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Figure 2 Example of basic trajectory

, DO229-2886 - Terms and abbreviations

List of terms

Term	Description

List of abbreviations

Abbreviation	Description
3D	Three-Dimensional space
AC	Advisory Circular
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
AWGN	Additive White Gaussian Noise
BAG	Becker Avionics Germany
C/A	Coarse Acquisition
CRC	Cyclic Redundancy Check
CSV	Comma-Separated Values
DOD	Department of Defence
DoF	Degrees of Freedom
EGNOS	European Geostationary Navigation Overlay Service
EMS	EGNOS Message Server
ESA	European Space Agency
ETSO	European Technical Standard Orders
FDE	Fault Detection and Exclusion
GDOP	Geometric Dilution of Precision
GEO	Geostationary
GIVE	Grid Ionospheric Vertical Error
GIVEI	Grid Ionospheric Vertical Error Indicator
GLONASS	Global Orbiting Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
HDOP	Horizontal Dilution of Precision
HIL	Hardware-In-the-Loop
HOW	Hand Over Word
HPL	Horizontal Protection Level
HW	Hardware
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IGP	Ionospheric Grid Point
IGS	International GNSS Service
IOD	Issue of Data

IODC	Issue of Data Clock
IODE	Issue of Data Ephemeris
IODF	Issue of Data Fast Correction
IODI	Issue of Data Ionospheric
IODP	Issue of Data PRN mask
IODS	Service Issue of Data
IQ	In-phase and Quadrature components
IS	Interface Specification
LAN	Local Area Network
LNAV	Lateral Navigation
LP	Localizer Performance without vertical guidance
LPV	Localizer Performance with Vertical guidance
MOPS	Minimum Operational Performance Standards
MSAS	Multi-functional Satellite-based Augmentation System
MT	Message Type
n/a	Not applicable
NAVSTAR	NAVigational Satellite Time And Ranging
NMCT	Navigation Message Correction Table
NMEA	National Marine Electronics Association
NSTB	National Satellite Test Bed
OR	Logical OR
OS	Open Service
PDOP	Positional Dilution of Precision
PNT	Positioning, Navigation and Timing
PPS	Pulse-Per-Second
PRN	Pseudo-Random Noise
QMH	Quality Management Handbook
QZSS	Quasi-Zenith Satellite System
RDP	Remote Desktop Protocol
RF	Radio Frequency
RINEX	Receiver INdependent EXchange format
RTCA	Radio Technical Commission for Aeronautics Inc.
SA	Selective Availability
SBAS	Satellite-Based Augmentation System
SDR	Software Defiend Radio
SIR	Simulation Iteration Rate
SIS	Signal-In-Space
SW	Software
TABS	Traffic Awareness Beacon System
TSO	Technical Standard Orders
UDRE	User Differential Range Error
UDREI	User Differential Range Error Indicator
URA	User Range Accuracy

US	United States of North America
VDOP	Vertical Dilution of Precision
VNAV	Vertical Navigation
VPL	Vertical Protection Level
WAAS	Wide Area Augmentation System

Link to update terms and abbreviations tables

1 Scope

1.1 Identification

This is GNSS Simulator Requirements Data for:

✔ **- DO-229E Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment**

1.2 Purpose

The purpose of this document is to describe the characteristics and functionality of the GNSS Simulator and provide a baseline for its usage during verification against RTCA DO-229E.

1.3 Document overview

Chapter 1 'Scope' introduces this document and contains list of applicable and referenced documents.

Chapter 2 'GNSS Simulator Requirements' defines requirements for equipment dedicated to simulation of GNSS system.

1.4 Applicable documents

✔ **- /QMH/**

Doc. No.	QMH 2000 Ausgabe 12
Issue	12
Title	Quality Management Manual
Publisher	BAG
Revision	N/A
Link	QMH 2000 Ausgabe 12 (Qualitätsmanagementhandbuch)

✔ **- /ETSOC145EA1/**

Doc. No.	ETSOC145EA1
Issue	25/07/2020
Title	AIRBORNE NAVIGATION SENSORS USING THE GLOBAL POSITIONING SYSTEM AUGMENTED BY THE SATELLITE-BASED AUGMENTATION SYSTEM
Publisher	EASA
Revision	(head)
Link	ETSOC145EA1

✔ **- /eC199/**

Doc. No.	ETSO-C199
Issue	2018-02-21
Title	European Technical Standard Order Traffic Awareness Beacon System (TABS)
Publisher	European Aviation Safety Agency

Link	ETSO-C199 - Traffic Awareness Beacon System (TABS)
Revision	10413

- /DO229/

Doc. No.	DO-229E
Issue	2016-12-15
Title	Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment
Publisher	RTCA
Link	DO-229E - 2.0 Equipment Performance
Revision	(head)

- /Annex10 V1/

Doc. No.	ICAO Annex 10, Volume I through Amendment 90
Issue	July 2018
Title	ICAO Annex 10, Volume I, Radio Navigation Aids
Publisher	International Civil Aviation Organization
Link	https://store.icao.int/en/annexes/annex-10
Revision	7

1.5 Referenced documents

- /IS-GPS-200/

Doc. No.	IS-GPS-200
Issue	7 December 2004
Title	NAVSTAR GPS Space Segment / Navigation User Interfaces
Publisher	Navstar Global Positioning System
Link	https://navcen.uscg.gov/pdf/IS-GPS-200D.pdf
Revision	D

