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650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Contents

Foreword

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1 Scope

The present document establishes the minimum requirements for both UE based and UE assisted FDD or TDD A-GNSS terminals which have NG-RAN access via gNB (in SA NR, NR-DC or NE-DC NR operation mode [2]) or via ng-eNB (in EN-DC operation mode [2]) and which are supporting A-GNSS in 5GS via LPP [3] between UE and LMF as described in TS 38.305 [17].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Multi-connectivity", Stage 2.

[3] 3GPP TS 36.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)".

[4] 3GPP TS 38.215: "NR; Physical layer; Measurements".

[5] ETSI TR 102 273-1-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 2: Examples and annexes".

[6] IS-GPS-200, Revision D, Navstar GPS Space Segment/Navigation User Interfaces, March 7th, 2006.

[7] P. Axelrad, R.G. Brown, "GPS Navigation Algorithms", in Chapter 9 of "Global Positioning System: Theory and Applications", Volume 1, B.W. Parkinson, J.J. Spilker (Ed.), Am. Inst. of Aeronautics and Astronautics Inc., 1996.

[8] S.K. Gupta, "Test and Evaluation Procedures for the GPS User Equipment", ION-GPS Red Book, Volume 1, p. 119.

[9] 3GPP TS 38.509: "5GS; Special conformance testing functions for User Equipment (UE)".

[10] IS-GPS-705, Navstar GPS Space Segment/User Segment L5 Interfaces, September 22, 2005.

[11] IS-GPS-800, Navstar GPS Space Segment/User Segment L1C Interfaces, September 4, 2008.

[12] IS-QZSS, Quasi Zenith Satellite System Navigation Service Interface Specifications for QZSS, Ver.1.1, July 31, 2009.

[13] Galileo OS Signal in Space ICD (OS SIS ICD), Issue 1.2, February 2014, European Union.

[14] Global Navigation Satellite System GLONASS Interface Control Document, Version 5.1, 2008.

[15] Specification for the Wide Area Augmentation System (WAAS), US Department of Transportation, Federal Aviation Administration, DTFA01-96-C-00025, 2001.

[16] BDS-SIS-ICD-2.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal (Version 2.0)", China Satellite Navigation Office, December 2013.

[17] 3GPP TS 38.300: "NR; Overall description; Stage-2".

[18] 3GPP TS 38.305: "NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN".

[19] 3GPP TS 37.571-1: "Evolved Universal Terrestrial Radio Access (E-UTRA); and Evolved Packet Core (EPC); User Equipment (UE) conformance specification for UE positioning; Part 1: Terminal conformance".

[20] 3GPP TS 38.508-1: "5GS; User Equipment (UE) conformance specification; Part 1: Common test environment".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply:

EN-DC: E-UTRA-NR Dual Connectivity as defined in TS 37.340 [2].

en-gNB: as defined in TS 37.340 [2].

gNB: as defined in in TS 38.300 [17].

Horizontal Dilution Of Precision (HDOP): measure of position determination accuracy that is a function of the geometrical layout of the satellites used for the fix, relative to the receiver antenna

NE-DC: NR-E-UTRA Dual Connectivity as defined in TS 37.340 [2].

ng-eNB: as defined in TS 38.300 [17].

NR-DC: NR-NR Dual Connectivity as defined in TS 37.340 [2].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

B1I	BeiDou B1I navigation signal with carrier frequency of 1561.098 MHz.
E1	Galileo E1 navigation signal with carrier frequency of 1575.420 MHz.
E5	Galileo E5 navigation signal with carrier frequency of 1191.795 MHz.
E6	Galileo E6 navigation signal with carrier frequency of 1278.750 MHz.
G1	GLONASS navigation signal in the L1 sub-bands with carrier frequencies 1602 MHz ± k × 562.5 kHz.
G2	GLONASS navigation signal in the L2 sub-bands with carrier frequencies 1246 MHz ± k × 437.5 kHz.
k	GLONASS channel number, k = -7…13.
L1 C/A	GPS or QZSS L1 navigation signal carrying the Coarse/Acquisition code with carrier frequency of 1575.420 MHz.
L1C	GPS or QZSS L1 Civil navigation signal with carrier frequency of 1575.420 MHz.
L2C	GPS or QZSS L2 Civil navigation signal with carrier frequency of 1227.600 MHz.
L5	GPS or QZSS L5 navigation signal with carrier frequency of 1176.450 MHz.
$\mathbf{G}$	Geometry Matrix.
$\rho_{GNSS_m,i}$	Measured pseudo-range of satellite *i* of $GNSS_m$.
$\mathbf{W}$	Weighting Matrix.
$\mathbf{1}_{GNSS_m,i}$	Line of sight unit vector from the user to the satellite *i* of $GNSS_m$.
$\mathbf{x}$	State vector of user position and clock bias.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

5GS	5G System
A-GNSS	Assisted Global Navigation Satellite System
A-GPS	Assisted - Global Positioning System
AWGN	Additive White Gaussian Noise
BDS	BeiDou Navigation Satellite System
C/A	Coarse/Acquisition
DC	Dual Connectivity
DUT	Device Under Test
ECEF	Earth Centred, Earth Fixed
E-UTRA	Evolved UMTS Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
EN-DC	E-UTRA-NR Dual Connectivity
FDD	Frequency Division Duplex
GEO	Geostationary Earth Orbit
GLONASS	GLObal'naya NAvigatsionnaya Sputnikovaya Sistema (Engl.: Global Navigation Satellite System)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HDOP	Horizontal Dilution Of Precision
ICD	Interface Control Document
IGSO	Inclined Geosynchronous Satellite Orbit
IS	Interface Specification
LMF	Location Management Function
LOS	Line Of Sight
LPP	LTE Positioning Protocol
MEO	Medium Earth Orbit
NE-DC	NR-E-UTRA Dual Connectivity
NR	NR Radio Access
NR-DC	NR-NR Dual Connectivity
QZSS	Quasi-Zenith Satellite System
RRC	Radio Resource Control
SBAS	Space Based Augmentation System
SFN	System Frame Number
SS	System Simulator
SV	Space Vehicle
TDD	Time Division Duplex
TOW	Time Of Week
TTFF	Time To First Fix
UE	User Equipment
WLS	Weighted Least Square
WGS-84	World Geodetic System 1984

3.4 Test tolerances

The requirements given in the present document make no allowance for measurement uncertainty. The test specification TS 37.571-1 [19] defines test tolerances. These test tolerances are individually calculated for each test. The test tolerances are then added to the limits in the present document to create test limits. The measurement results are compared against the test limits as defined by the shared risk principle.

Shared Risk is defined in ETR 273-1-2 [7], clause 6.5.

4 General

4.1 Introduction

The present document defines the minimum requirements for both UE based and UE assisted FDD or TDD A-GNSS terminals which have NG-RAN access via gNB (in SA NR, NR-DC or NE-DC operation mode [2]) or via ng-eNB (in EN-DC operation mode [2]) and which are supporting A-GNSS in 5GS via LPP [3] between UE and LMF as described in TS 38.305 [17].

4.2 Measurement parameters

4.2.1 UE based A-GNSS measurement parameters

In case of UE-based A-GNSS, the measurement parameters are contained in the *GNSS-LocationInformation* IE which is included in the *A-GNSS-ProvideLocationInformation* IE provided in the LPP message of type PROVIDE LOCATION INFORMATION. The measurement parameter in case of UE-based A-GNSS is the horizontal position estimate reported by the UE and expressed in latitude/longitude.

4.2.2 UE assisted A-GNSS measurement parameters

In case of UE-assisted A-GNSS, the measurement parameters are contained in the *GNSS-SignalMeasurementInformation* IE which is included in the *A-GNSS-ProvideLocationInformation* IE provided in the LPP message of type PROVIDE LOCATION INFORMATION. The measurement parameters in case of UE-assisted A-GNSS are the UE GNSS code phase measurements, as specified in TS 38.215 [4]. The UE GNSS code phase measurements are converted into a horizontal position estimate using the procedure detailed in Annex F.

4.3 Response time

Max Response Time is defined as the time starting from the moment that the UE receives the LPP message of type REQUEST LOCATION INFORMATION, and ending when the UE starts sending the LPP message of type PROVIDE LOCATION INFORMATION. The response times specified for all test cases are TTFF unless otherwise stated, i.e. the UE shall not re-use any information on GNSS time, location or other aiding data that was previously acquired or calculated and stored internally in the UE. A dedicated test message 'RESET UE POSITIONING STORED INFORMATION' is defined in TS 38.509 [9] clause 5.6 for the purpose of deleting this information and is detailed in clause B.1.10.

