shall" in the test cases listed herein is only used to indicate that the test case purpose, procedure, and/or result may not be as expected if the specified "shall" or "must" item is not used or followed. As the section is informative in nature, the use of "shall" or "must" is not meant to imply a specific requirement. Their use is meant to indicate instances where the test objectives of the recommended test cases may not be achieved.

If the device supports SIB8 or SIB16, based on operators request, A-GNSS sensitivity test for LTE or LTE Category M1 device shall be tested with the following logic:

1>If the device supports both SIB8 and SIB16 for A-GPS demodulation performance:
    2>If the device supports both LTE and CDMA:
        3>Execute testing in all bands using SIB8.
    2>Else (i.e. the device is LTE only or the device supports only LTE and legacy 3GPP modes):
        3>Execute testing in all bands using SIB16.
1>Else:
    2>If the device supports SIB8 only:
        3>Execute testing in all bands using SIB8.

2>If the device supports SIB16 only:
3>Execute testing in all bands using SIB16.

A-GNSS test parameters shall follow Table 2.5-2 with the exceptions below:

1. All satellite power levels shall be set to the same power level.
2. The network emulator shall broadcast SIB8 (including the fields and settings shown below) or SIB16 (including all mandatory and optional fields). UTC Time in SIB16 and CDMA system time in SIB8 shall be synchronized to within +/- 100ns of GNSS time.

```
sib8 :
       {
          systemTimeInfo
          {
            cdma-EUTRA-Synchronisation TRUE,
            cdma-SystemTime synchronousSystemTime : 'xxxxxxxx
                              xxxxxxxx xxxxxxxx xxxxxxxx xxxxxxx'
          },
          searchWindowSize 8,
          parameters1XRTT
          {
          },
          csfb-SupportForDualRxUEs-r9 TRUE
       }
```

2.5.9 UE-based User Plane Positioning Procedures for A-GNSS Testing (Informative)

A-GNSS testing for LTE, LTE Cat M1, NR FR1 EN-DC, NR FR1 SA devices will use either User Plane or Control Plane Positioning procedures. This section is to specify the UE-based user plane positioning procedures for A-GNSS Testing.

UE-based user plane positioning procedures for A-GNSS testing will be using the Open Mobile Alliance (OMA) Secure User Plane (SUPL) 2.0 protocol defined in *OMA-AD-SUPL-V2_0-20110527-C* [13]. RRLP or LPP can be used as the underlying positioning protocol for SUPL 2.0 over the LTE or NR default bearer. The specific procedures for pattern measurement, sensitivity measurement and channel degradation measurement are the same as corresponding UE-based control plane positioning procedures in section 2.1 to 2.4.

Section 3 MBS (Informative)

3.1 Test Procedure

The procedure identified herein has been based on industry standards used during DUT conformance testing. However, some modifications were made to reduce test time, to reduce the Over-the-Air test solution complexity, and to account for specific Over-the-Air testing needs. The specific modifications are described in the corresponding cellular radio mode test specifics in Section 3.5. It is assumed that the DUT will be tested per the conformance testing requirements defined by the industry standards. Therefore, any device that does not specifically meet the requirements of the industry standards would be identified during the conformance testing.

The use of "shall" in the test cases listed herein is only used to indicate that the test case purpose, procedure, and/or result may not be as expected if the specified "shall" or "must" item is not used or followed. As the section is informative in nature, the use of "shall" or "must" is not meant to imply a specific requirement. Their use is meant to indicate instances where the test objectives of the recommended test cases may not be achieved.

MBS Receiver Sensitivity measurements shall be performed using test equipment that supports the relevant standards defined herein. Unless otherwise specified, the latest versions of the referenced 3GPP documents shall be used. The DUT's MBS receiver sensitivity will be the minimum MBS signal level that results in a passing result based on the relevant MBS test parameters defined herein.

The test will determine the Total Isotropic Sensitivity (TIS), the Near-Horizon Partial Isotropic Sensitivity considered over ±45 degrees $NHPIS_{\pm45}$ and the Near-Horizon Partial Isotropic Sensitivity considered over ±30 degrees $NHPIS_{\pm30}$ of the MBS receiver. The TIS test procedure based on receive signal strength derived from code phase RMS error as specified in *CTIA 01.20* [4] Section 4.7 will be used.

The test applies to UE-assisted MBS devices.

This test will consist of the following measurements:

- Radiated 3D RSS pattern measurement based on code phase RMS error
- Radiated MBS sensitivity measurement
- Radiated MBS intermediate channel degradation measurement

TIS, $NHPIS_{\pm45}$, and $NHPIS_{\pm30}$ shall be fully measured as described in Section 3.2.1 and 3.3.1, and calculated pursuant to the *CTIA 01.90* [1]. When operating the device at the channels specified and in all frequency bands and cellular radio modes where the DUT supports MBS and as defined herein. In all cases, the linearized RSS measurements based on code phase RMS error values shall be used in the calculations.

For both the full TIS test and the MBS intermediate channel degradation test, head with hand phantom and/or hand phantom testing shall be conducted based on device type, as specified in *CTIA 01.01* [2] Section 2.1.8. Refer to *CTIA 01.71* [3] for head and hand testing guidance. Perform each test in all functional use configurations, and with the DUT antenna extended and retracted, as applicable.

MBS OTA testing shall be performed with the device configured in its normal operating state with regards to the use of cellular diversity antennas.