- /IS-GPS-705/

Doc. No.	IS-GPS-705
Issue	23-MAR-2021
Title	NAVSTAR GPS Space Segment / User Segment L5 Interface
Publisher	Navstar Global Positioning System
Link	https://navcen.uscg.gov/pdf/gps/IS_GPS_705H.pdf
Revision	H

- /IS-GPS-800/

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Doc. No.	IS-GPS-800
Issue	13-APR-2021
Title	NAVSTAR GPS Space Segment/ User Segment L1C Interfaces
Publisher	Navstar Global Positioning System
Link	https://navcen.uscg.gov/pdf/gps/IS_GPS_800H.pdf
Revision	H

- /OS SIS ICD/

Doc. No.	OS SIS ICD
Issue	Issue 2.0, January 2021
Title	Galileo Open Service Signal-In-Space Interface Control Document
Publisher	European Space Agency ESA
Link	https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_OS_SIS_ICD_v2.0.pdf
Revision	n/a

- /IS-QZSS-PNT/

Doc. No.	IS-QZSS-PNT-00x
Issue	January 25, 2021
Title	QZSS Interface Specification Satellite Positioning, Navigation and Timing Service
Publisher	Cabinet Office, Government of Japan and Quasi-Zenith Satellite System Services Inc.
Link	https://qzss.go.jp/en/technical/download/pdf/ps-is-qzss/is-qzss-pnt-004.pdf
Revision	004

- /NMEA/

Doc. No.	NMEA 0183
Issue	November, 2018
Title	Standard for Interfacing Marine Electronic Devices
Publisher	National Marine Electronics Association
Link	n/a
Revision	4.11

- /RINEX/

Doc. No.	RINEX
Issue	28 November 2007
Title	The Receiver Independent Exchange Format
Publisher	International GNSS Service (IGS)
Link	https://kb.igs.org/hc/en-us/article_attachments/115007665027/rinex300.pdf
Revision	3.00

2 GNSS Simulator Requirements

2.1 Simulation engine

2.1.1 GPS satellites signals

✔, **DO229-2568, 2.1.1-1,** **Must Have, STTE - GPS L1C/A general assumption**

GNSS Simulator shall be able to transmit GPS L1C/A signals in conformance with /IS-GPS-200/.

✔, **DO229-2585, 2.1.1-2,** **Must Have, STTE - GPS signal frequency**

GNSS Simulator shall generate GPS signals for L1 band for pseudo-random noise code known as the Coarse Acquisition (C/A) code.

✔, **DO229-2580, 2.1.1-3,** **Must Have, STTE - GPS constellation**

GNSS simulator shall control GPS constellation according to /DO-229/ Appendix B.

✔, **DO229-2582, 2.1.1-4,** **Must Have, STTE - GPS satellites count**

GNSS Simulator shall be capable of simulating at least 12 GPS satellites during scenario.

Note: This value corresponds to average, total number of satellites' visible over the sky without obscuration at northern hemisphere.

Note: This value does not take into account GNSS Simulator hardware requirements for channel number and any multipath effects.

✔, **DO229-2581, 2.1.1-5,** **Must Have, STTE - GPS satellite power level**

The power level of simulated GPS satellite shall be under GNSS Simulator control.

✔, **DO229-2587, 2.1.1-6,** **Must Have, STTE - GPS satellites in navigation solution**

GNSS Simulator shall be able to:

- control and limit count of GPS satellites in navigation solution (example: only 5 in view and used in solution, 6 satellites or more in view and used in solution, exactly 5 with C/A code only),
- enable and disable each GPS satellite,
- enable new GPS satellite when appears over horizon or active elevation mask angle,
- select any combination of satellites in navigation solution to control dilution of precision level: HDOP, VDOP, GDOP.

These actions shall be available:

- before scenario run
- during ongoing scenario

✔, **DO229-2777, 2.1.1-7,** **Must Have, STTE - GPS satellite integrity status**

GNSS Simulator shall be able to control GPS health status of each GPS satellite during ongoing scenario.

To do so GNSS Simulator shall control:

- URA index value
- handover word (HOW) value

- values of subframes 1, 2, 3 (specifically value of health word in subframe 1)
- preamble value (different than 0x8B)

, DO229-2840, 2.1.1-8, Nice to Have, STTE - GPS Selective Availability

GNSS Simulator shall be able to model intentional GPS satellite degradation according to the US DOD Selective Availability (SA) implementation.

, DO229-2841, 2.1.1-9, Should Have, STTE - GPS time events

GNSS Simulator shall be able to test GPS End-of-Week, week rollovers and leap second transition events.

, DO229-2689, 2.1.1-10, Should Have, STTE - GPS cross-correlation effects

GNSS Simulator shall be able to simulate GPS cross-correlation effect by ensure 3000 km separation between GPS satellite positions derived from the almanac and broadcast ephemerides.

, DO229-2666, 2.1.1-11, Must Have, STTE - Content of GPS navigation messages

The data content of transmitting GPS navigation messages (LNAV) shall be recorded by GNSS Simulator.

, DO229-2665, 2.1.1-12, Must Have, STTE - Transmission time of GPS navigation message

The transmission time of GPS navigation messages shall be recorded by GNSS Simulator.

, DO229-2698, 2.1.1-13, Must Have, STTE - GPS navigation message CRC modification

It shall be possible to modify CRC part of GPS navigation message.

