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TECHNICAL SPECIFICATION

Universal Mobile Telecommunications System (UMTS);
Requirements for support of Assisted Galileo and Additional Navigation Satellite Systems (A-GANSS)
Frequency Division Duplex (FDD)
(3GPP TS 25.172 version 15.0.0 Release 15)

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Contents

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1 Scope

The present document establishes the minimum performance requirements for A-GANSS for FDD mode of UTRA for the User Equipment (UE) that supports A-GANSS. It includes the minimum performance requirements for both UE-based and UE-assisted A-GANSS. The minimum performance requirements also include combinations of A-GPS and A-GANSS.

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 TS 25.101: "User Equipment (UE) radio transmission and reception (FDD)".

[2] 3GPP TS 25.104: "Base Station (BS) radio transmission and reception (FDD)".

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

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

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

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

[7] "Galileo OS Signal in Space ICD (OS SIS ICD)", Draft 0, Galileo Joint Undertaking, May 23rd, 2006.

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

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

[10] 3GPP TS 25.171: "Requirements for support of Assisted Global Positioning System (A-GPS) Frequency Division Duplex (FDD)".

[11] 3GPP TS 34.171: "Terminal Conformance Specification, Assisted Global Positioning System (A-GPS) (FDD)".

[12] 3GPP TS 34.172: "Terminal Conformance Specification, Assisted Galileo and Additional Navigation Satellite Systems (A-GANSS) (FDD)".

[13] 3GPP TS 34.109: "Special conformance testing functions".

[14] 3GPP TS 25.331: "Radio Resource Control (RRC) protocol specification".

[15] 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".

[16] 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.

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

[18] 3GPP TS 25.215: "Physical layer; Measurements (FDD)".

[19] BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1I(Version 1.0), China Satellite Navigation Office, December 2012.

3 Definitions, symbols, abbreviations and test tolerances

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TS 25.101 [1], 3GPP TS 25.104 [2] and the following apply:

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.

3.2 Symbols

For the purposes of the present document, the following symbol applies:

B1I	BeiDou B1I navigation signal with carrier frequency of 1561.098 MHz.
c	Speed of light.
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:

A-GANSS	Assisted-Galileo and Additional Navigation Satellite Systems
A-GNSS	Assisted-GNSS
A-GPS	Assisted-Global Positioning System
AWGN	Additive White Gaussian Noise
BDS	BeiDou Navigation Satellite System
C/A	Coarse/Acquisition
DUT	Device Under Test
ECEF	Earth-Centered, Earth-Fixed
ECI	Earth-Centered-Inertial
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
GSS	GNSS System Simulator
HDOP	Horizontal Dilution Of Precision
ICD	Interface Control Document
IGSO	Inclined Geosynchronous Satellite Orbit
IS	Interface Specification
LOS	Line Of Sight
MEO	Medium Earth Orbit
QZS	Quasi-Zenith Satellite
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RRC	Radio Resource Control
SBAS	Space Based Augmentation System
SFN	System Frame Number
SS	FDD System Simulator
SV	Space Vehicle
TBD	To Be Determined
TOD	Time Of Day
TOW	Time Of Week
TTFF	Time To First Fix
UE	User Equipment
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network
WLS	Weighted Least Squares
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 3GPP TS 34.172 [12] 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 [15], subclause 6.5.

4 General

4.1 Introduction

The present document defines the minimum performance requirements for both UE-based and UE-assisted FDD A-GANSS terminals. The minimum performance requirements also include combinations of A-GPS and A-GANSS.

4.2 Measurement parameters

4.2.1 UE-based A-GANSS measurement parameters

In case of UE-based A-GANSS, the measurement parameters are contained in the RRC UE POSITIONING POSITION ESTIMATE INFO IE. The measurement parameter in case of UE-based A-GANSS is the horizontal position estimate reported by the UE and expressed in latitude/longitude.

4.2.2 UE-assisted A-GANSS measurement parameters

In case of UE-assisted A-GANSS, the measurement parameters are contained in the RRC UE POSITIONING GANSS MEASURED RESULTS IE. The measurement parameters in case of UE-assisted A-GANSS are the UE GANSS code measurements, as specified in 3GPP TS 25.215 [18]. The UE GANSS code measurements that may be combined with UE GPS code phase measurements as specified in 3GPP TS 25.215 [18] 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 has received the final RRC measurement control message containing reporting criteria different from "No Reporting" sent before the UE sends the measurement report containing the position estimate or the GANSS and GPS measured result, and ending when the UE starts sending the measurement report containing the position estimate or the GPS and GANSS measured result on the Uu interface. The response times specified for all test cases are Time-to-First-Fix (TTFF) unless otherwise stated, i.e. the UE shall not re-use any information on GANSS and GPS 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' has been defined in TS 34.109 [13] clause 5.4 for the purpose of deleting this information and is detailed in subclause B.1.10.

