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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 7^{th}, 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.
G	Geometry Matrix.
$\rho_{GNSS_m,i}$	Measured pseudo-range of satellite *i* of $GNSS_m$.
W	Weighting Matrix.
$\mathbf{1}_{GNSS_m,i}$	Line of sight unit vector from the user to the satellite *i* of $GNSS_m$.
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.