, DO229-2683, 2.1.1-14, Must Have, STTE - GPS clock and ephemeris data setting

It shall be possible to set the clock (including relativistic corrections) and ephemeris data (including IODC and IODE) in the GPS navigation message (subframes 1, 2 and 3) for each GPS satellite in a scenario during its runtime phase.

, DO229-2656, 2.1.1-15, Must Have, STTE - GPS ionospheric corrections setting

It shall be possible to set the ionospheric corrections in the GPS navigation message (subframe 4) for each GPS satellite in a scenario during its runtime phase.

, DO229-2662, 2.1.1-16, Must Have, STTE - Navigation Message Correction Table

It shall be possible to set the Navigation Message Correction Table (NMCT) in the GPS navigation message (Almanac data, Subframe 4 and 5, Page 13).

2.1.2 SBAS satellites signals

, DO229-2569, 2.1.2-1, Must Have, STTE - SBAS general assumption

GNSS Simulator shall be able to transmit SBAS signals in conformance with:

- the signal-in-space format is in accordance with Appendix A of /DO229/,
- the SBAS standards and recommended practices in /Annex10 V1/.

, DO229-2570, 2.1.2-2, Must Have, STTE - SBAS function

SBAS signals shall simulate geostationary SBAS satellites to broadcast integrity, correction data and ranging signals to GPS/SBAS receiver.

, DO229-2559, 2.1.2-3, Must Have, STTE - SBAS functionality activation

It shall be possible to enable and disable SBAS functionality in a scenario during its runtime phase.

Note: It references to test procedure: /C199/-A2.2.6.7

, DO229-2571, 2.1.2-4, Must Have, STTE - SBAS service provider

Selection of different SBASs providers (WAAS, EGNOS, MSAS) shall be available by GNSS Simulator. It shall be possible to create a scenario with simultaneously simulation of two different SBASs providers.

, DO229-2566, 2.1.2-5, Must Have, STTE - SBAS satellite count

GNSS Simulator shall be capable of simulating at least 2 SBAS satellites during scenario. Number of simulated SBAS satellites shall be controlled by scenario.

, DO229-2563, 2.1.2-6, Must Have, STTE - SBAS satellite power level

The power level of simulated SBAS satellite shall be under GNSS Simulator control.

, DO229-2697, 2.1.2-7, Must Have, STTE - SBAS satellite PRN codes

It shall be possible to simulate SBAS satellites with PRN codes arbitrary selected from valid range from 120 to 158 and outside this range (e.g. 62-119, 159-210) - see Table A-4 of /DO229/ (DO229-1951 - A.4.4.2 PRN Mask Assignments Message Type 1).

Note: PRN codes: GPS 1-32, GLONASS 38-61, SBAS 120-158, SBAS QZSS 183-192, QZSS 193-202.

, DO229-2778, 2.1.2-8, Must Have, STTE - SBAS satellite integrity status

GNSS Simulator shall be able to control SBAS health status (UNHEALTHY, HEALTHY, UNMONITORED) of each SBAS satellite during ongoing scenario.

GNSS Simulator shall be able to designate SBAS/GPS satellite health status by means of setting/changing:

- UDREI in range 0..15.
- URA index in range 0..15

during ongoing scenario.

, DO229-2690, 2.1.2-9, Should Have, STTE - SBAS cross-correlation effects

GNSS Simulator shall be able to simulate SBAS cross-correlation effect by ensure 200 km separation between SBAS satellite positions derived from the almanac and broadcast ephemerides.

, DO229-2567, 2.1.2-10, Must Have, STTE - SBAS ionospheric corrections activation

It shall be possible to enable and disable SBAS ionospheric corrections in a scenario during its runtime phase.

, DO229-2558, 2.1.2-11, Must Have, STTE - Content of SBAS messages

The data content of all available transmitted SBAS messages shall be recorded by GNSS Simulator.

Note: These correction data are required for offline calculation and validation of HPL_{SBAS} , VPL_{SBAS}
Note: HPL_{SBAS} and VPL_{SBAS} are calculated according to Appendix J.

, DO229-2560, 2.1.2-12, Must Have, STTE - Transmission time of SBAS message

The transmission time of SBAS messages shall be recorded by GNSS Simulator.

, DO229-2696, 2.1.2-13, Must Have, STTE - SBAS message CRC modification

It shall be possible to modify CRC part of SBAS messages.

, DO229-2702, 2.1.2-14, Must Have, STTE - SBAS message types

GNSS Simulator shall be able to generate SBAS message types 0, 1, 2, 3, 4, 5, 6, 7, 9, 10, 17, 18, 24, 25, 26, 27 and 28.

It shall be also possible to generate message types:

- reserved for future use: 8, 11, 13-16, 19-23 or 29-63 and
- not used: 12, 62, 63

✔, **DO229-2705, 2.1.2-15, Must Have, STTE - SBAS MT 0 - Do Not Use for Safety Applications**

GNSS Simulator shall be able to generate single SBAS Message Type 0 with custom data content for specified PRN code. It shall be possible regardless of generation state of others message types 1-7, 9-10, 17-18, 24-28 for this PRN code.

✔, **DO229-2561, 2.1.2-16, Must Have, STTE - SBAS MT 0 - with MT 2 contents**

It shall be possible to send SBAS Message Type 0 with data content of Message Type 2 at specific time and for specific duration of running scenario.