4.4 Time assistance

Time assistance is the provision of GNSS time to the UE from the network via LPP messages. Currently two different GNSS time assistance methods can be provided by the network.

a) Coarse time assistance is always provided by the network and provides current GNSS time to the UE. The time provided is within ±2 seconds of GNSS system time. It is signalled to the UE by means of the *gnss-DayNumber* and *gnss-TimeOfDay* fields in the *gnss-SystemTime* IE.

b) Fine time assistance is optionally provided by the network and adds the provision to the UE of the relationship between the GNSS system time and the current E-UTRAN or NR time. The accuracy of this relationship is ±10 μs of the actual relationship. This addresses the case when the network can provide an improved GNSS time accuracy. It is signalled to the UE by means of the *gnss-SystemTime* IE and the *gnss-ReferenceTimeForCells* IE.

The specific GNSS system time is identified through the *gnss-TimeID* field of the *GNSS-SystemTime* IE. In case where several GNSSs are used in the tests, only one *gnss-TimeID* is used to determine the Time of Day. For all the constellations, the *gnss-TimeModels* IE shall be available at the SS, as specified in Annex E.

4.4.1 Use of fine time assistance

The use of fine time assistance to improve the GNSS performance of the UE is optional for the UE, even when fine time assistance is signalled by the network. Thus, there are a set minimum performance requirements defined for all UEs and additional minimum performance requirements that are valid for fine time assistance capable UEs only. These requirements are specified in clause 5.1.2 for UEs that support A-GPS L1 C/A only and in clause 6.1.2 for UEs that support other GNSSs.

4.5 RRC states

The minimum A-GNSS performance requirements are specified in clauses 5 and 6 for RRC_CONNECTED state. The test and verification procedures are separately defined in annex B.

4.6 Error definitions

The 2D position error is defined by the horizontal difference in meters between the ellipsoid point reported or calculated from the LPP message of type PROVIDE LOCATION INFORMATION and the actual position of the UE in the test case considered.

4.7 UEs supporting multiple constellations

Minimum performance requirements are defined for each global GNSS constellation (BDS, Galileo, GLONASS, GPS/Modernized GPS). UEs supporting multiple global constellations shall meet the minimum performance requirements for a combined scenario where each UE supported constellation is simulated.

NOTE: For test cases where signals from “GPS” and “Modernized GPS” are included, “GPS” and “Modernized GPS” are considered as a single constellation, unless otherwise specified.

4.8 UEs supporting multiple signals

For UEs supporting multiple signals, different minimum performance requirements may be associated with different signals. The satellite simulator shall generate all signals supported by the UE. Signals not supported by the UE do not need to be simulated. The relative power levels of each signal type for each GNSS are defined in Table 4.1. The individual test scenarios in clause 6 define the reference signal power level for each satellite. The power level of each simulated satellite signal type shall be set to the reference signal power level defined in each test scenario in clause 6 plus the relative power level defined in Table 4.1.

Table 4.1: Relative signal power levels for each signal type for each GNSS

	BDS			**Galileo**		**GLONASS**		**GPS/Modernized GPS**		**QZSS**		**SBAS**	
Signal power levels relative to reference power levels	B1I	D1	0 dB	E1	0 dB	G1	0 dB	L1 C/A	0 dB	L1 C/A	0 dB	L1	0 dB
		D2	+5 dB										
				E6	+2 dB	G2	-6 dB	L1C	+1.5 dB	L1C	+1.5 dB		
				E5	+2 dB			L2C	-1.5 dB	L2C	-1.5 dB		
								L5	+3.6 dB	L5	+3.6 dB		

NOTE 1: For test cases which involve “Modernized GPS”, the satellite simulator shall also generate the GPS L1 C/A signal if the UE supports “GPS” in addition to “Modernized GPS”.

NOTE 2: The signal power levels in the Test Parameter Tables represent the total signal power of the satellite per channel not e.g. pilot and data channels separately.

NOTE 3: For test cases which involve "BDS", D1 represents MEO/IGSO satellites B1I signal type and D2 represents GEO satellites B1I signal type.

5 A-GNSS minimum performance requirements (UE supports A-GPS L1 C/A only)

5.0 Introduction

The minimum performance requirements specified in clause 5 apply for UEs that support A-GPS L1 C/A only. The requirements for UEs that support other or additional A-GNSSs are specified in clause 6.

The A-GNSS minimum performance requirements are defined by assuming that all relevant and valid assistance data is received by the UE in order to perform GPS L1 C/A measurements and/or position calculation. This clause does not include nor consider delays occurring in the various signalling interfaces of the network.

In the following clauses the minimum performance requirements are based on availability of the assistance data information and messages defined in annexes D and E.

5.1 Sensitivity

A sensitivity requirement is essential for verifying the performance of A-GNSS receiver in weak satellite signal conditions. In order to test the most stringent signal levels for the satellites the sensitivity test case is performed in AWGN channel. This test case verifies the performance of the first position estimate, when the UE is provided with only coarse time assistance and when it is additionally supplied with fine time assistance.

5.1.1 Coarse time assistance

In this test case 8 satellites are generated for the terminal. AWGN channel model is used.

Table 5.1: Test parameters

Parameters	Unit	Value
Number of generated satellites	-	8
HDOP Range	-	1.1 to 1.6
Propagation conditions	-	AWGN
GNSS Coarse time assistance error range	seconds	±2
GPS L1 C/A Signal for one satellite	dBm	-142
GPS L1 C/A Signal for remaining satellites	dBm	-147

5.1.1.1 Minimum requirements (Coarse time assistance)

The position estimates shall meet the accuracy and response time specified in Table 5.2.

Table 5.2: Minimum requirements (coarse time assistance)

Success rate	2-D position error	Max response time
95 %	100 m	20 s

5.1.2 Fine time assistance

This requirement is only valid for fine time assistance capable UEs. In this requirement 8 satellites are generated for the terminal. AWGN channel model is used.

Table 5.3: Test parameters for fine time assistance capable terminals

Parameters	Unit	Value
Number of generated satellites	-	8
HDOP Range	-	1.1 to 1.6
Propagation conditions	-	AWGN
GNSS Coarse time assistance error range	seconds	±2
GPS L1 C/A Fine time assistance error range	µs	±10
GPS L1 C/A Signal for all satellites	dBm	-147

5.1.2.1 Minimum requirements (Fine time assistance)

The position estimates shall meet the accuracy and response time requirements in Table 5.4.

Table 5.4: Minimum requirements for fine time assistance capable terminals

Success rate	2-D position error	Max response time
95 %	100 m	20 s

5.2 Nominal accuracy

Nominal accuracy requirement verifies the accuracy of A-GNSS position estimate in ideal conditions. The primarily aim of the test is to ensure good accuracy for a position estimate when satellite signal conditions allow it. This test case verifies the performance of the first position estimate.

In this requirement 8 satellites are generated for the terminal. AWGN channel model is used.

Table 5.5: Test parameters

Parameters	Unit	Value
Number of generated satellites	-	8
HDOP Range	-	1.1 to 1.6
Propagation conditions	-	AWGN
GNSS Coarse time assistance error range	seconds	±2
GPS L1 C/A Signal for all satellites	dBm	-130

5.2.1 Minimum requirements (nominal accuracy)

The position estimates shall meet the accuracy and response time requirements in Table 5.6.

Table 5.6: Minimum requirements

Success rate	2-D position error	Max response time
95 %	30 m	20 s

5.3 Dynamic range

The aim of a dynamic range requirement is to ensure that a GNSS receiver performs well when visible satellites have rather different signal levels. Strong satellites are likely to degrade the acquisition of weaker satellites due to their cross-correlation products. Hence, it is important in this test case to keep use AWGN in order to avoid loosening the requirements due to additional margin because of fading channels. This test case verifies the performance of the first position estimate.

In this requirement 6 satellites are generated for the terminal. AWGN channel model is used.

Table 5.7: Test parameters

Parameters	Unit	Value
Number of generated satellites	-	6
HDOP Range	-	1.4 to 2.1
GNSS Coarse time assistance error range	seconds	±2
Propagation conditions	-	AWGN
GPS L1 C/A Signal for 1st satellite	dBm	-129
GPS L1 C/A Signal for 2nd satellite	dBm	-135
GPS L1 C/A Signal for 3rd satellite	dBm	-141
GPS L1 C/A Signal for 4th satellite	dBm	-147
GPS L1 C/A Signal for 5th satellite	dBm	-147
GPS L1 C/A Signal for 6th satellite	dBm	-147

5.3.1 Minimum requirements (dynamic range)

The position estimates shall meet the accuracy and response time requirements in Table 5.8.

Table 5.8: Minimum requirements

Success rate	2-D position error	Max response time
95 %	100 m	20 s

5.4 Multi-path scenario

The purpose of the test case is to verify the receiver's tolerance to multipath while keeping the test setup simple. This test case verifies the performance of the first position estimate.