3.2 Radiated 3D RSS Pattern Measurement

3.2.1 General

The pattern data shall be determined by averaging RSS measurements derived from code phase RMS error measurements of all visible MBS beacons for each measurement at each point on the sphere. For each measurement, RSS corresponds to:

$$20 \times log_{10}\left(\frac{0.336 \times T_{chip}}{codephaseRMSError}\right)$$

in dB units and

$$\frac{0.336^2 \times T_{chip}^2}{codephaseRMSError^2}$$

in linear terms, where T_{chip} is 293.052 meters and $codephaseRMSError$ is the value in meters as specified in sub-clause 6.5.4.2 of the *3GPP TS 36.355* [14] specification. The upper bound of the pseudo-range value given in the floating-point mapping is used. The MBS simulator shall provide the number of beacons specified herein and each beacon shall be at the same power. All code phase RMS error measurements shall be done with the MBS engine in a tracking mode or by using individual UE-assisted measurements. Orthogonal linear polarizations will be measured. For one measurement report, the RSS measurements derived based on the reported code phase RMS error values shall be averaged. If it is necessary to obtain more measurements to reduce uncertainty, repeat the measurement requests at the same position and polarization and independently average the RSS values corresponding to the reported code phase RMS error values for each measurement report. After a sufficient number of measurement requests have been made, average the average results that were obtained for each measurement request. Sufficient averaging shall be completed to ensure that the uncertainty is less than the value included in the uncertainty budget. The RSS pattern measurements shall be performed with any supported cellular radio mode using a low TX power to conserve battery power and to minimize self-interference. The transmit power shall be guaranteed to be 10 dB or more below the maximum TX power.

The RSS pattern data shall be linearized per the linearization method specified in *CTIA 01.20* [4] Section 4.7.2 using code phase RMS error measurements. Note that when the Alternate Test Procedure for TIS Single Point Offset Test can be and is used for MBS testing, the 3D RSS patterns do not need to be measured and the linearization step does not need to be applied for other applicable operating bands and cellular radio modes.

3.3 Radiated MBS Sensitivity Measurement

3.3.1 General

The radiated MBS sensitivity search shall be performed at the position/polarization where the peak RSS value derived from the code phase RMS error value was obtained. The DUT's MBS receiver sensitivity will be the minimum MBS signal level that results in a passing result for the applicable MBS Sensitivity test specified herein. The maximum MBS sensitivity search step size shall be no more than 0.5 dB when the MBS beacon power level is near the MBS sensitivity level. The DUT shall be transmitting at maximum power at the declared MBS sensitivity level. The transmit power settings for maximum power shall be as defined in the cellular radio mode test specifics in Section 3.5. In order to minimize test time, the DUT measurements may be performed on a single call as long as each DUT measurement report is the result of a separate request. The DUT is not required to be power cycled in between measurements. When operating in UE-assisted mode, the MBS information does have to be cleared in between measurement requests using the RESET function defined in *3GPP TS 36.509* [18] for MBS. Refer to *CTIA 01.20* [4] Section 6 and *CTIA 01.71* [3] Section 2 for test set-up illustrations.

The radiated sensitivity tests for a particular band/antenna configuration should be performed without disturbing the setup to minimize uncertainty in the sensitivity search. If the DUT will be disturbed during the test, a corresponding uncertainty component shall be included in the uncertainty budget.

3.3.2 Single Band Optimization

The Single Band Optimization is employed to minimize test time, by performing the radiated MBS sensitivity procedure in one band, chosen using specified criteria, and performing pass/fail checks for the remainder of the supported bands. The radiated MBS sensitivity measurement shall be performed at the position/polarization where the peak RSS value was obtained during the radiated 3D RSS pattern measurement for MBS for the band from the list in *CTIA 01.50* [5] Table 4.1.1-1 that is supported by the DUT, has the uplink closest to the M-LMS band and supports the narrowest channels, in each cellular radio mode and in each usage mode (BHHR, BHHL, HR, and HL) using the Alternate Test Procedure for TIS Single Point Offset Test specified in *CTIA 01.20* [4] Section 4.4*.* However, the Alternate Test Procedure for TIS Single Point Offset Test cannot be used with dynamically tuned MBS antennas when the tuning of the MBS antenna changes between the reference cellular protocol/band and with the protocol/band being evaluated. In the case with dynamically tuned MBS antennas, the MBS sensitivity measurement as defined above shall be made in the same cellular radio mode and operating band as the full MBS OTA sensitivity measurement and the alternative pass/fail test specified in the steps below shall not be used.

For all other operating bands within the same cellular radio mode and usage mode (BHHR, BHHL, HR, and HL), the following steps shall be performed.