Note: It references to test procedure: /C199/-A2.2.6.7

✔, **DO229-2755, 2.1.2-17, Must Have, STTE - SBAS MT 1 - PRN mask switching and assignments**

GNSS Simulator shall be able to generate the same SBAS messages with different IODPs simultaneously.

GNSS Simulator shall be able to simulate PRN mask switching during the transition period between two PRN masks (MT1) with different IODPs. The SBAS correction messages shall keep up with changing of IODPs.

✔, **DO229-2763, 2.1.2-18, Must Have, STTE - SBAS MT 2-5, 24 - Fast corrections for SBAS satellite**

GNSS Simulator shall provide fast corrections applied to each SBAS satellite range measurement used (by receiver) in position solution.

✔, **DO229-2772, 2.1.2-19, Must Have, STTE - SBAS MT 24 - Fast corrections**

GNSS Simulator shall be able to broadcast SBAS Message Type 24 if there are 6 or fewer satellites in a block (mixed correction message).

✔, **DO229-2562, 2.1.2-20, Must Have, STTE - SBAS MT 2-5 - UDREI setting capability**

It shall be possible to change User Differential Range Error Indicator (UDREI) in Fast Corrections Message Type 2, 3, 4, 5 for each GPS satellite separately. UDREI value shall be settable at specific time and for specific duration of running scenario.

Note: It references to test procedure: /C199/-A2.2.6.8

✔, **DO229-2565, 2.1.2-21, Must Have, STTE - SBAS MT 2-5 - Fast corrections for GPS pseudorange ramp errors**

GNSS Simulator shall be able to automatically compensate GPS pseudorange ramp errors for each GPS satellite separately by means of SBAS fast correction Message Type 2, 3, 4, 5 at specific time of running scenario.

Note: It references to test procedure: /C199/-A2.2.6.9

✔, **DO229-2769, 2.1.2-22, Should Have, STTE - SBAS MT 6 - Integrity Information**

GNSS Simulator shall be able to generate single SBAS Message Type 6 with $IODF_j$ that matches IODF in the associated fast correction message (MT 2-5 and 24) and modifiable data content. It shall be possible regardless of generation timing of message types 2-5 and 24.

, DO229-2775, 2.1.2-23, Must Have, STTE - SBAS MT 7 - Fast Correction Degradation Factor

GNSS Simulator shall be able to generate SBAS Message Type 7 with declared system latency time (t_{iat}) and the fast correction degradation factor indicator (ai_i) for each of 51 satellites.

, DO229-2776, 2.1.2-24, Must Have, STTE - SBAS MT 9 - GEO Navigation Message

GNSS Simulator shall be able to generate SBAS Message Type 9 with GEO navigation information. It shall contain SBAS satellite orbit information to determine the location of each SBAS satellite being tracked by receiver.

, DO229-2796, 2.1.2-25, Must Have, STTE - SBAS MT 10 - Degradation Factors

GNSS Simulator shall be able to generate SBAS Message Type 10 with declared degradation factors as described in /DO229/ Table A-9.

, DO229-2779, 2.1.2-26, Must Have, STTE - SBAS MT 17 - GEO Almanacs

GNSS Simulator shall be able to broadcast periodically SBAS Message Type 17 with almanac data for at least two SBAS satellites (if available) above the minimum mask angle.

, DO229-2948, 2.1.2-27, Should Have, STTE - SBAS MT 17 - GEO Almanacs for different SBAS providers

GNSS Simulator shall be able to generate Message Type 17 that contains an almanac data of SBAS satellite from a different SBAS service than sender (case with simultaneously simulation of two different SBASs providers).

, DO229-2794, 2.1.2-28, Must Have, STTE - SBAS MT 18 - Ionospheric Grid Point Masks

GNSS Simulator shall be able to broadcast SBAS Message Type 18 with the mask definition of ones and zeros that indicate which grid point (IGP) have an associated ionospheric delay given in Message Type 26. Each grid point shall identify latitude and longitude for each correction in the associated Message Type 26.

, DO229-2949, 2.1.2-29, Should Have, STTE - SBAS MT 18 - Ionospheric Grid Point Masks with different IODI

GNSS Simulator shall be able to generate corrections with different IODI simultaneously during the transition period between masks.

, DO229-2795, 2.1.2-30, Must Have, STTE - SBAS MT 26 - Ionospheric Grid Point Delays

GNSS Simulator shall be able to broadcast SBAS Message Type 26 with vertical delay and GIVEI for each grid point defined by Message Type 18.

It shall be possible to change IODI of MT26 independently with IODI setting in MT18.

, DO229-2787, 2.1.2-31, Must Have, STTE - SBAS MT 25 - Long Term Corrections

GNSS Simulator shall be able to broadcast SBAS Message Type 25 with the long-term clock and ephemeris corrections for all GPS satellites and for all SBAS satellites operated by different SBAS provider than the satellite providing corrections.

Note: Message Type 9 is used to prevent slow varying SBAS satellite errors. For example, WAAS does not broadcast Message Type 25 for WAAS satellites, but it could broadcast them for EGNOS and MSAS satellites.

, DO229-2788, 2.1.2-32, Must Have, STTE - SBAS MT 25 - Validation for GPS satellite

It shall be possible to change the Issue of Data (SBAS IOD) for each GPS satellite and Time-of-Day Applicability (t_0) in MT25 .