In this requirement 5 satellites are generated for the terminal. Two of the satellites have one tap channel representing LOS signal. The three other satellites have two-tap channel, where the first tap represents LOS signal and the second reflected and attenuated signal as specified in Annex C.2.

Table 5.9: Test parameters

Parameters	Unit	Value
Number of generated satellites (Satellites 1, 2 unaffected by multi-path) (Satellites 3, 4, 5 affected by multi-path)	-	5
GNSS Coarse time assistance error range	seconds	±2
HDOP Range	-	1.8 to 2.5
GPS L1 C/A Signal for satellite 1, 2	dBm	-130
GPS L1 C/A Signal for satellite 3, 4, 5	dBm	LOS signal of -130 dBm, multi-path signal of -136 dBm

5.4.1 Minimum requirements (multi-path scenario)

The position estimates shall meet the accuracy and response time requirements in Table 5.10.

Table 5.10: Minimum requirements

Success rate	2-D position error	Max response time
95 %	100 m	20 s

5.5 Moving scenario and periodic update

The purpose of the test case is to verify the receiver's capability to produce GNSS measurements or location fixes on a regular basis, and to follow when it is located in a vehicle that slows down, turns or accelerates. A good tracking performance is essential for certain location services. A moving scenario with periodic update is well suited for verifying the tracking capabilities of an A-GNSS receiver in changing UE speed and direction. In the requirement the UE moves on a rectangular trajectory, which imitates urban streets. AWGN channel model is used. This test is not performed as a TTFF test.

In this requirement 5 satellites are generated for the terminal. The UE is requested to use periodical reporting with a reporting interval of 2 seconds.

The UE moves on a rectangular trajectory of 940 m by 1 440 m with rounded corner defined in Figure 5.1. The initial reference is first defined followed by acceleration to final speed of 100 km/h in 250 m. The UE then maintains the speed for 400 m. This is followed by deceleration to final speed of 25 km/h in 250 m. The UE then turn 90 degrees with turning radius of 20 m at 25 km/h. This is followed by acceleration to final speed of 100 km/h in 250 m. The sequence is repeated to complete the rectangle.

Table 5.11: Trajectory Parameters

Parameter	Distance (m)	Speed (km/h)
l_{11}, l_{15}, l_{21}, l_{25}	20	25
l_{12}, l_{14}, l_{22}, l_{24}	250	25 to 100 and 100 to 25
l_{13}	400	100
l_{23}	900	100

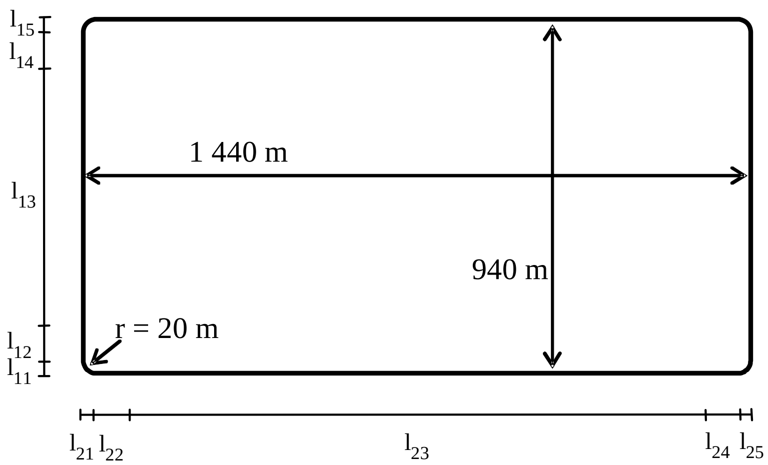


Figure 5.1: Rectangular trajectory of the moving scenario and periodic update test case

Table 5.12: Test Parameters

Parameters	Unit	Value
Number of generated satellites	-	5
HDOP Range	-	1.8 to 2.5
Propagation condition	-	AWGN
GPS L1 C/A signal for all satellites	dBm	-130

5.5.1 Minimum requirements (moving scenario and periodic update)

The position estimates shall meet the accuracy requirement of Table 5.13 with the periodical reporting interval defined in Table 5.13 after the first reported position estimates.

NOTE: In the actual testing the UE may report error messages until it is able to acquire GNSS measured results or a position estimate. The test equipment shall only consider the first measurement report different from an error message as the first position estimate in the requirement in Table 5.13.

Table 5.13: Minimum requirements

Success Rate	2-D position error	Periodical reporting interval
95 %	100 m	2 s

6 A-GNSS minimum performance requirements (UE supports other or additional GNSSs)

6.0 Introduction

The minimum performance requirements specified in clause 6 apply for UEs that support other A-GNSSs than GPS L1 C/A, or multiple A-GNSSs which may or may not include GPS L1 C/A. The requirements for UEs that support A-GPS L1 C/A only are specified in clause 5.

The A-GNSS minimum performance requirements are defined by assuming that all relevant and valid assistance data is received by the UE in order to perform GNSS measurements and/or position calculation. This clause does not include nor consider delays occurring in the various signalling interfaces of the network.

In the following clauses the minimum performance requirements are based on availability of the assistance data information and messages defined in annexes D and E.

6.1 Sensitivity

A sensitivity requirement is essential for verifying the performance of A-GNSS receiver in weak satellite signal conditions. In order to test the most stringent signal levels for the satellites the sensitivity test case is performed in AWGN channel. This test case verifies the performance of the first position estimate, when the UE is provided with only coarse time assistance and when it is additionally supplied with fine time assistance.

6.1.1 Coarse time assistance

In this test case 6 satellites are generated for the terminal. AWGN channel model is used.

Table 6.1: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 6.2
	Total number of generated satellites	-	6
	HDOP range		1.4 to 2.1
	Propagation conditions	-	AWGN
	GNSS coarse time assistance error range	seconds	±2
BDS	Reference high signal power level	dBm	-136
	Reference low signal power level	dBm	-145
Galileo	Reference high signal power level	dBm	-142
	Reference low signal power level	dBm	-147
GLONASS	Reference high signal power level	dBm	-142
	Reference low signal power level	dBm	-147
GPS(1)	Reference high signal power level	dBm	-142
	Reference low signal power level	dBm	-147
NOTE 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 6.2: Power level and satellite allocation

		Satellite allocation for each constellation		
		GNSS-1(1)	GNSS-2	GNSS-3
Single constellation	High signal level	1	-	-
	Low signal level	5	-	-
Dual constellation	High signal level	1	-	-
	Low signal level	2	3	-
Triple constellation	High signal level	1	-	-
	Low signal level	1	2	2
Note 1: For GPS capable receivers, GNSS-1, i.e. the system having the satellite with high signal level, shall be GPS.				

6.1.1.1 Minimum requirements (Coarse time assistance)

The position estimates shall meet the accuracy and response time specified in Table 6.3.

Table 6.3: Minimum requirements (coarse time assistance)

System	Success rate	2-D position error	Max response time
All	95 %	100 m	20 s

6.1.2 Fine time assistance

This requirement is only valid for fine time assistance capable UEs. In this requirement 6 satellites are generated for the terminal. AWGN channel model is used.

Table 6.4: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 6.5
	Total number of generated satellites	-	6
	HDOP range		1.4 to 2.1
	Propagation conditions	-	AWGN
	GNSS coarse time assistance error range	seconds	±2
	GNSS fine time assistance error range	μs	±10
BDS	Reference signal power level	dBm	-147
Galileo	Reference signal power level	dBm	-147
GLONASS	Reference signal power level	dBm	-147
GPS(1)	Reference signal power level	dBm	-147
NOTE 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 6.5: Satellite allocation

	Satellite allocation for each constellation		
	GNSS-1	GNSS-2	GNSS-3
Single constellation	6	-	-
Dual constellation	3	3	-
Triple constellation	2	2	2

6.1.2.1 Minimum requirements (Fine time assistance)

The position estimates shall meet the accuracy and response time requirements in Table 6.6.

Table 6.6: Minimum requirements for fine time assistance capable terminals

System	Success rate	2-D position error	Max response time
All	95 %	100 m	20 s

6.2 Nominal accuracy

Nominal accuracy requirement verifies the accuracy of A-GNSS position estimate in ideal conditions. The primarily aim of the test is to ensure good accuracy for a position estimate when satellite signal conditions allow it. This test case verifies the performance of the first position estimate.

In this requirement 6 satellites are generated for the terminal. If SBAS is to be tested one additional satellite shall be generated. AWGN channel model is used. The number of simulated satellites for each constellation is as defined in Table 6.8.