1. Ensure that the chamber positioner(s) are positioned at the location & polarization where the peak RSS value was obtained during the radiated 3D RSS pattern measurement for MBS for the band from the list given in *CTIA 01.50* [5] Table 4.1.1-1 that is supported by the DUT, has the uplink closest to the M-LMS band and the narrowest supported channels.
2. Note the downlink power level which corresponds to the DUT's peak radiated MBS sensitivity as described in Step 1 above, which will be referred to as $MBS\ EIS_{(peak,reference\ band)}$.
3. Change to the test frequency associated with the next operating band for the cellular radio mode in use and adjust the MBS signal level to the RF power level calculated by the following formula:

Equation 3.3.2-1

$$\begin{aligned} MBS\ Signal\ Level(\mathrm{dBm}) \\ &= MBS\ EIS_{(peak,reference\ band)}(\mathrm{dBm}) \\ &+ MBS\ Linearized\ RSS_{(peak,band\ under\ test)}(\mathrm{dBm}) \\ &- MBS\ Linearized\ RSS_{(peak,reference\ band)}(\mathrm{dBm}) + 3(\mathrm{dB}) \end{aligned}$$

4. Perform the MBS sensitivity procedure as defined in the cellular radio mode test specifics in Section 3.5 with the exception that pass/fail will be determined at only the MBS signal level calculated in step 3.
5. Repeat steps 3 and 4 for each remaining operating band for the cellular radio mode in use.
6. Repeat steps 1 through 5 for each remaining cellular radio mode in the existing usage mode.

7. Repeat steps 1 through 6 for each remaining usage mode (BHHR, BHHL, HR, and HL) based on device type, as specified in Test Scope, Requirements, and Applicability. Perform each test with the DUT antenna extended and retracted, as applicable.
8. Report the pass/fail status of each measurement taken in step 4 above.

3.4 Radiated MBS Intermediate Channel Degradation Measurement

3.4.1 General

In addition to performing the sensitivity scan at the middle channel, the difference in sensitivity of the MBS receiver will be evaluated with the cellular transceiver active for all intermediate cellular channels. This difference in sensitivity will be determined by measuring the difference in the radiated RSS at the mid-channel and the radiated RSS result at each of the intermediate channels with the cellular transmitter active at maximum power. This test will be called the MBS intermediate channel degradation test.

For this test, the radiated RSS shall be measured at the position/polarization where the peak RSS was obtained.

The RSS measurements for each band/antenna configuration should be performed without disturbing the setup to minimize uncertainty in MBS intermediate channel degradation test. If the DUT will be disturbed during the test, a corresponding uncertainty component shall be included in the uncertainty budget.

The basic test sequence for performing this MBS intermediate channel degradation test is as follows:

1. Set up the beacon simulator with the number of beacons specified for the radiated 3D RSS pattern measurement at the same power. The MBS beacon power and scenario shall be set according to the recommendations in the cellular radio mode test specifics in Section 3.5.
2. Enable a call using the appropriate cellular radio protocol.
3. Enable the MBS engine.
4. Obtain an MBS lock and start tracking.
5. Set the cellular radio channel to the middle channel and the transmit power level to maximum power as defined in the cellular radio mode test specifics in Section 3.5.
6. Transmit the code phase RMS error of the visible MBS beacons over the existing cellular radio link. Record the averaged RSS based on the code phase RMS error of the visible MBS beacons. If additional measurements are required to minimize uncertainty, the measurements should be made prior to moving to the next step. Calculate the average RSS (or average over repeated measurements of averages) and linearize the result using the data from the earlier linearization process.
7. Change the cellular radio channel to a channel in the intermediate channel list for each appropriate cellular radio mode and operating band in *CTIA 01.50* [5]. It is up to the implementer to determine how to change channels.
8. Transmit the code phase RMS error of the visible MBS beacons over the existing cellular radio link. Record the averaged RSS code phase RMS error of the visible MBS beacons. If additional measurements are required to minimize uncertainty, the measurements should be made prior to moving to the next step. Calculate the average RSS (or average over repeated measurements of averages) and linearize the result using the data from the earlier linearization process.
9. Repeat steps 7 and 8 for each channel in the intermediate channel list for each appropriate cellular radio mode and operating band in *CTIA 01.50* [5].
10. Repeat steps 5 through 9 for each cellular radio mode and operating band supported by the DUT.

Alternatively, the measurements defined above may be achieved by using the methodology defined for the radiated 3D RSS pattern measurement defined in Section 3.2 except that transmit power level will be set to maximum power, as defined in the cellular radio mode test specifics in Section 3.5.

The MBS intermediate channel degradation is the difference between the linearized average RSS (or average over repeated measurements of averages) with the transmitter at the mid-channel and the lowest linearized average RSS (or average over repeated measurements of averages) with the transmitter at any intermediate channel (including the mid-channel). Therefore, the MBS intermediate channel degradation will always be zero or greater. Report the MBS intermediate channel degradation.

As specified above, the average RSS measurement of all visible MBS beacons at each instance in time will be used. Sufficient averaging over time of measurements shall be completed to ensure that the uncertainty is less than the value specified in the lab's uncertainty budget.

$$MBS_{ICD} = \text{MBS degradation due to intermediate channel jamming}$$

$$RSS_{mid\text{-}channel} = \text{Linearized RSS with the mid-channel}$$

$$RSS_{min\ IC} = \text{minimum linearized RSS across all intermediate cellular channels}$$

$$MBS_{ICD} = RSS_{mid\text{-}channel} - RSS_{min\ IC} \text{ (in dB)}$$

3.5 Cellular Radio Mode Test Specifics

3.5.1 LTE Single Carrier

3.5.1.1 LTE MBS Testing: General

MBS Receiver Sensitivity measurements shall be performed using test equipment that supports the relevant portions of *3GPP TS 37.571* [6]. Unless otherwise specified, the latest versions of the referenced 3GPP documents shall be used.