, DO229-2791, 2.1.2-33, Must Have, STTE - SBAS MT 25 - Aging

GNSS Simulator shall be able to generate long-term correction based on the old ephemeris for a specific time after the GPS broadcast ephemeris has changed.

, DO229-2789, 2.1.2-34, Must Have, STTE - SBAS MT 25 - Suspension

It shall be possible to suspend broadcasting of Message Type 25.

, DO229-2564, 2.1.2-35, Must Have, STTE - SBAS MT 25 - Long term corrections for GPS offset clock errors

GNSS Simulator shall be able to automatically compensate GPS satellite offset clock errors for each GPS satellite separately by means of SBAS long term corrections in Message Type 25 with velocity code 0 at specific time of running scenario.

Note: It references to test procedure: /C199/-A2.2.6.9

, DO229-2782, 2.1.2-36, Must Have, STTE - SBAS MT 27 - SBAS Service Message

GNSS Simulator shall be able to broadcast SBAS Message Type 27 with δUDRE factors for characterization of residual errors specific to geographic regions. Message Type 27 shall allow to define an arbitrary region and associated degradation of performance.

GNSS Simulator shall be able to simulate IODS switching driven by changing content of Message Type 27. The SBAS service messages shall keep up with changing of IODS.

Note: Message Type 27 is optional on the part of SBAS providers (WAAS and MSAS do not broadcast this message).

, DO229-2610, 2.1.2-37, Must Have, STTE - SBAS MT 28 - Clock-Ephemeris Covariance Matrix

GNSS Simulator shall be able to broadcast Message Type 28 to provide the relative covariance matrix for clock and ephemeris errors within defined region of applicability.

It shall be possible to change IODP of MT28 independently with IODP setting in MT1.

, DO229-2784, 2.1.2-38, Must Have, STTE - SBAS Message Broadcast Intervals

GNSS Simulator shall be able to generate SBAS messages with broadcast intervals as defined by Table A-25 of /DO229/ (DO229-2950 - A.4.7 Timing).

GNSS Simulator shall adjust the maximum fast correction broadcast interval to ensure that fast corrections (MT 2-5 and 24) do not time-out prematurely (function of fast corrections degradation factor broadcast in MT7, DO229-1929 - A.4.4.5 Fast Correction Degradation Factor Message Type 7).

Generation schedule shall ensure that valid SBAS message will be generated at least one time per 4 seconds - required for approach LNAV/VNAV, LP, LPV.

, DO229-2785, 2.1.2-39, Must Have, STTE - SBAS Combining Data from Separate Message Broadcasts

GNSS Simulator shall be able to generate corrections and integrity data for all simulated satellites derived from the same SBAS signal (PRN code) - required for approach LNAV/VNAV, LP, LPV.

GNSS Simulator shall be able to generate:

- the fast correction, and
- variance σ^2_{UDRE} (the accuracy of combined fast and long-term error corrections), and
- long-term corrections, and
- ionospheric correction, and

- variance σ^2_{GIVE} (accuracy of the ionospheric delay corrections), and
- fast correction degradation factor δUDRE, and
- any Type 10 message degradation factors data

for each simulated individual GPS and SBAS satellite derived from the same SBAS signal (PRN code).

2.1.3 Additional satellites signals

, DO229-2797, 2.1.3-1, Must Have, STTE - Galileo E1 general assumption

GNSS Simulator shall be able to transmit Galileo E1 signals in conformance with /OS SIS ICD/.

, DO229-2941, 2.1.3-2, Should Have, STTE - Galileo E5 general assumption

GNSS Simulator shall be able to transmit Galileo E5 signals in conformance with /OS SIS ICD/.

, DO229-2936, 2.1.3-3, Should Have, STTE - GPS L1C general assumption

GNSS Simulator shall be able to transmit GPS L1C signals in conformance with /IS-GPS-800/.

, DO229-2937, 2.1.3-4, Should Have, STTE - GPS L2C general assumption

GNSS Simulator shall be able to transmit GPS L2C signals in conformance with /IS-GPS-200/.

, DO229-2938, 2.1.3-5, Should Have, STTE - GPS L5 general assumption

GNSS Simulator shall be able to transmit GPS L5 signals in conformance with /IS-GPS-705/.

, DO229-2939, 2.1.3-6, Should Have, STTE - QZSS L1C/A general assumption

GNSS Simulator shall be able to transmit QZSS L1C/A signals in conformance with /IS-QZSS-PNT/.

2.1.4 Constellation geometries

, DO229-2751, 2.1.4-1, Must Have, STTE - Dilution Of Precision availability

Simulator GNSS shall provide value of:

- Vertical Dilution of Precision (VDOP)
- Horizontal Dilution of Precision (HDOP)
- Geometric Dilution of Precision (GDOP)
- Position Dilution of Precision (PDOP)

of active (visible) constellation.

, DO229-2774, 2.1.4-2, Must Have, STTE - Elevation mask

GNSS Simulator shall be able to control mask angle. It is a fixed elevation angle referenced to the user's horizon below which satellites are ignored by the receiver software.

, DO229-2768, 2.1.4-3, Nice to Have, STTE - Satellite constellation freeze mode

This is an experimental mode. It is not a mandatory option.

GNSS Simulator should generate satellite constellation for certain moment of time with satellite velocities set to zero and the satellite positions are to be frozen at the values for the selected geometry.

This ensures that HPL will not change during the run.