4.4 Time assistance

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

a) Coarse time assistance is always provided by the network and provides current GANSS time to the UE. The time provided is within ±2 seconds of GANSS system time. It is signalled to the UE by means of the GANSS Day and GANSS TOD fields in the GANSS Reference Time assistance data IE.

b) Fine time assistance is optionally provided by the network and adds the provision to the UE of the relationship between the GANSS system time and the current UTRAN time. The accuracy of this relationship is ±10 μs of the actual relationship. This addresses the case when the network can provide an improved GANSS time accuracy. It is signalled to the UE by means of the SFN and UTRAN GANSS timing of cell frames fields in the GANSS Reference Time assistance data IE.

The specific GANSS system time is identified through the GANSS Time ID field of the GANSS Reference Time IE. In case where several GANSS are used in the tests, only one GANSS Time ID is used to determine the Time of Day. For all the constellations, the GANSS Time Model assistance and UTC Model assistance shall be available at the system simulator, as specified in Annex E.

The time of applicability of time assistance is the beginning of the System Frame of the message containing the GANSS Reference time.

4.4.1 Use of fine time assistance

The use of fine time assistance to improve the GANSS 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 subclause 5.1.2.

4.5 RRC states

The minimum A-GANSS performance requirements are specified in clause 5 for different RRC states that include Cell_DCH and Cell_FACH. Cell_PCH and URA_PCH states are for further study. The test and verification procedures are separately defined in Annex B.

4.6 2D position error

The 2D position error is defined by the horizontal difference in meters between the ellipsoid point reported or calculated from the UE Measurement Report and the actual position of the UE in the test case considered.

4.7 User equipment supporting multiple constellations

Minimum performance requirements are defined for each global GANSS constellation (Galileo, Modernized GPS,GLONASS and BDS). 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 User equipment 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 4.8-1. The individual test scenarios in clause 5 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 5 plus the relative power level defined in Table 4.8-1.

Table 4.8-1: Relative signal power levels for each signal type for each GNSS

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

The A-GANSS minimum performance requirements are defined by assuming that all relevant and valid assistance data is received by the UE in order to perform GPS and GANSS 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 subclauses the minimum performance requirements are based on availability of the assistance data information and messages defined in Annexes D and E.

The requirements in CELL_PCH and URA_PCH states are for further study.

5.1 Sensitivity

A sensitivity requirement is essential for verifying the performance of A-GANSS 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 6 satellites are generated for the terminal. AWGN channel model is used.

Table 5.1.1-1: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 5.1.1-2
	Total number of generated satellites	-	6
	HDOP range		1.4 to 2.1
	Propagation conditions	-	AWGN
	GANSS coarse time assistance error range	seconds	±2
Galileo	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
GLONASS	Reference high signal power level	dBm	-142
	Reference low signal power level	dBm	-147
BDS	Reference high signal power level	dBm	-136
	Reference low signal power level	dBm	-145
Note 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 5.1.1-2: 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.				

5.1.1.1 Minimum requirements (coarse time assistance)

The position estimates shall meet the accuracy and response time specified in table 5.1.1.1-1.

Table 5.1.1.1-1: Minimum requirements (coarse time assistance)

System	Success rate	2-D position error	Max response time
All	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 6 satellites are generated for the terminal. AWGN channel model is used.

Table 5.1.2-1: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 5.1.2-2
	Total number of generated satellites	-	6
	HDOP range		1.4 to 2.1
	Propagation conditions	-	AWGN
	GANSS coarse time assistance error range	seconds	±2
	GANSS fine time assistance error range	μs	±10
Galileo	Reference signal power level	dBm	-147
GPS(1)	Reference signal power level	dBm	-147
GLONASS	Reference signal power level	dBm	-147
BDS	Reference signal power level	dBm	-147
Note 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 5.1.2-2: 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

5.1.2.1 Minimum requirements (fine time assistance)

The position estimates shall meet the accuracy and response time requirements in table 5.1.2.1-1.

Table 5.1.2.1-1: Minimum requirements for fine time assistance capable terminals

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

5.2 Nominal accuracy

Nominal accuracy requirement verifies the accuracy of A-GANSS 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 5.2-2.

Table 5.2-1: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 5.2-2
	Total number of generated satellites	-	6 or 7(2)
	HDOP Range	-	1.4 to 2.1
	Propagation conditions	-	AWGN
	GANSS coarse time assistance error range	seconds	±2
GPS(1)	Reference signal power level for all satellites	dBm	-128.5
Galileo	Reference signal power level for all satellites	dBm	-127
GLONASS	Reference signal power level for all satellites	dBm	-131
QZSS	Reference signal power level for all satellites	dBm	-128.5
SBAS	Reference signal power level for all satellites	dBm	-131
BDS	Reference signal power level for all satellites	dBm	-133
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 5.2-2: 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., GPS, Galileo, GLONASS and BDS.				

5.2.1 Minimum requirements (nominal accuracy)

The position estimates shall meet the accuracy and response time requirements in table 5.2.1-1.