MBS testing for LTE Devices will use either User Plane or Control Plane Positioning procedures. Testing is only required in either User Plane or Control Plane and the positioning procedure used for test shall be selected by the manufacturer. The selection should be made with input from the target operators. In the absence of operator input, then Control Plane Positioning procedures shall be used.

When utilizing User Plane Positioning procedures, MBS for LTE devices will be tested using the Open Mobile Alliance (OMA) Secure User Plane (SUPL) 2.0 protocol defined in *OMA-AD-SUPL-V2_0* [13] and *OMA-TS-ULP-V2_0_3* [19] with LPP used as the underlying positioning protocol for SUPL 2.0 over the LTE default bearer.

When utilizing User Plane Positioning procedures, the test applies to LTE devices supporting LPP positioning protocol. The test requires that the device support SUPL 2.0 as the User Plane protocol.

When utilizing Control Plane Positioning procedures, MBS for LTE devices will be tested using the LPP positioning protocol necessary for testing the Control Plane based tests in *3GPP TS 37.571-1* [6] over the LTE default bearer.

Table 4.1.2-1 in *CTIA 01.50* [5] specifies the mid-channel test channels and UL and DL allocations for LTE.

For the tests that operate at maximum output power, the UE transmit power shall be set to the maximum by sending continuous uplink power control "up" commands in every uplink scheduling information to the UE and allowing at least 200ms for the UE to reach its maximum level.

For the tests that do not operate at maximum output power such as the radiated 3D RSS pattern measurement, it is up to the implementer to utilize UE power control such that the requirement specified can be met.

The radiated MBS intermediate channel degradation measurements shall be made at the intermediate channels defined in *CTIA 01.50* [5] Section 4.1.2.1.

3.5.1.2 MBS Test Procedure for LTE

For the MBS radiated 3D RSS pattern measurement and the MBS intermediate channel degradation measurement, the MBS simulator shall implement the scenario defined in *3GPP TS 37.571-1* [6] subclause 11.3.5 except with modifications that the number of MBS beacons is 10 (one beacon in each of the 10 beacon slots in a transmission period) and the signal level is -110dBm, to facilitate linearization based on code phase RMS error.

The MBS radiated receiver sensitivity measurements shall be performed using the MBS *3GPP TS 37.571-1* [6] Test Scenario 11.2.5, using the sample size and pass/fail criteria shown in Table 3.5.1.2-1.

Table 3.5.1.2-1 Sample Size and Pass/Fail Criteria for MBS Sensitivity Search Procedure

Pass criteria	At 33 test samples, 0 error samples OR At 46 test samples, 1 error sample OR At 58 test samples, 2 error samples OR At 69 test samples, 3 error samples OR At 79 test samples, 4 error samples OR At 89 test samples, 5 error samples OR At 100 test samples, 10 or fewer error samples
Fail criteria	At 100 or fewer test samples, 11 error samples

The test tolerance or test parameter relaxation for the absolute MBS signal level in C.2.3 in *3GPP TS 37.571-1* [6] shall not be used in reporting the sensitivity measurement results. The MBS engine shall be cold started for every location attempt.

For MBS radiated receiver sensitivity measurements, the MBS simulator shall implement scenario as defined in *3GPP TS 37.571-1* [6] Section 11.2.5.

The MBS radiated receiver sensitivity measurements will be performed for the LTE bands, channel numbers, and the allocations specified in Table 4.1.2-1 in *CTIA 01.50* [5].

Section 4 Stand-Alone GNSS Test Methodology and Test Procedure (Informative)

4.1 Purpose

The purpose of this appendix is to define the test methodology and test procedure to measure stand-alone GNSS performance. Two methods are defined enabling different levels of testing for different classes of devices. The first method measures stand-alone GNSS acquisition sensitivity with location accuracy requirements similar to A-GNSS in Section 2 and will be called the stand-alone GNSS acquisition sensitivity method. The second method measures stand-alone GNSS tracking sensitivity without any accuracy requirements and will be called stand-alone GNSS tracking sensitivity method.

Note that the sensitivity criteria for both methods have offsets from each other and also to the A-GNSS sensitivity criteria.

4.2 Scope

The scope of this appendix will define the communication protocol and mechanism to enable testing standalone GNSS performance with acquisition sensitivity or with tracking sensitivity.

4.3 Communication Protocol

In A-GNSS, the communication between the DUT and the system to collect measurement data is via the signaling protocol defined in each of the corresponding cellular technologies, e.g. RRLP in GSM, RRC in WCDMA, and LPP and SUPL in LTE. For standalone GNSS DUT's, those signaling protocols are not applicable.

4.3.1 Stand-Alone GNSS Acquisition Sensitivity Method

To simplify the design and implementation effort to support different types of DUTs, e.g. wearables, IoT, etc., with various bearer interfaces (e.g., Bluetooth®, 802.11x, LTE, WCDMA, GSM, etc.), the communication protocol is defined to be running on the TCP/IP transport layer. It is generic and can support multiple operating systems of different types of DUTs and communication interfaces. Also, it can support new communication interfaces as long as they support TCP/IP.

The protocol is request/response based. According to the test procedure, the system sends a request to the DUT and the DUT acts on the command and provides a response to the system. The format of the message is defined as follows:

Request/Response Messages:

```
<Message ID> <PARAM1 ID>:<PARAM1 VALUE>;

        <PARAM2 ID>:<PARAM2 VALUE>;

        <PARAMN ID>:<PARAMN VALUE><CR><LF>
```

There are 6 messages needed to enable standalone GNSS with acquisition sensitivity testing. They are REQ_RESET_GNSS, RESP_RESET_GNSS, REQ_CN_MEASUREMENT, RESP_CN_MEASUREMENT, REQ_LOCATION and RESP_LOCATION.