Note: This requirement may be necessary for testing offline FDE algorithms. Further investigation is required.

2.1.5 Trajectory and platform dynamics

, DO229-2814, 2.1.5-1, Must Have, STTE - Motion model

GNSS Simulator shall be supplied with 6DoF motion modelling (X, Y, Z, pitch, yaw, roll).

, DO229-2843, 2.1.5-2, Must Have, STTE - Lever arm effect in trajectory

GNSS Simulator shall generate trajectories centered on the aircraft vehicle itself. GNSS Simulator shall also support additional dynamics and positional offsets due to specified antenna placement (lever arm).

, DO229-2813, 2.1.5-3, Must Have, STTE - Predefined trajectories

GNSS Simulator shall be supplied with a set of predefined trajectories, e.g. circular, racetrack, fixed (static).

, DO229-2807, 2.1.5-4, Should Have, STTE - Airborne trajectory creator/editor

GNSS Simulator shall be able to enter and edit 6DoF motion trajectory of simulated object.

GNSS Simulator shall be supplied with a set of predefined maneuvers: straight, turn, climb, accelerate.

, DO229-2773, 2.1.5-5, Must Have, STTE - Airborne trajectory from user motion file

GNSS Simulator shall be able to use trajectory information from external file in ASCII/CSV or /NMEA/ format.

Note: Format file shall be subject of discussion. CSV, NMEA.

Note: Lever-arm effects due to antenna positioning shall be handled automatically.

, DO229-2815, 2.1.5-6, Nice to Have, STTE - Hardware-in-the-loop capability

GNSS Simulator shall be able to input of aircraft trajectory information in real-time. Trajectory data can be supplied asynchronously via remote connection.

Note: Lever-arm effects due to antenna positioning shall be handled automatically.

Note: The system latency in closed-loop is defined by separate performance requirement.

, DO229-2790, 2.1.5-7, Must Have, STTE - Example of trajectory

GNSS Simulator shall be able to reflect, numerically or by means of dedicated editor, trajectories presented below.