Table 6.7: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 6.8
	Total number of generated satellites	-	6 or 7(2)
	HDOP Range	-	1.4 to 2.1
	Propagation conditions	-	AWGN
	GNSS coarse time assistance error range	seconds	±2
BDS	Reference signal power level for all satellites	dBm	-133
Galileo	Reference signal power level for all satellites	dBm	-127
GLONASS	Reference signal power level for all satellites	dBm	-131
GPS(1)	Reference signal power level for all satellites	dBm	-128.5
QZSS	Reference signal power level for all satellites	dBm	-128.5
SBAS	Reference signal power level for all satellites	dBm	-131
NOTE 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities. NOTE 2: 7 satellites apply only for SBAS case.			

If QZSS is supported, one of the GPS satellites will be replaced by a QZSS satellite with respective signal support. If SBAS is supported, the SBAS satellite with the highest elevation will be added to the scenario.

Table 6.8: Satellite allocation

	Satellite allocation for each constellation			
	GNSS 1(1)	GNSS 2(1)	GNSS 3(1)	SBAS
Single constellation	6	--	--	1
Dual constellation	3	3	--	1
Triple constellation	2	2	2	1
NOTE 1: GNSS refers to global systems i.e. BDS, Galileo, GLONASS, GPS.				

6.2.1 Minimum requirements (nominal accuracy)

The position estimates shall meet the accuracy and response time requirements in Table 6.9.

Table 6.9: Minimum requirements

System	Success rate	2-D position error	Max response time
All	95 %	15 m	20 s

6.3 Dynamic range

The aim of a dynamic range requirement is to ensure that a GNSS receiver performs well when visible satellites have rather different signal levels. Strong satellites are likely to degrade the acquisition of weaker satellites due to their cross-correlation products. Hence, it is important in this test case to keep use AWGN in order to avoid loosening the requirements due to additional margin because of fading channels. This test case verifies the performance of the first position estimate.

In this requirement 6 satellites are generated for the terminal. Two different reference power levels, denoted as "high" and "low" are used for each GNSS. The allocation of "high" and "low" power level satellites depends on the number of supported GNSSs and it is defined in Table 6.11. AWGN channel model is used.

Table 6.10: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 6.11
	Total number of generated satellites	-	6
	HDOP Range	-	1.4 to 2.1
	Propagation conditions	-	AWGN
	GNSS coarse time assistance error range	seconds	±2
BDS	Reference high signal power level	dBm	-133.5
	Reference low signal power level	dBm	-145
Galileo	Reference high signal power level	dBm	-127.5
	Reference low signal power level	dBm	-147
GLONASS	Reference high signal power level	dBm	-131.5
	Reference low signal power level	dBm	-147
GPS(1)	Reference high signal power level	dBm	-129
	Reference low signal power level	dBm	-147
NOTE 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 6.11: Power level and satellite allocation

		Satellite allocation for each constellation		
		GNSS 1(1)	GNSS 2(1)	GNSS 3(1)
Single constellation	High signal level	2	--	--
	Low signal level	4	--	--
Dual constellation	High signal level	1	1	--
	Low signal level	2	2	--
Triple constellation	High signal level	1	1	1
	Low signal level	1	1	1
NOTE 1: GNSS refers to global systems i.e. BDS, Galileo, GLONASS, GPS.				

6.3.1 Minimum requirements (dynamic range)

The position estimates shall meet the accuracy and response time requirements in Table 6.12.

Table 6.12: Minimum requirements

System	Success rate	2-D position error	Max response time
All	95 %	100 m	20 s

6.4 Multi-path scenario

The purpose of the test case is to verify the receiver's tolerance to multipath while keeping the test setup simple. This test case verifies the performance of the first position estimate.

In this requirement 6 satellites are generated for the terminal. Some of the satellites have a one tap channel representing the LOS signal. The other satellites have a two-tap channel, where the first tap represents the LOS signal and the second represents a reflected and attenuated signal as specified in Annex C.2. The number of satellites generated for each GNSS as well as the channel model used depends on the number of systems supported by the UE and is defined in Table 6.14. The channel model as specified in Annex C.2 further depends on the generated signal.

Table 6.13: Test parameter

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 6.14
	Total number of generated satellites	-	6
	HDOP range		1.4 to 2.1
	Propagation conditions	-	AWGN
	GNSS coarse time assistance error range	seconds	±2
BDS	Reference signal power level	dBm	-133
Galileo	Reference signal power level	dBm	-127
GLONASS	Reference signal power level	dBm	-131
GPS(1)	Reference signal power level	dBm	-128.5
NOTE 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 6.14: Channel model allocation

		Channel model allocation for each constellation		
		GNSS-1	GNSS-2	GNSS-3
Single constellation	One-tap channel	2	--	--
	Two-tap channel	4	--	--
Dual constellation	One-tap channel	1	1	--
	Two-tap channel	2	2	--
Triple constellation	One-tap channel	1	1	1
	Two-tap channel	1	1	1

6.4.1 Minimum requirements (multi-path scenario)

The position estimates shall meet the accuracy and response time requirements in Table 6.15.

Table 6.15: Minimum requirements

System	Success rate	2-D position error	Max response time
All	95 %	100 m	20 s

6.5 Moving scenario and periodic update

The purpose of the test case is to verify the receiver's capability to produce GNSS measurements or location fixes on a regular basis, and to follow when it is located in a vehicle that slows down, turns or accelerates. A good tracking performance is essential for certain location services. A moving scenario with periodic update is well suited for verifying the tracking capabilities of an A-GNSS receiver in changing UE speed and direction. In the requirement the UE moves on a rectangular trajectory, which imitates urban streets. AWGN channel model is used. This test is not performed as a TTFF test.

In this requirement 6 satellites are generated for the terminal. The UE is requested to use periodical reporting with a reporting interval of 2 seconds.

The UE moves on a rectangular trajectory of 940 m by 1 440 m with rounded corner defined in Figure 6.1. The initial reference is first defined followed by acceleration to final speed of 100 km/h in 250 m. The UE then maintains the speed for 400 m. This is followed by deceleration to final speed of 25 km/h in 250 m. The UE then turn 90 degrees with turning radius of 20 m at 25 km/h. This is followed by acceleration to final speed of 100 km/h in 250 m. The sequence is repeated to complete the rectangle.

Table 6.16: Trajectory Parameters

Parameter	Distance (m)	Speed (km/h)
l_{11}, l_{15}, l_{21}, l_{25}	20	25
l_{12}, l_{14}, l_{22}, l_{24}	250	25 to 100 and 100 to 25
l_{13}	400	100
l_{23}	900	100

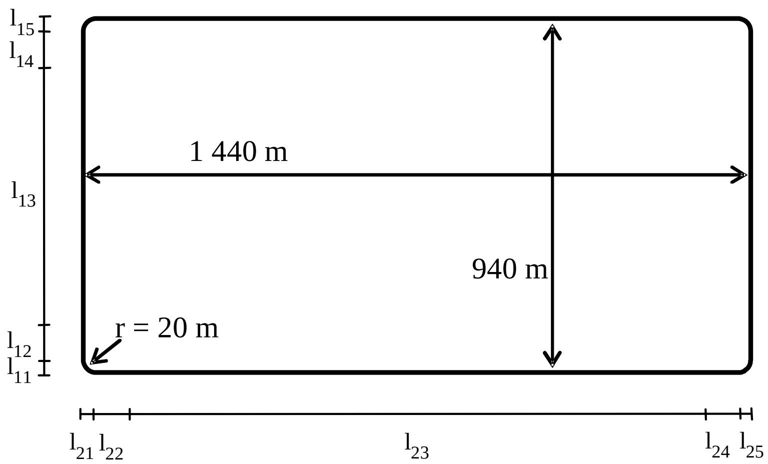


Figure 6.1: Rectangular trajectory of the moving scenario and periodic update test case

Table 6.17: Test Parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 6.18
	Total number of generated satellites	-	6
	HDOP Range per system	-	1.4 to 2.1
	Propagation conditions	-	AWGN
	GNSS coarse time assistance error range	seconds	±2
BDS	Reference signal power level for all satellites	dBm	-133
Galileo	Reference signal power level for all satellites	dBm	-127
GLONASS	Reference signal power level for all satellites	dBm	-131
GPS(1)	Reference signal power level for all satellites	dBm	-128.5
NOTE 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 6.18: Satellite allocation

	Satellite allocation for each constellation		
	GNSS 1(1)	GNSS 2(1)	GNSS 3(1)
Single constellation	6	--	--
Dual constellation	3	3	--
Triple constellation	2	2	2
NOTE 1: GNSS refers to global systems i.e. BDS, Galileo, GLONASS, GPS.			

6.5.1 Minimum requirements (moving scenario and periodic update)

The position estimates shall meet the accuracy requirement of Table 6.19 with the periodical reporting interval defined in Table 6.19 after the first reported position estimates.

NOTE: In the actual testing the UE may report error messages until it is able to acquire GNSS measured results or a position estimate. The test equipment shall only consider the first measurement report different from an error message as the first position estimate in the requirement in Table 6.19.