Table 5.2.1-1: Minimum requirements

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

5.3 Dynamic range

The aim of a dynamic range requirement is to ensure that a GANSS 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 5.3-2. AWGN channel model is used.

Table 5.3-1: Test parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 5.3-2
	Total number of generated satellites	-	6
	HDOP Range	-	1.4 to 2.1
	Propagation conditions	-	AWGN
	GANSS coarse time assistance error range	seconds	±2
Galileo	Reference high signal power level	dBm	-127.5
	Reference low signal power level	dBm	-147
GPS$^{(1)}$	Reference high signal power level	dBm	-129
	Reference low signal power level	dBm	-147
GLONASS	Reference high signal power level	dBm	-131.5
	Reference low signal power level	dBm	-147
BDS	Reference high signal power level	dBm	-133.5
	Reference low signal power level	dBm	-145
Note 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 5.3-2: 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., GPS, Galileo, GLONASS and BDS.				

5.3.1 Minimum requirements (dynamic range)

The position estimates shall meet the accuracy and response time requirements in table 5.3.1-1.

Table 5.3.1-1: Minimum requirements

System	Success rate	2-D position error	Max response time
All	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 test 6 satellites are generated for the terminal. Some of the satellites have a one tap channel representing the Line-Of-Sight (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 5.4-2. The channel model as specified in Annex C.2 further depends on the generated signal.

Table 5.4-1: Test parameter

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 5.4-2
	Total number of generated satellites	-	6
	HDOP range		1.4 to 2.1
	Propagation conditions	-	AWGN
	GANSS coarse time assistance error range	seconds	±2
Galileo	Reference signal power level	dBm	-127
GPS[(1)]	Reference signal power level	dBm	-128.5
GLONASS	Reference signal power level	dBm	-131
BDS	Reference signal power level	dBm	-133
Note 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 5.4-2: 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

5.4.1 Minimum requirements (multi-path scenario)

The position estimates shall meet the accuracy and response time requirements in table 5.4.1-1.

Table 5.4.1-1: Minimum requirements

System	Success rate	2-D position error	Max response time
All	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 GANSS 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-GANSS 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 Time to First Fix (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 1440 m with rounded corner defined in figure 5.5-1. 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 5.5-1: 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

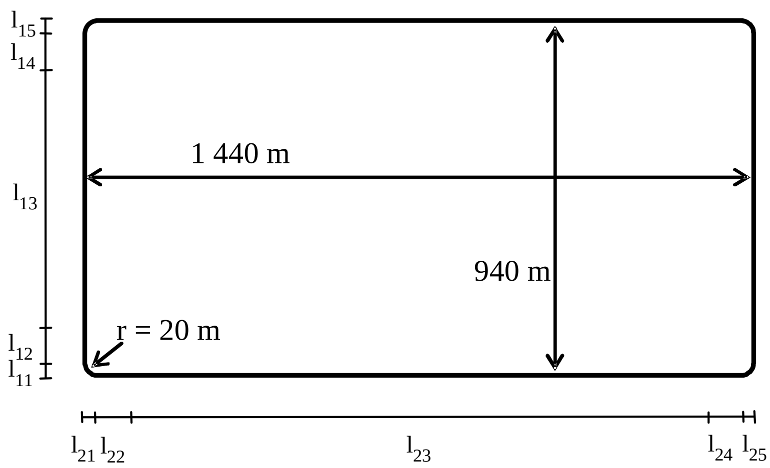

Figure 5.5-1: Rectangular trajectory of the moving scenario and periodic update test case

Table 5.5-2: Test Parameters

System	Parameters	Unit	Value
	Number of generated satellites per system	-	See Table 5.5-3
	Total number of generated satellites	-	6
	HDOP Range per system	-	1.4 to 2.1
	Propagation conditions	-	AWGN
	GANSS coarse time assistance error range	seconds	±2
Galileo	Reference signal power level for all satellites	dBm	-127
GPS(1)	Reference signal power level for all satellites	dBm	-128.5
GLONASS	Reference signal power level for all satellites	dBm	-131
BDS	Reference signal power level for all satellites	dBm	-133
Note 1: "GPS" here means GPS L1 C/A, Modernized GPS, or both, dependent on UE capabilities.			

Table 5.5-3: 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., GPS, Galileo, GLONASS and BDS.			

5.5.1 Minimum requirements (moving scenario and periodic update)

The position estimates shall meet the accuracy requirement of table 5.5.1-1 with the periodical reporting interval defined in table 5.5.1-1 after the first reported position estimates.

NOTE: In the actual testing the UE may report error messages until it has been able to acquire GPS/GANSS 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 5.5.1-1.

Table 5.5.1-1: 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 are specified in 3GPP TS 34.172 [12]. 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 3GPP TS 34.172 [12].

Annex B (normative): Test conditions

B.1 General

This annex specifies the additional parameters that are needed for the test cases specified in clause 5 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 measurement control message.