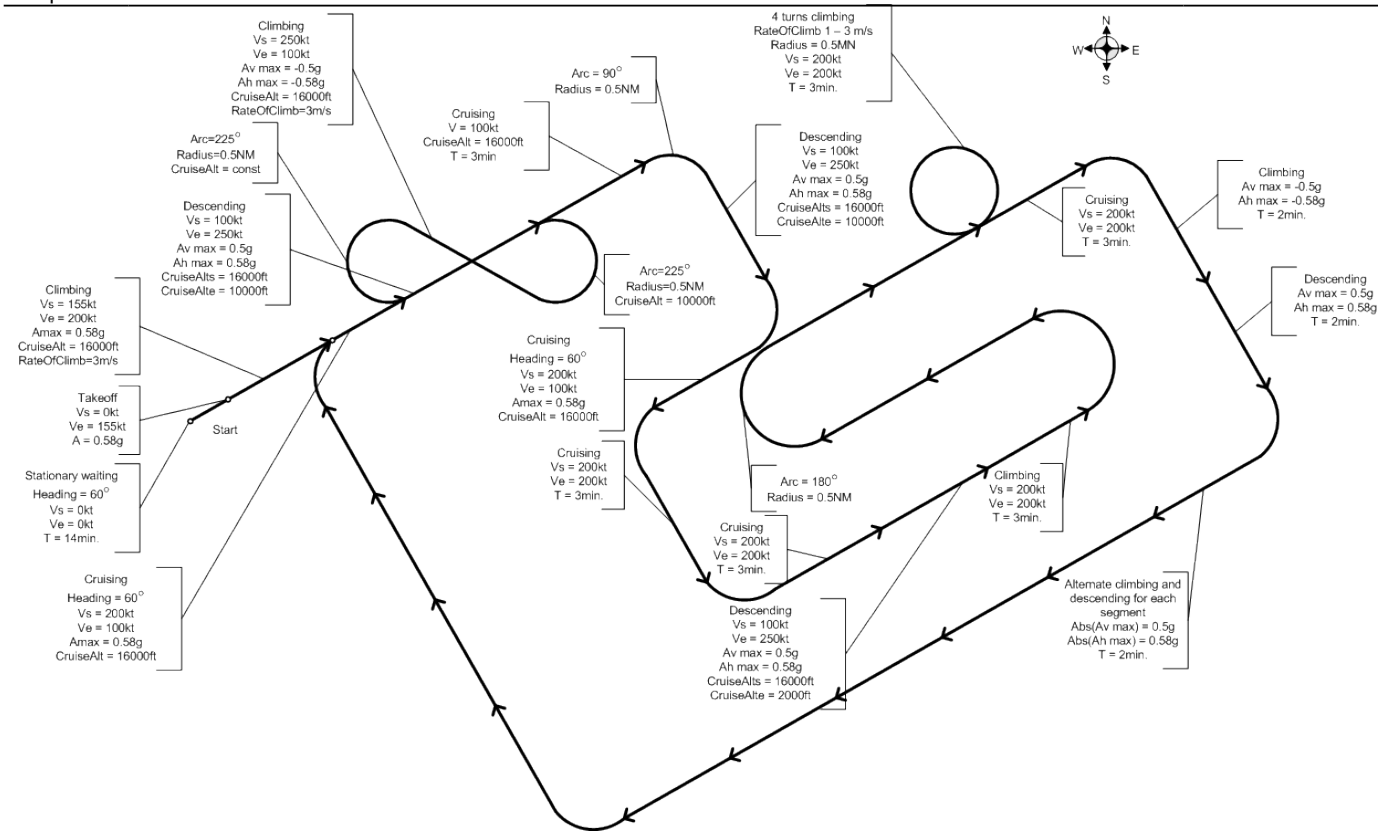

Figure 1 Example of trajectory for static and dynamic flight scenario

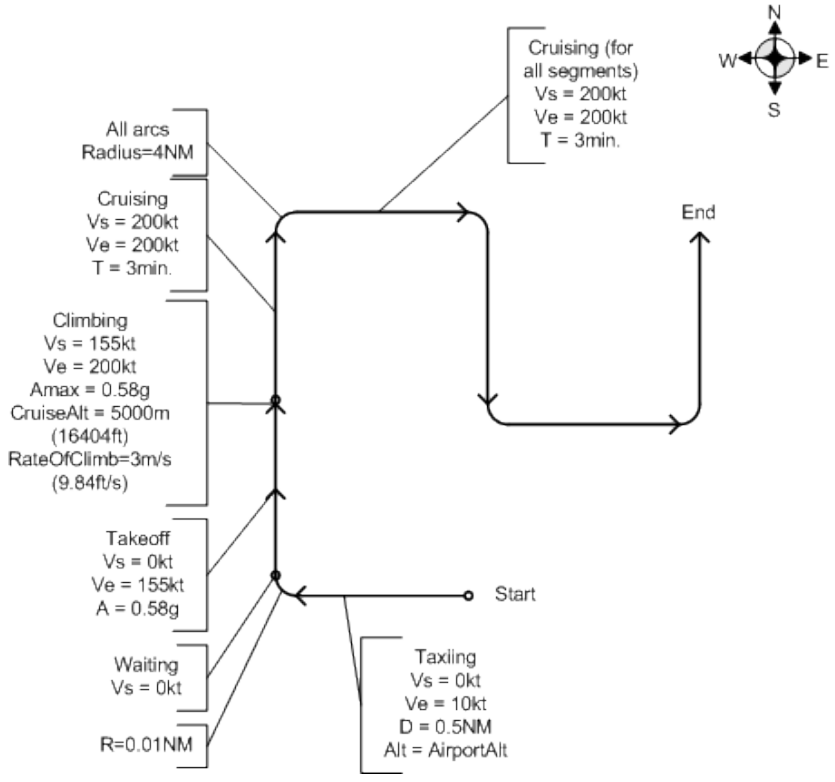

Figure 2 Example of basic trajectory

✔, **DO229-2771, 2.1.5-8,** ❗ **Must Have, STTE - Normal and abnormal maneuvers**

GNSS Simulator shall be supplied with airborne trajectory models.

GNSS Simulator shall be able to simulate aircraft object with dynamic specified as below:

Table 1 Dynamic of aircraft object

Navigation Mode	Type of maneuvers	Ground Speed	Horizontal Acceleration	Vertical Acceleration	Total Jerk
En Route and Terminal Mode	Normal maneuvers	800 kt	0.58 g	0.5 g	0.25 g/s
	Abnormal maneuvers	800 kt	2 g	1.5 g	0.74 g/s
LNAV, LNAV/VNAV, LPV, LP	Normal maneuvers	250 kt	0.58 g	0.5 g	0.25 g/s
	Abnormal maneuvers	250 kt	2 g	1.5 g	0.74 g/s

GNSS Simulator shall take into account acceleration and jerk limits.

g = acceleration of gravity = 9.8 m/s2.

, DO229-2951, 2.1.5-9, Should Have, STTE - Dynamic limitations

GNSS Simulator shall ensure that motion/maneuvers don't exceed defined limits (velocity, acceleration, jerk).

Dynamic limitations for determined objects (velocity, acceleration, jerk) shall be applied and regulated.

, DO229-2770, 2.1.5-10, Should Have, STTE - Horizontal velocity accuracy test - ETSO-C199 (AC 20-138D)

GNSS Simulator shall be able to simulate platform dynamics for the horizontal velocity accuracy test as defined in table:

Table 2 Platform Dynamics for Horizontal Velocity Accuracy Test (table source AC 20-138D Appendix 4)

Time (s)		Dynamics	Start Jerk (g/s)				End Jerk (g/s)			
From	To		North	East	Down	Total	North	East	Down	Total
0	T	Static	0	0	0	0	0	0	0	0
T+1	T+71	0.58g longitudinal acceleration to 411 m/s	0.xx *Note 1*	0.xx *Note 1*	0	0.25	0.xx *Note 1*	0.xx *Note 1*	0	0.25
T+72	T+129	Straight un-accelerated flight	0	0	0	0	0	0	0	0
T+130	T+194	-0.45g longitudinal acceleration to 125 m/s	0.xx *Note 1*	0.xx *Note 1*	0	0.2	0.xx *Note 1*	0.xx *Note 1*	0	0.2
T+195	T+254	Straight un-accelerated flight	0	0	0	0	0	0	0	0
T+255	T+325	turn 180° with 0.58g lateral acceleration	0.xx *Note 1*	0.xx *Note 1*	0	0.25	0.xx *Note 1*	0.xx *Note 1*	0	0.25
T+326	T+420	Straight un-accelerated flight	0	0	0	0	0	0	0	0

Note 1: The components of the jerk in the north and east direction depends on the heading chosen in the scenario.