Table 6.19: Minimum requirements

System	Success rate	2-D position error	Periodical reporting interval
All	95 %	50 m	2 s

Annex A (normative): Test cases

A.1 Conformance tests

The conformance tests for E-UTRA A-GNSS specified in TS 37.571-1 [19]. Statistical interpretation of the requirements is described in clause A.2.

A.2 Requirement classification for statistical testing

Requirements in the present document are either expressed as absolute requirements with a single value stating the requirement, or expressed as a success rate. There are no provisions for the statistical variations that will occur when the parameter is tested.

Annex B lists the test parameters needed for the tests. The test will result in an outcome of a test variable value for the DUT inside or outside the test limit. Overall, the probability of a "good" DUT being inside the test limit(s) and the probability of a "bad" DUT being outside the test limit(s) should be as high as possible. For this reason, when selecting the test variable and the test limit(s), the statistical nature of the test is accounted for.

When testing a parameter with a statistical nature, a confidence level has to be set. The confidence level establishes the probability that a DUT passing the test actually meets the requirement and determines how many times a test has to be repeated. The confidence levels are defined for the final tests in TS 37.571-1 [19].

Annex B (normative): Test conditions

B.1 General

This annex specifies the additional parameters that are needed for the test cases specified in clauses 5 and 6 and applies to all tests unless otherwise stated.

B.1.1 Parameter values

Additionally, amongst all the listed parameters (see annex E), the following values for some important parameters are to be used in the LPP Request Location Information message.

Table B.1: Parameter values

Information element	Value - TTFF tests (except nominal accuracy test)	Value - TTFF tests (nominal accuracy test)	Value - Periodic tests
periodicalReporting	Not present	Not present	Present
> reportingAmount	N/A	N/A	'ra-Infinity' (Infinite)(1)
> reportingInterval	N/A	N/A	'ri2' (2 seconds)
qos			
> horizontalAccuracy			
>> accuracy (test cases in clause 5)	19 (51.2 m)	10 (15.9 m)	19 (51.2 m)
>> accuracy (test cases in clause 6)	19 (51.2 m)	6 (7.7 m)	13 (24.5 m)
> responseTime	20 (seconds)	20 (seconds)	Not present
NOTE 1: Infinite means during the complete test time.			

In the Sensitivity test case with Fine Time Assistance, the following parameter values are used in the LPP Provide Assistance Data message.

Table B.2: Parameters for Fine Time Assistance test

Information element	Value
GNSS-ReferenceTimeForOneCell	
> networkTime	
>> frameDrift	0
> referenceTimeUnc	24 (11.11 μs)

B.1.2 Time assistance

For every Test Instance in each TTFF test case, the IE *gnss-TimeOfDay* shall have a random offset, relative to GNSS system time, within the error range of Coarse Time Assistance defined in the test case. This offset value shall have a uniform random distribution.

In addition, for every Fine Time Assistance Test Instance the IE *networkTime* shall have a random offset, relative to the true value of the relationship between the two time references, within the error range of Fine Time Assistance defined in the test case. This offset value shall have a uniform random distribution.

For the Moving Scenario and Periodic Update Test Case the IE *gnss-TimeOfDay* shall be set to the nominal value.

B.1.3 GNSS reference time

For every Test Instance in each TTFF test case, the GNSS reference time shall be advanced so that, at the time the fix is made, it is at least 2 minutes later than the previous fix.

B.1.4 Reference and UE locations

There is no limitation on the selection of the reference location, consistent with achieving the required HDOP for the Test Case. For each test instance the reference location shall change sufficiently such that the UE shall have to use the new assistance data. The uncertainty of the semi-major axis is 3 km. The uncertainty of the semi-minor axis is 3 km. The orientation of major axis is 0 degrees. The uncertainty of the altitude information is 500 m. The confidence factor is 68 %.

For every Test Instance in each TTFF test case, the UE location shall be randomly selected to be within 3 km of the Reference Location. The Altitude of the UE shall be randomly selected between 0 m to 500 m above WGS-84 reference ellipsoid. These values shall have uniform random distributions.

For test cases which include satellites from regional systems, such as QZSS and SBAS, the reference location shall be selected within the defined coverage area of the systems.

B.1.5 Satellite constellation and assistance data

B.1.5.1 UE supports A-GPS L1 C/A only

In the case of test cases in clause 5 (UE supports A-GPS L1 C/A only), the GPS satellite constellation shall consist of 24 satellites. Almanac assistance data shall be available for all these 24 satellites. At least 9 of the satellites shall be visible to the UE (that is above 5 degrees elevation with respect to the UE). Other assistance data shall be available for 9 of these visible satellites. In each test, signals are generated for only a sub-set of these satellites for which other assistance data is available. The number of satellites in this sub-set is specified in the test. The satellites in this sub-set shall all be above 15 degrees elevation with respect to the UE. The HDOP for the test shall be calculated using this sub-set of satellites. The selection of satellites for this sub-set shall be selected consistent with achieving the required HDOP for the test.

B.1.5.2 UE supports other A-GNSSs

In the case of test cases in clause 6 (UE supports other GNSSs), the satellite constellation shall consist of 35 satellites for BDS (5 GEO, 27 MEO, 3 IGSO); 27 satellites for Galileo; 24 satellites for GLONASS; 27 satellites for GPS/Modernized GPS; 3 satellites for QZSS; 2 satellites for SBAS. Almanac assistance data shall be available for all these satellites. At least 7 of the satellites per BDS, Galileo, GLONASS, GPS/Modernized GPS constellation shall be visible to the UE (that is, above 15 degrees elevation with respect to the UE). At least 1 of the satellites for QZSS shall be within 15 degrees of zenith; and at least 1 of the satellites for SBAS shall be visible to the UE. For BDS with reference location in Asia, at least 1 of the visible satellites shall be a GEO (above 15 degrees elevation with respect to the UE). All other satellite specific assistance data shall be available for all visible satellites. In each test, signals are generated for only 6 satellites (or 7 if SBAS is included). The HDOP for the test shall be calculated using these satellites. The simulated satellites for BDS, Galileo, GLONASS GPS/Modernized GPS shall be selected from the visible satellites for each constellation consistent with achieving the required HDOP for the test. For BDS with reference location in Asia, 1 of the simulated satellites shall be a GEO.

NOTE: Currently up to 30 BDS satellites (maximum 22 MEO) can be supported.

B.1.6 Atmospheric delays

Typical Ionospheric and Tropospheric delays shall be simulated, and the corresponding values inserted into the *GNSS-Ionospheric Model* IE.

B.1.7 E-UTRA or NR frequency and frequency error

In all test cases with E-UTRA frequency, the E-UTRA frequency used shall be the mid-range for the E-UTRA operating band. The E-UTRA frequency with respect to the GNSS carrier frequency shall be offset by +0.025 PPM.

In all test cases with NR, the NR frequency used shall be as specified in TS 38.508-1 [20], clause 4.3.1. The NR frequency with respect to the GNSS carrier frequency shall be offset by + 0.025 PPM.

B.1.8 Information elements

The information elements that are available to the UE in all the test cases are listed in annex E.

B.1.9 GNSS signals

The GNSS signal is defined at the A-GNSS antenna connector of the UE. For UE with integral antenna only, a reference antenna with a gain of 0 dBi is assumed.

B.1.10 RESET UE POSITIONING STORED INFORMATION Message

In order to ensure each Test Instance in each TTFF test is performed under TTFF conditions, a dedicated test message (*RESET UE POSITIONING STORED INFORMATION*) defined in TS 38.509 [9] clause 5.6 shall be used.

When the UE receives the '*RESET UE POSITIONING STORED INFORMATION*' message, with the IE *UE POSITIONING TECHNOLOGY* set to AGNSS it shall:

- discard any internally stored GNSS reference time, reference location, and any other aiding data obtained or derived during the previous test instance (e.g. expected ranges and Doppler);
- accept or request a new set of reference time or reference location or other required information, as in a TTFF condition;
- calculate the position or perform GNSS measurements using the 'new' reference time or reference location or other information.

B.1.11 GNSS system time offsets

If more than one GNSS is used in a test, the accuracy of the GNSS-GNSS Time Offsets used at the SS shall be better than 3 ns.

B.1.12 Sensors

The minimum performances shall be met without the use of any data coming from sensors that can aid the positioning.

Annex C (normative): Propagation conditions

C.1 Static propagation conditions

The propagation for the static performance measurement is an Additive White Gaussian Noise (AWGN) environment. No fading and multi-paths exist for this propagation model.

C.2 Multi-path case

Doppler frequency difference between direct and reflected signal paths is applied to the carrier and code frequencies. The Carrier and Code Doppler frequencies of LOS and multi-path for GNSS signal are defined in table C.1.