Table B.1.1-1: Parameter values

Information element	Value - TTFF tests (except nominal accuracy test)	Value - TTFF tests (nominal accuracy test)	Value - Periodic tests
Measurement Reporting Mode	Periodical reporting	Periodical reporting	Periodical reporting
Amount of reporting	1	1	Infinite (see Note)
Reporting interval	20 000 ms	20 000 ms	2 000 ms
Horizontal accuracy	51.2 m	7.7 m	24.5 m
Vertical accuracy	102 m	102 m	102 m
Note: Infinite means during the complete test time.			

In the Sensitivity test case with Fine Time Assistance, the following parameter values are used.

Table B.1.1-2: Parameters for fine time assistance test

Information element	Value
$T_{UTRAN\text{-}GPS}$ drift rate	0
$T_{UTRAN\text{-}GANSS}$ drift rate	0
UE Positioning GPS Reference Time Uncertainty	10.2 μs
GANSS TOD Uncertainty	10.2 μs

B.1.2 Time assistance

For every Test Instance in each TTFF test case, the GANSS/GPS Reference Time shall have a random offset, relative to GANSS/GPS 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 UTRAN GPS/GANSS timing of cell frames 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 GANSS/GPS Reference Time shall be set to the nominal value.

B.1.3 GANSS reference time

For every Test Instance in each TTFF test case, the GANSS reference time (and GPS reference time, if applicable) 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

The satellite constellation shall consist of 24 satellites for GLONASS; 27 satellites for GPS, Modernized GPS and Galileo; 3 satellites for QZSS; 2 satellites for SBAS and 35 satellites for BDS (5 GEO, 27 MEO, 3 IGSO). Almanac assistance data shall be available for all these satellites. At least 7 of the satellites per GPS, Modernized GPS, Galileo, GLONASS and BDS 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 GPS, Modernized GPS, Galileo, GLONASS and BDS 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 delay

Typical Ionospheric and Tropospheric delays shall be simulated and the corresponding values inserted into the Ionospheric Model IEs.

B.1.7 Sensors

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

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 Time to First Fix (TTFF) conditions, a dedicated test signal (*RESET UE POSITIONING STORED INFORMATION*) defined in TS 34.109 [13] clause 5.4 shall be used.

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

- discard any internally stored GPS and GANSS 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 system simulator shall be better than 3 ns.

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 GANSS signals are defined in table C.2-1.

Table C.2-1: 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.2-2, and N is the ratio between the transmitted carrier frequency of the signals and the transmitted chip rate as shown in table C.2-3 (where k in table C.2-3 is the GLONASS frequency channel number).

Table C.2-2: Relative Delay and Attenuation of Non Line of Sight Signals

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

Table C.2-3: Ratio between the transmitted carrier frequency of the signals and the transmitted chip rate

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

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 GANSS, is defined in this subclause.

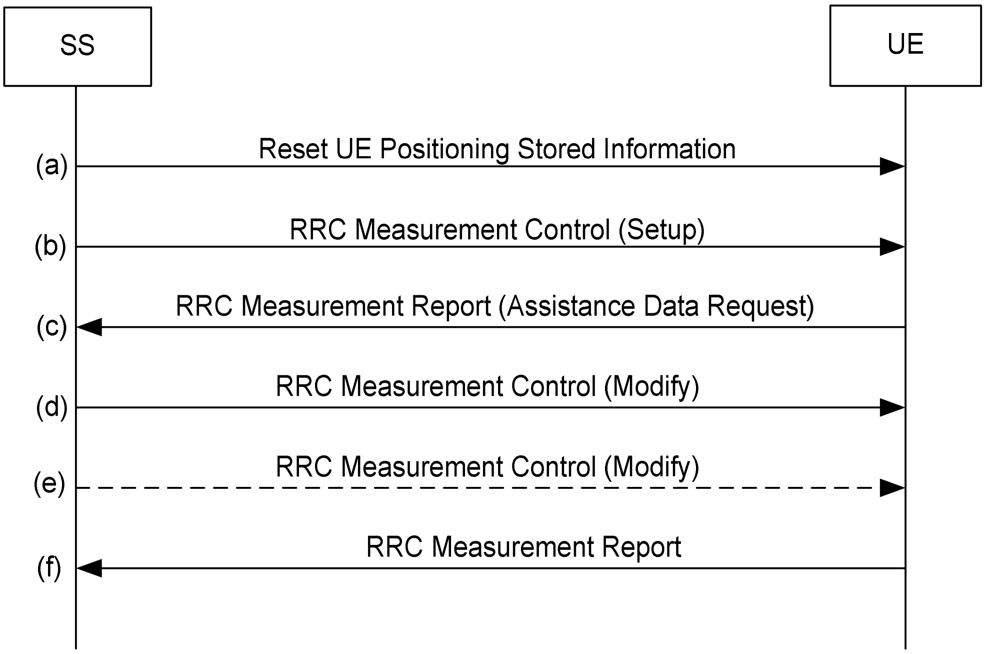

Figure D.2-1: Measurement Sequence Chart for the TTFF Test Cases

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

(b) The system simulator sends a RRC MEASUREMENT CONTROL message without assistance data including the following information elements:

MEASUREMENT COMMAND	Setup
CHOICE *MEASUREMENT TYPE*	UE positioning measurement
UE POSITIONING REPORTING QUANTITY	
>Method Type	set to either 'UE assisted' or 'UE based', dependent on the test case;
>Positioning Methods	set to 'GPS';
>Horizontal Accuracy	as defined in Annex B;
>Vertical Accuracy	as defined in Annex B;
>Additional Assistance Data Request	TRUE
>GANSS Positioning Methods	set according to the UE capabilities and test case;
MEASUREMENT VALIDITY	
>UE state	All states
CHOICE REPORTING CRITERIA	Periodical reporting criteria
>Amount of reporting	1 (see Annex B);
>Reporting interval	20 seconds (see Annex B);

(c) The UE responds with a RRC MEASUREMENT REPORT message including the *UE POSITIONING ERROR* IE with 'Error Reason' set to 'Assistance data missing', and including a request for additional GPS and/or GANSS assistance data.

(d) – (e) The system simulator provides the requested assistance data that are available as defined in Annex E in one or more RRC MEASUREMENT CONTROL messages with MEASUREMENT COMMAND IE set to 'modify' and the CHOICE REPORTING CRITERIA set to 'no reporting' in all but the last RRC MEASUREMENT CONTROL message. The last RRC MEASUREMENT CONTROL message which is required to deliver the entire set of requested assistance data in step (c) includes the CHOICE REPORTING CRITERIA set to 'Periodical reporting criteria' as defined in step (b).

(f) The UE sends a RRC MEASUREMENT REPORT message including the IE UE POSITIONING MEASURED RESULTS with UE POSITIONING POSITION ESTIMATE INFO present in case of UE-based, or UE POSITIONING GPS MEASURED RESULTS and/or UE POSITIONING GANSS MEASURED RESULTS present in case of UE-assisted GANSS.

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

D.3 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 GANSS, is defined in this subclause.

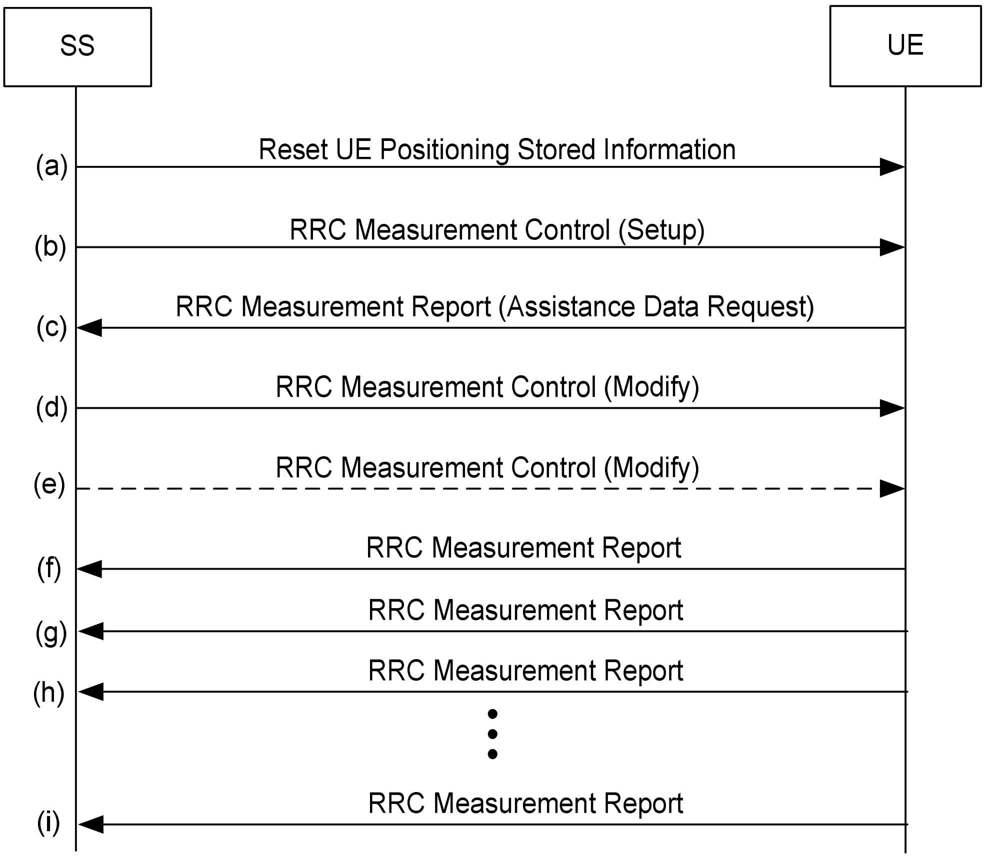

Figure D.3-1: Measurement Sequence Chart for the Moving Scenario and Periodic Update Test Case

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

(b) The system simulator sends a RRC MEASUREMENT CONTROL message without assistance data including the following information elements:

MEASUREMENT COMMAND	Setup
CHOICE *MEASUREMENT TYPE*	UE positioning measurement

UE POSITIONING REPORTING QUANTITY	
>Method Type	set to either 'UE assisted' or 'UE based', dependent on the test case;
>Positioning Methods	set to 'GPS';
>Horizontal Accuracy	as defined in Annex B;
>Vertical Accuracy	as defined in Annex B;
>Additional Assistance Data Request	TRUE
>GANSS Positioning Methods	set according to the UE capabilities and test case;
MEASUREMENT VALIDITY	
>UE state	All states
CHOICE REPORTING CRITERIA	Periodical reporting criteria
>Amount of reporting	infinite (see Annex B);
>Reporting interval	2 seconds (see Annex B);

(c) The UE responds with a RRC MEASUREMENT REPORT message including the *UE POSITIONING ERROR* IE with 'Error Reason' set to 'Assistance data missing', and including a request for additional GPS and/or GANSS assistance data.

(d) – (e) The system simulator provides the requested assistance data that are available as defined in Annex E in one or more RRC MEASUREMENT CONTROL messages with MEASUREMENT COMMAND IE set to 'modify' and the CHOICE REPORTING CRITERIA set to 'no reporting' in all but the last RRC MEASUREMENT CONTROL message. The last RRC MEASUREMENT CONTROL message which is required to deliver the entire set of requested assistance data in step (c) includes the CHOICE REPORTING CRITERIA set to 'Periodical reporting criteria' as defined in step (b).

(f) The UE sends a RRC MEASUREMENT REPORT message including the IE UE POSITIONING MEASURED RESULTS with UE POSITIONING POSITION ESTIMATE INFO present in case of UE-based, or UE POSITIONING GPS MEASURED RESULTS and/or UE POSITIONING GANSS MEASURED RESULTS present in case of UE-assisted GANSS.

(g) – (i) The UE continues to provide RRC MEASUREMENT REPORT messages as in step (g) until the moving trajectory has been completed.

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

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 3GPP TS 25.331 [14], where the details are defined.

E.2 GPS assistance data

The GPS L1 C/A assistance data are as defined in 3GPP TS 25.171 [10], Annex E.

E.3 GANSS assistance data

a) **UE Positioning GANSS Reference Time IE.** This information element is defined in subclause 10.3.7.96o of 3GPP TS 25.331 [14].

Table E.3-1: GANSS reference time IE

Name of the IE	Fields of the IE	All tests except Sensitivity Fine Time Assistance	Sensitivity Fine Time Assistance test
UE Positioning GANSS Reference Time			
	GANSS Day	Yes	Yes
	GANSS TOD	Yes	Yes
	GANSS TOD Uncertainty	Yes	Yes
	GANSS Time ID	Yes	Yes
	UTRAN GANSS Reference Time		
	>UTRAN GANSS Timing of Cell Frames		Yes
	>CHOICE mode		Yes
	>>FDD		Yes
	>>>Primary CPICH Info		Yes
	>SFN		Yes
	$T_{UTRAN-GANSS}$ Drift Rate		Yes

b) **UE Positioning GANSS Reference UE Position IE.** This information element is defined in subclause 10.3.8.4c of 3GPP TS 25.331 [14].

Table E.3-2: GANSS reference location IE

Name of the IE	Fields of the IE
UE Positioning GANSS Reference UE Position	Ellipsoid point with Altitude and uncertainty ellipsoid

c) **UE Positioning GANSS Ionospheric Model IE.** This information element is defined in subclause 10.3.7.92a of 3GPP TS 25.331 [14].

Table E.3-3: GANSS ionospheric model IE

Name of the IE	Fields of the IE
UE Positioning GANSS Ionospheric Model	

d) **UE Positioning GANSS Additional Ionospheric Model IE.** This information element is defined in subclause 10.3.7.92b of 3GPP TS 25.331 [14].

Table E.3-4: GANSS additional ionospheric model IE

Name of the IE	Fields of the IE
UE Positioning GANSS Additional Ionospheric Model	

e) **UE Positioning GANSS Time Model IE.** This information element is only required for multi system tests, and is defined in subclause 10.3.7.97a of 3GPP TS 25.331 [14].

Table E.3-5: GANSS time model IE

Name of the IE	Fields of the IE
UE Positioning GANSS Time Model	
	GNSS_TOD_ID For each GNSS included in the test.

f) **UE Positioning GANSS Navigation Model IE.** This information element is defined in subclause 10.3.7.94a of 3GPP TS 25.331 [14].

Table E.3-6: GANSS navigation model IE

Name of the IE	Fields of the IE
UE Positioning GANSS Navigation Model	

g) **UE Positioning GANSS Additional Navigation Models IE.** This information element is defined in subclause 10.3.7.94b of 3GPP TS 25.331 [14].