The detailed definition and description of each message is in Table 4.3.1-1 .

Table 4.3.1-1 Message Definition and Description for Stand-Alone GNSS Acquisition Sensitivity Method

Message ID	Description	Direction	Parameters and Values
REQ_RESET_GNSS	Request UE to clear all GNSS data, all historical data and results	System to DUT	TYPE:<COLD/WARM/HOT> Example REQ_RESET_GNSS TYPE:COLD
RESP_RESET_GNSS	Response whether the reset GNSS command succeeded or not	Device to DUT	RESULT:<OK/FAIL> Example RESP_RESET_GNSS RESULT:FAIL RESP_RESET_GNSS RESULT:OK;
REQ_CN_MEASUREMENT	Request UE to measure C/N_0 for GNSS	System to DUT	GNSS:<GPS/GPS,GALILEO/GPSL5>; ACCURACY:<H/M/L>; ---- Default value is "H" and the other values ("M" and "L") are for future development. MAX_RESP_TIME:<#> ----- unit is second(s) Example REQ_CN_MEASUREMENT GNSS:GPS;ACCURACY:H;MAX_RESP_TIME:120
RESP_CN_MEASUREMENT	Response to report C/N_0 measurement	DUT to System	RESULT:<OK/FAIL>; TOTAL:<#>; GNSS:<GPS/GALILEO/GPSL5-->; ----- A "--" is used when the device cannot determine the satellite constellation. SAT_ID:<#>; ----- A "--" is used when the device cannot identify the satellite. CN:<#>; ----- unit is dB, ";" not used for last satellite Examples RESP_CN_MEASUREMENT RESULT:FAIL; RESP_CN_MEASUREMENT RESULT:OK;TOTAL:3;GNSS: --;SAT_ID:--;CN:40;GNSS:--;SAT_ID:--;CN:38;GNS S:--;SAT_ID:--;CN:35 RESP_CN_MEASUREMENT RESULT:OK;TOTAL:4;GNSS: GPS;SAT_ID:1;CN:40;GNSS:GPS;SAT_ID:3;CN:3 8;GNSS:GALILEO;SAT_ID:20;CN:35;GNSS:GPSL5;SAT_ID:1;CN:42
REQ_LOCATION	Request UE to report current location	System to DUT	GNSS:<GPS/GPS,GALILEO/GPSL5>; ACCURACY:<H/M/L>; MAX_RESP_TIME:<#> ----- unit is second(s) Example REQ_LOCATION GNSS:GPS;ACCURACY:H; MAX_RESP_TIME:120

Message ID	Description	Direction	Parameters and Values
RESP_LOCATION	Response to report UE location	DUT to System	RESULT:<OK/FAIL>; LAT:<#>; LONG:<#>; ALT:<#> Examples RESP_LOCATION RESULT:FAIL; RESP_LOCATION RESULT:OK;LAT:35.7500588894;LONG:139.6753 692627;ALT:300.00

4.3.2 Stand-Alone GNSS Tracking Sensitivity Method

To simplify the design and implementation effort to support simpler DUTs, e.g., wearables, IoT, etc., with Bluetooth support, the communication protocol is defined to be the serial port interface.

Only one message needs to be supported to enable stand-alone GNSS with tracking sensitivity testing. A device dependent command is sent from the test system to the DUT over the Bluetooth serial port interface to start sending the GNSS receiver data in *National Marine Electronics Association (NMEA) 0183* [20] format from the DUT to the test system over the Bluetooth serial port interface. The *NMEA 0183* [20] standard defines the format of the data sent by the GNSS receiver to the Bluetooth engine on the same DUT. To reduce the amount of data being transferred, the DUT software may be configured to ignore all satellites other than those being measured.

4.4 Procedure

In general, the test procedure is similar to A-GNSS defined in Section 2.1. The test will measure the Total Isotropic Sensitivity (TIS), the Upper Hemisphere Isotropic Sensitivity (UHIS) (theta = 0 to 90 degrees) and the Partial Isotropic GNSS Sensitivity (PIGS) (theta = 0 to 120 degrees) of the GNSS receiver. The test consists of:

- Radiated 3D C/N_0 pattern measurement
- Radiated GNSS sensitivity measurement

TIS, UHIS, and PIGS shall be fully measured as described in the following Section 4.5 and Section 4.6 and calculated pursuant to the *CTIA 01.90* [1]. In all cases, the linearized C/N_0 values shall be used in the calculations. The DUT shall be tested in each functional configuration (antenna extended and retracted, etc.) and test position (hand, head, wrist) as recommended by the manufacturer. For test positioning requirements refer to appropriate sections of *CTIA 01.71* [3] for devices used with head and hands, Notebooks and Tablets, Integrated Devices and body wearable devices.

4.5 Radiated 3D C/N_0 Pattern Measurement

The pattern data shall be determined by averaging Carrier-to-Noise (C/N_0) measurements of all visible GNSS satellites for each measurement at each point on the sphere. The GNSS satellite simulator shall provide the number of satellites specified herein and each satellite vehicle shall be at the same power.