Table C.1: Multipath case

Initial relative delay [m]	Carrier Doppler frequency of tap [Hz]	Code Doppler frequency of tap [Hz]	Relative mean power [dB]
0	Fd	Fd / N	0
X	Fd - 0.1	(Fd-0.1) /N	Y
NOTE: Discrete Doppler frequency is used for each tap.			

Where the X and Y depends on the GNSS signal type and is shown in Table C.2, and N is the ratio between the transmitted carrier frequency of the signals and the transmitted chip rate as shown in Table C.3 (where k in Table C.3 is the GLONASS frequency channel number).

Table C.2: Parameter values

System	Signals	X [m]	Y [dB]
BDS	B1I	75	-4.5
Galileo	E1	125	-4.5
	E5a	15	-6
	E5b	15	-6
GLONASS	G1	275	-12.5
	G2	275	-12.5
GPS/Modernized GPS	L1 C/A	150	-6
	L1C	125	-4.5
	L2C	150	-6
	L5	15	-6

Table C.3: Ratio between carrier frequency and chip rate

System	Signals	N
BDS	B1I	763
Galileo	E1	1540
	E5a	115
	E5b	118
GLONASS	G1	3135.03 + k · 1.10
	G2	2438.36 + k · 0.86
GPS/Modernized GPS	L1 C/A	1540
	L1C	1540
	L2C	1200
	L5	115

The initial carrier phase difference between taps shall be randomly selected between 0 and 2π. The initial value shall have uniform random distribution.

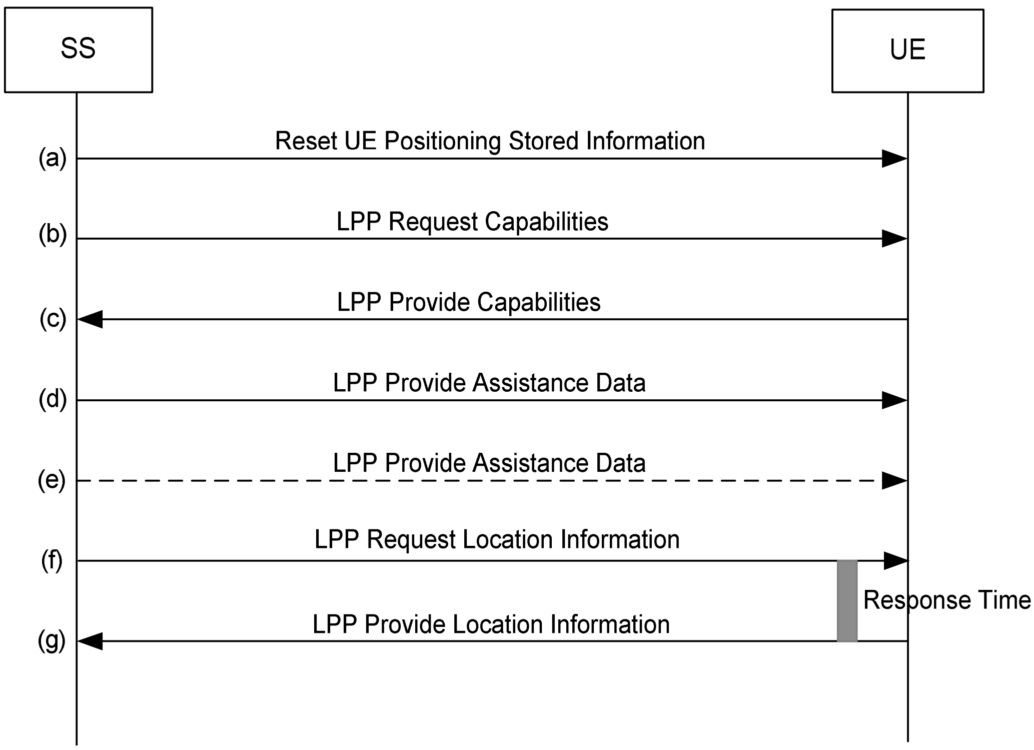
Annex D (normative): Measurement sequence chart

D.1 General

The measurement Sequence Charts that are required in all the test cases, are defined in this clause.

D.2 TTFF measurement sequence chart

The measurement sequence chart for the TTFF test cases, for both UE-assisted and UE-based GNSS, is defined in this clause.



(a) The SS sends a RESET UE POSITIONING STORED INFORMATION message with the IE *UE POSITIONING TECHNOLOGY* set to AGNSS.

(b) The SS sends an LPP message of type REQUEST CAPABILITIES including the *A-GNSS-RequestCapabilities* IE set to TRUE.

(c) The UE sends an LPP message of type PROVIDE CAPABILITIES including the *A-GNSS-ProvideCapabilities* IE with the *AssistanceDataSupportList* included, indicating the assistance data supported by the UE.

(d) – (e) The SS provides the assistance data that are supported by the UE and available as defined in Annex E and Table E.1 in one or more LPP messages of type PROVIDE ASSISTANCE DATA.

(f) The SS sends an LPP message of type REQUEST LOCATION INFORMATION including the information elements defined in Table D.1.

(g) The UE sends an LPP message of type PROVIDE LOCATION INFORMATION including either the *GNSS-SignalMeasurementInformation* or *GNSS-LocationInformation* IE, dependent on the test case (UE-assisted or UE-based, respectively).

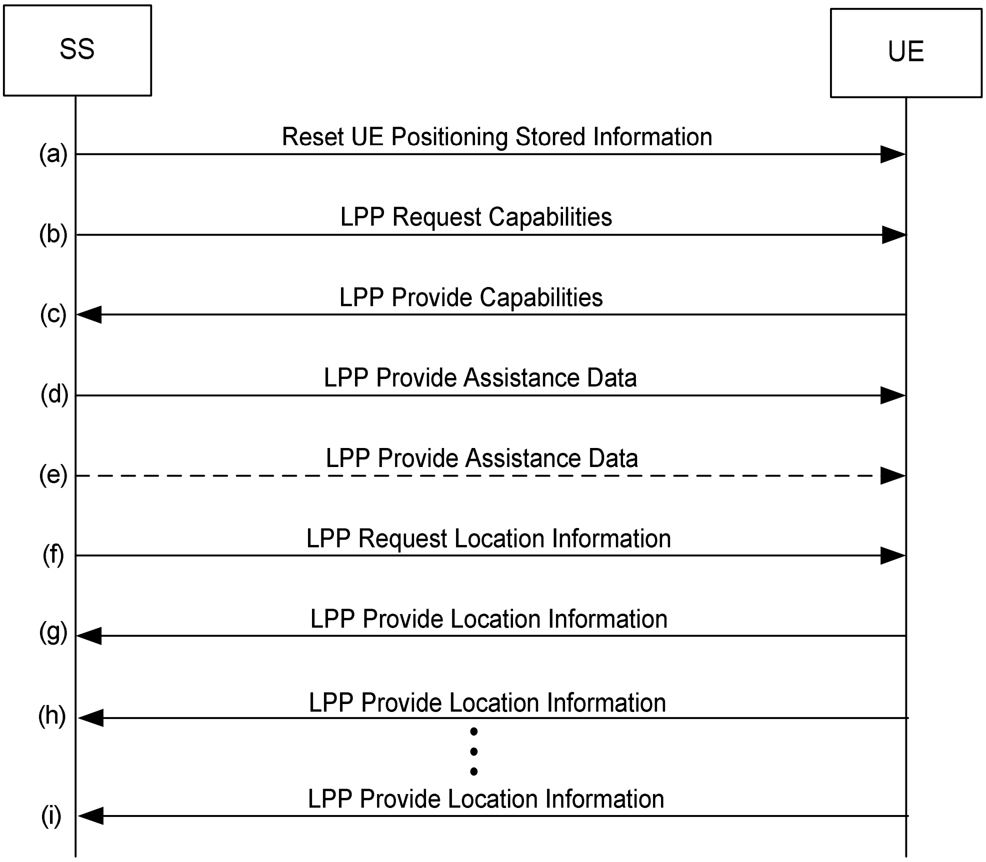
Steps (a) to (g) are repeated for each test instance.

Table D.1: LPP Request Location Information content for TTFF test cases.

Information Element	Value/remark	Comment
RequestLocationInformation		
> commonIEsRequestLocationInformation		
>> locationInformationType	'locationEstimateRequired' or 'locationMeasurementsRequired'	Depending on test case and UE capabilities, i.e., UE-based or UE-assisted
>> additionalInformation	'onlyReturnInformationRequested'	
>> qos		
>>> horizontalAccuracy	As defined in Annex B.1.1	
>>> verticalCoordinateRequest	FALSE	
>>> responseTime	'20'	20 seconds
> a-gnss-RequestLocationInformation		
>> gnss-PositioningInstructions		
>>> gnssMethods		
>>>> gnss-ids	According to UE capabilities	
>>> fineTimeAssistanceMeasReq	FALSE	
>>> adrMeasReq	FALSE	
>>> multiFreqMeasReq	TRUE or FALSE	Depending on UE capabilities
>>> assistanceAvailability	FALSE	

D.3 Moving scenario and periodic update measurement sequence chart

The measurement sequence chart for the moving scenario and periodic update test case, for both UE-assisted and UE-based GNSS, is defined in this clause.