Table E.3-7: GANSS navigation model IE

Name of the IE	Fields of the IE
UE Positioning GANSS Navigation Model	

Table E.3-8: GANSS clock and orbit model choices

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

h) **UE Positioning GANSS Reference Measurement Information IE.** This information element is defined in subclause 10.3.7.88b of 3GPP TS 25.331 [14].

Table E.3-9: GANSS reference measurement information IE

Name of the IE	Fields of the IE
UE Positioning GANSS Reference Measurement Information	
	SatID
	Doppler (0th order term)
	Doppler (1st order term)
	Doppler Uncertainty
	Code Phase
	Integer Code Phase
	Code Phase Search Window
	Azimuth
	Elevation

i) UE Positioning GANSS Almanac IE. This information element is defined in subclause 10.3.7.89a of 3GPP TS 25.331 [14].

Table E.3-10: GANSS almanac model IE

Name of the IE	Fields of the IE
UE Positioning GANSS Almanac	

Table E.3-11: GANSS almanac choices

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

j) UE Positioning GANSS UTC Model IE. This information element is defined in subclause 10.3.7.97c of 3GPP TS 25.331 [14].

Table E.3-12: GANSS UTC model IE

Name of the IE	Fields of the IE
UE Positioning GANSS UTC Model	

k) UE Positioning GANSS Additional UTC Models IE. This information element is defined in subclause 10.3.7.97d of 3GPP TS 25.331 [14].

Table E.3-13: GANSS additional UTC model IE

Name of the IE	Fields of the IE
UE Positioning GANSS Additional UTC Models IE	

Table E.3-14: GANSS UTC model choices

GANSS	UTC Model Choice
Galileo	UE Positioning GANSS UTC Model
Modernized GPS	Model-1
GLONASS	Model-2
QZSS QZS-L1	UE Positioning GANSS UTC Model
QZSS QZS-L1C/L2C/L5	Model-1
SBAS	Model-3
BDS	Model-4

l) **UE Positioning GANSS Auxiliary Information IE.** This information element is defined in subclause 10.3.7.97f of 3GPP TS 25.331 [14].

Table E.3-15: GANSS auxiliary information IE

Name of the IE	Fields of the IE
UE Positioning GANSS Auxiliary Information IE	

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-GANSS 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 [3], [4], [5], [6], [7], [8], [9], [16] and [17].

F.2 UE measurement reports

In case of UE-assisted A-GANSS, the measurement parameters are contained in the RRC UE POSITIONING GANSS MEASURED RESULTS IE (subclause 10.3.7.93a in 3GPP TS 25.331 [14]). In case the UE provides also measurements on the GPS L1 C/A signal, the measurement parameters are contained in the RRC UE POSITIONING GPS MEASURED RESULTS IE (subclause 10.3.7.93 in 3GPP TS 25.331 [14]). The measurement parameters required for calculating the UE position are:

1) Reference Time: The UE has two choices for the Reference Time:
    a) "UE GANSS Timing of Cell Frames" and/or "UE GPS Timing of Cell Frames";
    b) "GANSS TOD msec" and/or "GPS TOW msec" if GPS L1 C/A signal measurements are also provided.

NOTE: It is not expected that an UE will ever report both a GANSS TOD and a GPS TOW. However if two time stamps are provided and they derive from different user times, be aware that no compensation is made for this difference and this could affect the location accuracy.

2) Measurement Parameters for each GANSS and GANSS Signal: 1 to <maxGANSSSat>:
    a) "Satellite ID"; mapping according to table 10.3.7.88b in 3GPP TS 25.331 [14];
    b) "GANSS Code Phase";
    c) "GANSS Integer Code Phase";
    d) "GANSS Integer Code Phase Extension";
    e) "Code Phase RMS Error";
3) Additional Measurement Parameters in case of GPS L1 C/A signal measurements are also provided: 1 to <maxSat>:
    a) "Satellite ID (SV PRN)";
    b) "Whole GPS chips";
    c) "Fractional GPS Chips";
    d) "Pseudorange RMS Error".

Additional information required at the system simulator:

1) "UE Positioning GANSS Reference UE Position" or "UE Positioning GPS Reference UE Position" (subclause 10.3.8.4c in 3GPP TS 25.331 [14]):
   Used for initial approximate receiver coordinates.
2) "UE Positioning GANSS Navigation Model" and "UE Positioning GANSS Additional Navigation Models" (subclauses 10.3.7.94a and 10.3.7.94b in 3GPP TS 25.331 [14]):

Contains the ephemeris and clock correction parameters as specified in the relevant ICD of each supported GANSS; used for calculating the satellite positions and clock corrections.

3) "UE Positioning GANSS Ionospheric Model" (subclause 10.3.7.92a in 3GPP TS 25.331 [14]):
Contains the ionospheric parameters which allow the single frequency user to utilize the ionospheric model as specified in [7] for computation of the ionospheric delay.

4) "UE Positioning GANSS Additional Ionospheric Model" (subclause 10.3.7.92b in 3GPP TS 25.331 [14]):
Contains the ionospheric parameters which allow the single frequency user to utilize the ionospheric model as specified in [6] for computation of the ionospheric delay.