Orthogonal linear polarizations will be measured. For one measurement, the reported satellite C/N_0 values shall be averaged. If it is necessary to obtain more measurements to reduce measurement uncertainty, repeat the measurements at the same position and polarization and independently average the reported satellite C/N_0 values for each measurement report. After a sufficient number of measurements have been made, average the average results that were obtained for each measurement report. Sufficient averaging shall be used to ensure that the measurement uncertainty is less than the value included in the measurement uncertainty budget. The C/N_0 pattern data shall be linearized per the linearization method specified in *CTIA 01.20* [4] Section 4.7.2.

The radiated 3D C/N_0 pattern measurement shall be performed for GPS L1 and GPS L5. The GPS L1 and GPS L5 satellite simulator shall implement GNSS Scenario as specified in Table 2.5.1-1 for LTE. The scenario shall be reset before the initial satellites become no longer visible. The scenario shall be executed as required in the corresponding test specifications defined in Table 2.5.1-1 for LTE with the exception that random errors shall not be applied to the UE locations and the alternating locations requirement shall not be implemented.

The reference signal power level shall be -130 dBm for all GNSS satellites.

Although outside the recommendations outlined in this test procedure, it is possible to improve measurement time and reduce the number of non-achievable measurement points (no satellites reported) for DUTs with low antenna gain, by increasing the reference signal power level as long as the highest reported C/N_0 by the DUT is confirmed to be in the linear region of the receiver during the linearization step. Most GNSS receivers are linear up to 48 dB C/N_0. Note that the same reference signal power level must be used for the entire radiated 3D C/N_0 pattern measurement and when correlating the single point C/N_0 to the single point sensitivity measurement.

For GPS L5, the reported metric shall be average 3D C/N_0 for the L1 satellites and the average 3D C/N_0 for the L5 satellites. Both sets of 3D C/N_0 pattern data shall be linearized prior to calculating the average 3D C/N_0. The set of 3D C/N_0 pattern data for the L1 satellites used to the calculate average 3D C/N_0 will come from a previous measurement of the GPS L1 and not from the GPS L5 measurement. Average 3D C/N_0 is calculated in the same way as TRP, except C/N_0 pattern data is used instead of EIRP pattern data. Higher values of average 3D C/N_0 represent better OTA performance, similar to TRP. UH 3D C/N_0 is similar to UHIS in that that same portion of the pattern is used to calculate both metrics. Partial Integrated GPS 3D C/N_0 (PIG 3D C/N_0) is similar to PIGS in that that same portion of the pattern is used to calculate both metrics.

For GPS L5 radiated 3D C/N_0 pattern measurement, it is necessary to compensate the GPS L1 power level to achieve similar C/N_0 on the GPS L1 and GPS L5 satellites, which is caused by the difference in antenna gain between GPS L1 and GPS L5 frequencies. For each point on the 3D C/N_0 pattern measurement, the power level of the GPS L1 and GPS L5 satellites shall be initially set to deliver -130 dBm to an isotropic radiator. After the C/N_0 for the GPS L1 and GPS L5 satellites have been measured, the GPS L1 signal power shall be adjusted (if needed) to achieve a C/N_0 within 3 dB of the C/N_0 measured for the GPS L5 satellites. The GPS L1 power level estimate is based on the average C/N_0 measurements made on the GPS L1 satellite vehicles. The GPS L5 C/N_0 averaging method shall be the same C/N_0 averaging method used to estimate the GPS L1 power level.

4.5.1 Stand-alone GNSS Acquisition Sensitivity Method

In this method, each measurement is initiated with a measurement request message, and reported with a measurement report message.

4.5.2 Stand-alone GNSS Tracking Sensitivity Method

In this method, measurements are continually reported in NMEA format over the Bluetooth serial port interface. In order to ensure that the reported C/N_0 values are stable and accurate, wait 5 seconds after changing the angle or polarization, and then monitor the C/N_0 values. Average the satellites in each measurement report. Continue until 5 consecutive average measurement report results with a maximum deviation of less than 1 dB are received. C/N_0 results may be considered outliers and removed from the average when the results deviate (higher or lower) by more than 3 dB from the median C/N_0 of the reported satellites. Although outside the recommendations outlined in this test procedure it is possible to improve measurement time by reducing the deviation to 1.5 dB when identifying outliers.

Note that the same procedure used to collect the C/N_0 data for the 3D pattern will be used during the linearization process.

4.6 Radiated GNSS Sensitivity Measurement

The radiated GNSS sensitivity search shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere. The DUT's GNSS receiver sensitivity will be the minimum GNSS signal level that results in a passing result for the applicable GNSS Sensitivity test specified herein. The maximum GNSS sensitivity search step size shall be no more than 0.5 dB when the satellite vehicle power level is near the GNSS sensitivity level.

The conducted GNSS sensitivity of the DUT shall also be measured at the antenna connector, if available. It is preferable that the DUT be the same as utilized for the TIS measurements. However, if the DUT does not readily support an antenna port for conducted measurements, a separate modified DUT may be provided for all conducted measurements. If no connector is available, the conducted sensitivity measurement is not required. Ideally, the sensitivity measurement will be performed with the same instrumentation in an equivalent configuration in order to minimize the measurement uncertainty involved. A different sensitivity measurement device may be used as long as any differences in absolute measurement accuracy are accounted for, either in corrections to the recorded sensitivity level or increased reported measurement uncertainty for the conducted measurement. Refer to *CTIA 01.20* [4] Section 6 for more information on conducted sensitivity measurements and cabling setups.