(a) The SS sends a RESET UE POSITIONING STORED INFORMATION message with the IE *UE POSITIONING TECHNOLOGY* set to AGNSS.

(b) The SS sends an LPP message of type REQUEST CAPABILITIES including the *A-GNSS-RequestCapabilities* IE set to TRUE.

(c) The UE sends an LPP message of type PROVIDE CAPABILITIES including the *A-GNSS-ProvideCapabilities* IE with the *AssistanceDataSupportList* included, indicating the assistance data supported by the UE.

(d) – (e) The SS provides the assistance data that are supported by the UE and available as defined in Annex E and table E.1 in one or more LPP messages of type PROVIDE ASSISTANCE DATA.

(f) The SS sends an LPP message of type REQUEST LOCATION INFORMATION including the information elements defined in Table D.2.

(g) – (i) The UE provides LPP messages of type PROVIDE LOCATION INFORMATION including either the *GNSS-SignalMeasurementInformation* or *GNSS-LocationInformation* IE, dependent on the test case (UE-assisted or UE-based, respectively) until the moving trajectory is completed.

NOTE: The UE may report error messages at step (g) until it is able to acquire GNSS signals.

Table D.2: LPP Request Location Information content for moving scenario and periodic update test case.

Information Element	Value/remark	Comment
RequestLocationInformation		
> commonIEsRequestLocationInformation		
>> locationInformationType	‘locationEstimateRequired’ or ‘locationMeasurementsRequired’	Depending on test case and UE capabilities, i.e., UE-based or UE-assisted
>> periodicalReporting		
>>> reportingAmount	‘ra-Infinity’	As defined in Annex B.1.1
>>> reportingInterval	‘ri2’	As defined in Annex B.1.1
>> additionalInformation	‘onlyReturnInformationRequested’	
>> qos		
>>> horizontalAccuracy	As defined in Annex B.1.1	
>>> verticalCoordinateRequest	FALSE	
> a-gnss-RequestLocationInformation		
>> gnss-PositioningInstructions		
>>> gnssMethods		
>>>> gnss-ids	According to UE capabilities	
>>> fineTimeAssistanceMeasReq	FALSE	
>>> adrMeasReq	FALSE	
>>> multiFreqMeasReq	FALSE	
>>> assistanceAvailability	FALSE	

Annex E (normative): Assistance data required for testing

E.1 Introduction

This annex defines the assistance data IEs available at the SS in all test cases. The assistance data shall be given for satellites as defined in B.1.5.

The information elements are given with reference to TS 36.355 [3], where the details are defined.

Table E.1 defines the assistance data elements which shall be provided to the UE in the tests (steps (d) and (e) in the message sequence according to annexes D.2 and D.3). The assistance data provided depends on the mode being used in the test case, the assistance data supported by the UE (indicated in step (c) in the message sequence according to annexes D.2 and D.3) and the GNSSs supported by the UE. Assistance data IEs not supported by the UE shall not be sent. Assistance data IEs supported by the UE but not listed in Table E.1 shall not be sent.

Table E.1: Assistance data to be provided to the UE

Assistance data IE supported by UE	Mode used in test case		
	UE-based	UE-assisted, GNSS-AcquisitionAssistance supported by UE	UE-assisted, GNSS-AcquisitionAssistance not supported by UE
GNSS-Reference Time	Yes	Yes	Yes
GNSS-ReferenceLocation	Yes	No	Yes
GNSS-IonosphericModel	Yes	No	No
GNSS-TimeModelList	Yes(1)	No	Yes(1)
GNSS-NavigationModel	Yes	No	Yes
GNSS-AcquisitionAssistance	No	Yes	No
GNSS-Almanac	No	No	Yes
GNSS-UTC-Model	Yes(3)	Yes(3)	Yes(3)
GNSS-AuxiliaryInformation	Yes(2)	Yes(2)	Yes(2)
NOTE 1: In case more than a single GNSS is supported by the UE. NOTE 2: In case the UE supports GLONASS, or more than one GNSS signal. NOTE 3: In case more than a single GNSS is supported by the UE and the UE supports GLONASS.			

E.2 GNSS assistance data

a) **GNSS-ReferenceTime IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.2: GNSS-ReferenceTime IE

Information Element	All tests except Sensitivity Fine Time Assistance	Sensitivity Fine Time Assistance test
GNSS-ReferenceTime		
> gnss-SystemTime		
>> gnss-TimeID	Yes	Yes
>> gnss-DayNumber	Yes	Yes
>> gnss-TimeOfDay	Yes	Yes
>> gnss-TimeOfDayFrac-msec	Yes	Yes
>> notificationOfLeapSecond	Yes if gnss-TimeID = 'glonass'	Yes if gnss-TimeID = 'glonass'
>> gps-TOW-Assist	Yes if gnss-TimeID = 'gps'	Yes if gnss-TimeID = 'gps'
> referenceTimeUnc	Yes	No
> gnss-ReferenceTimeForOneCell	No	Yes
>> networkTime		Yes
>>> secondsFromFrameStructureStart		Yes
>>> fractionalSecondsFromFrameStructureStart		Yes
>>> frameDrift		Yes
>>> cellID		Yes
>>> CHOICE eUTRA		
>>>> physCellId		Yes
>>>> cellGlobalIdEUTRA		Yes
>>>> earfcn/earfcn-v9a0		Yes
>>> CHOICE nr-r15		
>>>> nrPhysCellId-r15		Yes
>>>> nrCellGlobalID-r15		Yes
>>>> nrARFCN-r15		Yes
>> referenceTimeUnc		Yes

b) **GNSS-ReferenceLocation IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.3: GNSS-ReferenceLocation IE

Name of the IE	Fields of the IE
GNSS-ReferenceLocation	threeDlocation

c) **GNSS-IonosphericModel IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.4: GNSS-IonosphericModel IE

Name of the IE	Fields of the IE
GNSS-IonosphericModel	KlobucharModelParameter
	NeQuickModelParameter(1)
NOTE 1: Only required if GNSSs supported include Galileo.	

d) **GNSS-TimeModelList IE.** This information element is only required for multi system tests, and is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.5: GNSS-TimeModelList IE

Name of the IE	Fields of the IE
GNSS-TimeModelList	
	gnssTOID For each GNSS included in the test.
	deltaT

e) **GNSS-NavigationModel IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.6: GNSS-NavigationModel IE

Name of the IE	Fields of the IE
GNSS-NavigationModel	

Table E.7: GNSS Clock and Orbit Model choices

GNSS	Clock and Orbit Model choice
BDS	Model-6
Galileo	Model-1
GLONASS	Model-4
GPS L1 C/A	Model-2
Modernized GPS	Model-3
QZSS QZS-L1 C/A	Model-2
QZSS QZS-L1C/L2C/L5	Model-3
SBAS	Model-5

f) **GNSS-AcquisitionAssistance IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.8: GNSS-AcquisitionAssistance IE

Name of the IE	Fields of the IE
GNSS-AcquisitionAssistance	

g) **GNSS-Almanac IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.9: GNSS-Almanac IE

Name of the IE	Fields of the IE
GNSS-Almanac	

Table E.10: GNSS Almanac choices

GNSS	Almanac Model choice
BDS	Model-7
Galileo	Model-1
GLONASS	Model-5
GPS L1 C/A	Model-2
Modernized GPS	Model-3, 4
QZSS QZS-L1 C/A	Model-2
QZSS QZS-L1C/L2C/L5	Model-3, 4
SBAS	Model-6

h) **GNSS-UTC-Model IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.11: GNSS-UTC-Model IE

Name of the IE	Fields of the IE
GNSS-UTC-Model	

Table E.12: GNSS UTC Model choices

GNSS	UTC Model choice
BDS	Model-5
Galileo	Model-1
GLONASS	Model-3
GPS L1 C/A	Model-1
Modernized GPS	Model-2
QZSS QZS-L1 C/A	Model-1
QZSS QZS-L1C/L2C/L5	Model-2
SBAS	Model-4

i) **GNSS-AuxiliaryInformation IE.** This information element is defined in clause 6.5.2.2 of TS 36.355 [3].