5) "UE Positioning GANSS Time Model" (subclause 10.3.7.97a in 3GPP TS 25.331 [14]):
Contains the GNSS-GNSS Time Offset for each supported GANSS. Note, that "UE Positioning GANSS Time Model" IE contains only the sub-ms part of the offset. Any potential integer seconds offset may be obtained from "UE Positioning GPS UTC Model" (subclause 10.3.7.97 in 3GPP TS 25.331 [14]), "UE Positioning GANSS UTC Model" (subclause 10.3.7.97c in 3GPP TS 25.331 [14]), or "UE Positioning GANSS Additional UTC Models" (subclause 10.3.7.97d in 3GPP TS 25.331 [14]).

6) "UE Positioning GPS Navigation Model" (subclause 10.3.7.94 in 3GPP TS 25.331 [14]):
Contains the GPS ephemeris and clock correction parameters as specified in [3]; used for calculating the GPS satellite positions and clock corrections in case of GPS L1 C/A signal measurements are the only GPS measurements provided in addition to GANSS measurements.

7) "UE Positioning GPS Ionospheric Model" (subclause 10.3.7.92 in 3GPP TS 25.331 [14]):
Contains the ionospheric parameters which allow the single frequency user to utilize the ionospheric model as specified in [3] for computation of the ionospheric delay.

F.3 Weighted Least Squares (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 relative to the selected GNSS specific system time. 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 "GANSS Code Phase Ambiguity", or modulo 1 ms (the length of the C/A code period) in case of GPS L1 C/A signal measurements. 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 at the time of measurement is calculated, and the integer number of milliseconds to be added to the UE code phase measurements is obtained.

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

In case 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 system simulator:

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

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 "Code Phase RMS Error" and/or "Pseudorange RMS Error" values are used to calculate the weighting matrix for the WLS algorithm described in [16]. According to 3GPP TS 25.331 [14], the encoding for these fields 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 of $GNSS_j$:

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

The weighting Matrix **W** is defined as a diagonal matrix containing the estimated variances calculated from the "Code Phase RMS Error" and/or "Pseudorange RMS Error" 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 e.g., [16] 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 defined in [17] 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 (see subclause F.2) 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 [16].

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

   d) Calculate the "Geometry Matrix" **G** as defined in [16]:

$$\mathbf{G} \equiv \begin{bmatrix} -\hat{\mathbf{1}}^T_{GNSS_1,1} & 1 \\ -\hat{\mathbf{1}}^T_{GNSS_1,2} & 1 \\ \vdots & \vdots \\ -\hat{\mathbf{1}}^T_{GNSS_1,n} & 1 \\ \vdots & \vdots \\ -\hat{\mathbf{1}}^T_{GNSS_m,1} & 1 \\ -\hat{\mathbf{1}}^T_{GNSS_m,2} & 1 \\ \vdots & \vdots \\ -\hat{\mathbf{1}}^T_{GNSS_m,l} & 1 \end{bmatrix} \text{ with } \hat{\mathbf{1}}_{GNSS_m,i} \equiv \frac{\mathbf{r}_{s_{GNSS_m,i}} - \hat{\mathbf{r}}_u}{\left|\mathbf{r}_{s_{GNSS_m,i}} - \hat{\mathbf{r}}_u\right|}$$ 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 [16]:

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

   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 WGS84 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

Date	Meeting	Document	CR num	Rev	Comment	Version old	Version New
2010-02	RAN4#54	R4-100668			Text proposal for A-GANSS minimum performance requirements in UTRAN		0.0.1
2010-03	RAN#47	RP-100133			TS presented for information	0.0.1	1.0.0
2010-05	RAN4#55	R4-101671			Minor editorial corrections and allignments with GERAN	1.0.0	2.0.0
2010-05	RAN4#55	R4-101671			Approved by TSG RAN	2.0.0	10.0.0
2010-12	RP-50	RP-101350	001	1	Addition of Galileo sensitivity numbers in the A-GANSS minimum performance requirements in UMTS	10.0.0	10.1.0
2011-04	RP-51	RP-110351	002		Addition of missing values and references	10.1.0	10.2.0
2012-09	SP-57	-	-	-	Update to Rel-11 version (MCC)	10.2.0	11.0.0
2014-06	RP-64	RP-140924	004	2	CR to TS 25.172 on introduction BDS to A-GANSS of FDD mode of UTRA	11.0.0	12.0.0
2014-12	RP-66	RP-142151	005	-	Correction on BDS satellites number	12.0.0	12.1.0
2016-01	SP-70	-	-	-	Update to Rel-13 version (MCC)	12.1.0	13.0.0
2017-03	RP-75	-	-	-	Update to Rel-14 version (MCC)	13.0.0	14.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2018-06	SA#80	-	-	-	-	Update to Rel-15 version (MCC)	15.0.0

History

Document history		
V15.0.0	July 2018	Publication