The radiated GPS L1 sensitivity measurement shall be performed at the position/polarization where the peak C/N_0 value was obtained in the upper hemisphere. The GPS L1 satellite simulator shall implement GNSS Scenario as specified in Table 2.5.1-1 for LTE. The scenario shall be reset before the initial satellites become no longer visible. The scenario shall be executed as required in the corresponding test specifications defined in Table 2.5.1-1 for LTE with the exception that random errors shall not be applied to the UE locations and the alternating locations requirement shall not be implemented.

The radiated standalone GPS L5 sensitivity measurement is not required.

4.6.1 Stand-alone GNSS Acquisition Sensitivity Method

The GNSS information shall be cleared prior to every location attempt. The GPS L1 test parameters are defined below in Table 4.6.1-1.

Table 4.6.1-1 GPS L1 Test Parameters for Stand-Alone GNSS Acquisition Sensitivity Method

Test Parameter Description	Test Parameter Settings
Number of satellites	8
HDOP range	1.1 to 1.6
Propagation conditions	AWGN
GPS L1 time assistance	Coarse, ± 2 s
DUT response time	120 seconds
Success rate	38 successful fixes with the necessary accuracy out of 40 attempts (95%)

Test Parameter Description	Test Parameter Settings
Position accuracy	101.3 m

The satellite power levels for the sensitivity test are such that there will be one GPS L1 satellite, which transmits 5 dB higher than the other satellites. The reported sensitivity level will be based on the power of the weaker satellites. The above clarification means that, at signal levels -141 dBm and -146 dBm will lead to a sensitivity level report of -146 dBm, rather than -147 dBm.

4.6.2 Stand-alone GNSS Tracking Sensitivity Method

The satellite power levels for the GPS L1 sensitivity tests are such that all the GPS L1 satellites will transmit the same power. Note that this is different than what is required in Section 4.6.1.

For GPS L1 sensitivity tests, at each power level, to ensure that GNSS receiver has properly adjusted to the new power level, wait 10 seconds after changing the power level, and then monitor C/N_0 values. Average the satellites in the measurement report. C/N_0 results may be considered outliers and removed from the average when the results deviate (higher or lower) by more than 3 dB from the median C/N_0 of the reported satellites. Although outside the recommendations outlined in this test procedure it is possible to improve measurement time by reducing the deviation to 1.5 dB when identifying outliers. The sensitivity passes if 10 measurement reports with 4 or more satellites are received and the deviation in the average C/N_0 is less than 1 dB. A maximum of 20 consecutive reports can be monitored and if the pass criteria is not achieved within those 20 reports, then the sensitivity fails.

If at any point during the sensitivity search, the receiver reports that no satellites are visible during the sensitivity search, the signal level can be increased (e.g. -130 dBm) and dwell time increased so that the GNSS receiver can regain lock and then the sensitivity search can continue. Note that when adjusting the power level in large steps the response time for accurate C/N_0 for the GNSS receiver increases and the probability that the receiver will lose lock increases.

As with any offset method, as the number of offset points increases, the measurement uncertainty decreases. Four offset points are recommended for this method.

For GPS L1 sensitivity measurements, the sensitivity threshold shall be the minimum GPS L1 signal level at which 4 or more GPS L1 satellites are observed by the GPS L1 receiver.

4.7 Recommended Performance

Results shall be reported as specified in *CTIA 01.04* [21] using the figures of merit given in *CTIA 01.90* [1]. Table 4.7-1 and Table 4.7-2 contain the recommended performance requirements for stand-alone GPS L1 and GPS L5.

Table 4.7-1 Stand-Alone GPS L1 Maximum TIS/UHIS/PIGS Level (in dBm) Recommended Performance Requirements for the Primary Mechanical Mode[1]

Stand-Alone Method	Device Width (mm)[2]	BHHL and BHHR			HL and HR		
		TIS	UHIS	PIGS	TIS	UHIS	PIGS
Acquisition Sensitivity	≤72	TBD	TBD	TBD	TBD	TBD	TBD
	>72	TBD	TBD	TBD	TBD	TBD	TBD
	≤72	TBD	TBD	TBD	TBD	TBD	TBD

Stand-Alone Method	Device Width (mm)[2]	BHHL and BHHR			HL and HR		
		TIS	UHIS	PIGS	TIS	UHIS	PIGS
Tracking Sensitivity	>72	TBD	TBD	TBD	TBD	TBD	TBD

Note 1: Primary Mechanical Mode refers to device configured in preferred mode per manufacturer instructions (typically means antenna extended, fold or portrait slide open, but depends on form factor).

Note 2: Differences between requirements for devices wider and narrower than 72 mm reflect observed differences in OTA performance with different hand phantoms of up to 6 dB.