Table E.13: GNSS-AuxiliaryInformation IE

Name of the IE	Fields of the IE
GNSS-AuxiliaryInformation	

Annex F (normative): Converting UE-assisted measurement reports into position estimates

F.1 Introduction

To convert the UE measurement reports in case of UE-assisted mode of A-GNSS into position errors, a transformation between the "measurement domain" (code-phases, etc.) into the "state" domain (position estimate) is necessary. Such a transformation procedure is outlined in the following clauses. The details can be found in [6-8] and [10-16].

F.2 UE measurement reports

In case of UE-assisted A-GNSS, the measurement parameters are contained in the LPP *GNSS-SignalMeasurementInformation* IE (clause 6.5.2.6 in TS 36.355 [3]). The measurement parameters required for calculating the UE position are:

1) Reference Time: The UE has two choices for the Reference Time:

    a) "networkTime";

    b) "gnss-TOD-msec".

2) Measurement Parameters for each GNSS and GNSS signal: 1 to 64:

    a) " svID ";

    b) "codePhase";

    c) "integerCodePhase";

    d) "codePhaseRMSError".

Additional information required at the SS:

1) "GNSS-ReferenceLocation" (clause 6.5.2.2 in TS 36.355 [3]):
   Used for initial approximate receiver coordinates.

2) "GNSS-NavigationModel" (clause 6.5.2.2 in TS 36.355 [3]):
   Contains the GNSS ephemeris and clock correction parameters as specified in the relevant ICD of each supported GNSS; used for calculating the satellite positions and clock corrections.

3) "GNSS-IonosphericModel" (clause 6.5.2.2 in TS 36.355 [3]):
   Contains the ionospheric parameters which allow the single frequency user to utilize the ionospheric model as specified in the relevant ICD of each supported GNSS for computation of the ionospheric delay.

F.3 WLS position solution

The WLS position solution problem is concerned with the task of solving for four unknowns; x_u, y_u, z_u the receiver coordinates in a suitable frame of reference (usually ECEF) and b_u the receiver clock bias. It typically requires the following steps:

Step 1: Formation of pseudo-ranges

The observation of code phase reported by the UE for each satellite SV_i is related to the pseudo-range/c modulo the "gnss-CodePhaseAmbiguity". For the formation of pseudo-ranges, the integer number of milliseconds to be added to each code-phase measurement has to be determined first. Since 1 ms corresponds to a travelled distance of 300 km, the number of integer ms can be found with the help of reference location and satellite ephemeris. The distance between the reference location and each satellite SV_i is calculated and the integer number of milli-seconds to be added to the UE code phase measurements is obtained.

Step 2: Correction of pseudo-ranges for the GNSS-GNSS time offsets

In the case that the UE reports measurements for more than a single GNSS, the pseudo-ranges are corrected for the time offsets between the GNSSs relative to the selected reference time using the GNSS-GNSS time offsets available at the SS:

$$\rho_{GNSS_m,i} \equiv \rho_{GNSS_m,i} - c \cdot (t_{GNSS_k} - t_{GNSS_m}),$$

where $\rho_{GNSS_m,i}$ is the measured pseudo-range of satellite *i* of $GNSS_m$. The system time t_{GNSS_k} of $GNSS_k$ is the reference time frame, and $(t_{GNSS_k} - t_{GNSS_m})$ is the available GNSS-GNSS time offset, and *c* is the speed of light.

Step 3: Formation of weighting matrix

The UE reported "codePhaseRMSError" values are used to calculate the weighting matrix for the WLS algorithm [7]. According to TS 36.355 [3], the encoding for this field is a 6 bit value that consists of a 3 bit mantissa, X_i and a 3 bit exponent, Y_i for each SV_i:

$$w_i = RMSError = 0.5 \times \left(1 + \frac{X_i}{8}\right) \times 2^{Y_i}$$

The weighting Matrix **W** is defined as a diagonal matrix containing the estimated variances calculated from the "codePhaseRMSError" values:

$$\mathbf{W} = \mathrm{diag}\left\{1/w^2_{GNSS_1,1}, 1/w^2_{GNSS_1,2}, \cdots, 1/w^2_{GNSS_1,n}, \cdots, 1/w^2_{GNSS_m,1}, 1/w^2_{GNSS_m,2}, \cdots, 1/w^2_{GNSS_m,l}\right\}$$

Step 4: WLS position solution

The WLS position solution is described in reference [7] and usually requires the following steps:

1) Computation of satellite locations at time of transmission using the ephemeris parameters and user algorithms defined in the relevant ICD of the particular GNSS. The satellite locations are transformed into WGS-84 reference frame, if needed.

2) Computation of clock correction parameters using the parameters and algorithms as defined in the relevant ICD of the particular GNSS.

3) Computation of atmospheric delay corrections using the parameters and algorithms defined in the relevant ICD of the particular GNSS for the ionospheric delay, and using the Gupta model in reference [8] p. 121 equation (2) for the tropospheric delay. For GNSSs which do not natively provide ionospheric correction models (e.g., GLONASS), the ionospheric delay is determined using the available ionospheric model adapted to the particular GNSS frequency.

4) The WLS position solution starts with an initial estimate of the user state (position and clock offset). The Reference Location is used as initial position estimate. The following steps are required:

   a) Calculate geometric range (corrected for Earth rotation) between initial location estimate and each satellite included in the UE measurement report.

   b) Predict pseudo-ranges for each measurement including clock and atmospheric biases as calculated in 1) to 3) above and defined in the relevant ICD of the particular GNSS and [7].

   c) Calculate difference between predicted and measured pseudo-ranges $\Delta\boldsymbol{\rho}$

d) Calculate the "Geometry Matrix" **G** as defined in [7]:

$$\mathbf{G} \equiv \begin{bmatrix} -\hat{\mathbf{1}}^T_{GNSS_1,1} & 1 \\ -\hat{\mathbf{1}}^T_{GNSS_1,2} & 1 \\ \vdots & \vdots \\ -\hat{\mathbf{1}}^T_{GNSS_1,n} & 1 \\ \vdots & \vdots \\ -\hat{\mathbf{1}}^T_{GNSS_m,1} & 1 \\ -\hat{\mathbf{1}}^T_{GNSS_m,2} & 1 \\ \vdots & \vdots \\ -\hat{\mathbf{1}}^T_{GNSS_m,l} & 1 \end{bmatrix} \text{ with } \hat{\mathbf{1}}_{GNSS_m,i} \equiv \frac{\mathbf{r}_{s_{GNSS_m,i}} - \hat{\mathbf{r}}_u}{\left|\mathbf{r}_{s_{GNSS_m,i}} - \hat{\mathbf{r}}_u\right|}$$

where $\mathbf{r}_{s_{GNSSm,i}}$ is the satellite position vector for SV_i of $GNSS_m$ (calculated in 1) above), and $\hat{\mathbf{r}}_u$ is the estimate of the user location.

e) Calculate the WLS solution according to [7]:

$$\Delta\hat{\mathbf{x}} = \left(\mathbf{G}^T \mathbf{W} \mathbf{G}\right)^{-1} \mathbf{G}^T \mathbf{W} \Delta\boldsymbol{\rho}$$

f) Adding the $\Delta\hat{\mathbf{x}}$ to the initial state estimate gives an improved estimate of the state vector:

$$\hat{\mathbf{x}} \rightarrow \hat{\mathbf{x}} + \Delta\hat{\mathbf{x}}.$$

5) This new state vector $\hat{\mathbf{x}}$ can be used as new initial estimate and the procedure is repeated until the change in $\hat{\mathbf{x}}$ is sufficiently small.

Step 5: Transformation from Cartesian coordinate system to Geodetic coordinate system

The state vector $\hat{\mathbf{x}}$ calculated in Step 4 contains the UE position in ECEF Cartesian coordinates together with the UE receiver clock bias relative to the selected GNSS system time. Only the user position is of further interest. It is usually desirable to convert from ECEF coordinates x_u, y_u, z_u to geodetic latitude φ □, longitude λ and altitude h on the WGS-84 reference ellipsoid.

Step 6: Calculation of "2-D Position Errors"

The latitude φ / longitude λ obtained after Step 5 is used to calculate the 2-D position error.

Annex G (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2018-11	RAN4#89	R4-1814423				TS baseline created from TS 36.171.	0.1.0
2018-11	RAN4#89	R4-1814424				Updates from e-mail discussion	0.2.0
2018-12	RAN#82	RP-182325				V1.0.0 is submitted to RAN for 1-step approval	1.0.0
2018-12	RAN#82					Approved by plenary – Rel-15 spec under change control	15.0.0
2019-03	RAN#83	RP-190402	0001	1	F	CR on A-GNSS in 38.171	15.1.0
2019-12	RAN#86	RP-193002	0008	1	F	CR to TS 38.171: Corrections to A-GNSS requirements with NR	15.2.0

History

Document history		
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V15.1.0	May 2019	Publication
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