Table 4.7-2 Stand-Alone GPS L5 Minimum Average 3D C/N_0 / UH 3D C/N_0 / PIG 3D C/N_0 Level (in dBm) Recommended Performance Requirements for the Primary Mechanical Mode1

Stand-Alone Method	Device Width (mm)[2]	BHHL and BHHR			HL and HR		
		Average 3D C/N0	UH 3D C/N0	PIG 3D C/N0	Average 3D C/N0	UH 3D C/N0	PIG 3D C/N0
Acquisition Sensitivity	≤72	TBD	TBD	TBD	TBD	TBD	TBD
	>72	TBD	TBD	TBD	TBD	TBD	TBD
Tracking Sensitivity	≤72	TBD	TBD	TBD	TBD	TBD	TBD
	>72	TBD	TBD	TBD	TBD	TBD	TBD

Note 1: Primary Mechanical Mode refers to device configured in preferred mode per manufacturer instructions (typically means antenna extended, fold or portrait slide open, but depends on form factor).

Note 2: Differences between requirements for devices wider and narrower than 72 mm reflect observed differences in OTA performance with different hand phantoms of up to 6 dB.

Appendix A Revision History

The change history only tracks changes that were directly applied to this document. Changes to earlier document versions that became necessary after a new major version was created are not tracked in this document's change history. For example, CTIA 01.01 v8.0.0 was based off of CTIA 01.01 v6.0.2 and subsequent revisions to CTIA 01.01 v6.0.2 are not included in the change history for CTIA 01.01 v8.0.x.

Date	Version	Description
February 2022	4.0.0	Initial release Section 2: • Contents moved from SISO OTA test plan (Sections 6.13.1, 6.13.2, 6.13.3, 6.13.4 and 6.13.5) • Added contents for A-GALILEO E1 and A-GPS L5 for LTE • Added contents for A-GPS L1 for NR FR1 EN-DC • Removed A-GLONASS testing • Consolidation of common contents for radio modes under Section 2.5.1 Section 3: Contents moved from SISO OTA test plan (Section 6.18) Section 4: Contents moved from SISO OTA test plan (Appendix R)
October 2022	4.0.1	• Corrected several cross-references to CTIA 01.20 in sections 2, 3 and 4. • Updated Note 1 in Table 2.5.6.1-2 and Table 2.5.6.2-2 . • Removed misleading references to “mid bands” and “non-mid bands” from Section 2.5.6.1
December 2022	5.0.0	Section 2: • Added contents for A-GNSS (A-GPS L1 and L5, A-GALILEO E1) with NR FR1 SA. • Added contents for A-GPS L5 and A-GALILEO E1 with NR FR1 EN-DC. • Replaced configuration tables for LTE and NR FR1 EN-DC with references to CTIA 01.50. • Testing with SIB8 or SIB16 moved to clause 2.5.8 as informative. • Updated references to LTE Category M1. Section 4: • Added contents for GPS L5 stand-alone. Section 5: • Replaced references to configuration tables for LTE with references to CTIA 01.50.
March 2023	6.0.0	Section 2: • Updated and replaced ICD configuration tables for NR FR1 EN-DC with references to CTIA 01.50. Section 3: • Moved from Normative to Informative. A paragraph was added to ensure that any “shall” in this section do not imply any requirement.

Date	Version	Description
September 2023	6.0.1	Section 2: • Updated LTE Category M1 from Normative to Informative • Added UE-Based User Plane Positioning Procedures for A-GNSS Testing as informative • Added comment about possible extra testing for band 14 A-GNSS testing with alternate UL RB allocations
December 2023	6.0.2	Section 2: • Updated to clarify that only the mid-channel test channel is used for sensitivity tests for LTE, NR FR1 EN-DC and NR FR1 SA bands

April 2024	7.0.0	Section 2:
		• Updated NR FR1 SA band n14 UL RB allocation for radiated sensitivity test
		• Added NR FR1 EN-DC bands for A-GNSS tests to align with NR FR1 EN-DC bands in CTIA 01.50
		• Updated references to n77 as follows:
		    ○ "n77 USA Range A" to "n77 (R1)"
		    ○ "n77 USA Range B" to "n77 (R2)"
		    ○ "n77 Canada" to "n77 (R3)"
		• Updated Intermediate Channel tables 2.5.6.2-1, 2.5.6.2-2 and 2.5.6.2-3 for n77 (R1), n77 (R2), n77 (R3) and n77 (R4)
		Section 4:
		• Updated the example commands from GLONASS to GALILEO

September 2024	8.0.0	Section 2: • Updated Section 2.2.1 to add the priority list for cellular radio modes and table 2.2.1-1 • Added Section 2.2.5 for A-GALILEO E5A for radiated 3D C/N_0 pattern measurement procedure • Update Section 2.3.4 A-GALILEO E1 to specify to test highest priority supported cellular radio mode • Added Section 2.3.5 for A-GALILEO E5A for Radiated A-GNSS Sensitivity Measurement • Added Section 2.4.5 A-GALILEO E5A for Radiated A-GNSS Intermediate Channel Degradation Measurement • Updated Table 2.5.1-1 to add A-GALILEO E5A and update the note for A-GALILEO E1 • Updated Table 2.5.1-1 to correct measurement needed for A-GPS L5 and A-GALILEO E1 • Updated Section 2.5.6.1 to add alternative pass/fail test procedure for other bands for NR FR1 EN-DC A-GPS L1 and A-GALILEO E1

Date	Version	Description
April 2025	8.0.1	Section 2: • Corrected the text to remove NR FR1 SA requirement for MS based over SUPL and aligned with the requirement in CTIA 01.01 • Removed duplicated paragraph about one 5dB higher power satellite in sensitivity test • Corrected ICD channels for EN_DC band DC_48A_n5A in Table 2.5.6.2-1 and Table 2.5.6.2-3