The total jerk is not to exceed the vector combination of north, east, and down jerk components. The maximum total jerk to quickly achieve the desired dynamics should be used, but the jerk should not exceed the normal maneuver total jerk requirement of 0.25 g/s.
Note 2: The table and defined maneuver is an example. It would be recommended to define typical aircraft behaviors during all stages of flight (example: taxiing, take-off, flight maneuvers: constant altitude, climbing at 3°, etc.)

2.1.6 Signal propagation

2.1.6.1 Ionospheric corrections

, DO229-2842, 2.1.6.1-1, Must Have, STTE - Ionospheric corrections

GNSS Simulator shall allow selection of ionospheric delay correction model such as Klobuchar.

Note: Other models are also acceptable.

2.1.6.2 Tropospheric corrections

, DO229-2557, 2.1.6.2-1, Must Have, STTE - DO-229 Tropospheric Delay Correction Model

GNSS Simulator shall allow selection of tropospheric delay correction model defined by /DO229/ Appendix A, Section A.4.2.4.

Note: It references to test procedure: /C199/-A2.2.6.3

2.1.6.3 Multipath, terrain and earth obscuration

, DO229-2844, 2.1.6.3-1, Must Have, STTE - Multipath

GNSS Simulator shall support multipath modelling by simulating the impact of the local environment on satellite signals (reception of reflected signals).

Note: The following environment models are acceptable:

- *analytical modification of signal parameters in a controlled way (pseudorange offset, power loss, Doppler shift, carrier phase offset, etc.) OR*
- *3D environment representation based on 3-dimensional synthetic model.*

, DO229-2845, 2.1.6.3-2, Nice to Have, STTE - Terrain obscuration

GNSS Simulator shall include terrain obscuration model to simulate the temporary and intermittent masking of the satellite signals when manoeuvring at low altitude in urban, suburban or mountainous terrain.

GNSS Simulator shall be supplied with a set of predefined obscurations like canyons, mountains, flats, undulations.

2.1.7 Noise injection

, DO229-2798, 2.1.7-1, Must Have, STTE - Gaussian Noise injection

GNSS Simulator shall be able to produce additive Gaussian Noise (AWGN) to model realistic C/No on its RF output. Gaussian Noise shall be generated regardless of interference generation.

, DO229-2971, 2.1.7-2, Must Have, STTE - Broadband GNSS test noise

The GNSS Simulator shall be able to generate Broadband GNSS test noise ($I_{GNSS,Test}$) of spectral density equal to -172.4 dBm/Hz +5/-10 dB at the antenna port (see: Note 1) (the contribution of simulated satellites has been removed for the specified noise density).

The Broadband GNSS test noise shall have a bandwidth greater than the RF bandwidth of the equipment under test.

Note 1: RF signal path attenuation of GNSS Simulator with all necessary accessories shall be taken into account when adjusting GNSS test noise ($I_{GNSS,Test}$) spectral density.

2.1.8 Error simulation

, DO229-2556, 2.1.8-1, Must Have, STTE - GPS satellite offset clock errors (ephemeris errors)

It shall be possible to set GPS satellite offset clock error corresponding to offset clock error correction δa_{f0} for each GPS satellite separately at specific time of a scenario.

Note: It references to test procedure: /C199/-A2.2.6.9

, DO229-2803, 2.1.8-2, Must Have, STTE - GPS/SBAS automatic compensations

The system shall be able to generate automatically proper SBAS fast and long term corrections. It also shall reflect injected malfunctions of GPS satellites ramp errors, step errors. A clear and documented way of SBAS settings shall be available for a user. It shall be able to suspend automatic work of SBAS domain during ongoing scenario.

2.1.8.1 Step error generation

, DO229-2554, 2.1.8.1-1, Must Have, STTE - Method of pseudorange step generation

GNSS Simulator shall be able to generate sudden change of pseudorange (called a step error) of value at least 750 meters at any selected GPS satellite at specific time and for specific duration of running scenario by means of two methods:

1. sudden change in code phase,
2. a change of navigation data.

It shall be possible to remove (previously applied) step error at specific time of running scenario.

*Note: This requirement may be crucial for **TSO-C199** full compliance where A2.2.6.4 test is implemented.*

*Note: In **ETSO-C199** A2.2.6.4 test is removed and marked as reserved.*

Note: When a step is introduced by changing the broadcast ephemeris data, the pseudorange step does not occur until after receipt of a second set of the broadcast ephemeris (per Section /DO229/ 2.1.1.2).

2.1.8.2 Ramp error generation

, DO229-2555, 2.1.8.2-1, Must Have, STTE - Pseudorange ramp errors

It shall be possible to generate ramp-shape pseudorange errors: at least 10.0 meters/second with resolution at least 0.1m/s for each GPS satellite separately at specific time of running scenario with defined rate and for determined duration.

It shall be possible to remove (previously applied) ramp error at specific time of running scenario.

2.1.9 Jamming simulation

, DO229-2862, 2.1.9-1, Must Have, STTE - Jamming simulation

GNSS Simulator shall support the jamming of GNSS receiver by means of simulation ground based jammers. Jamming simulation shall allow creation of jamming transmitters defined by their location (fixed and dynamic), antenna pattern, signal type, and power levels.

GNSS Simulator shall enable to inject custom jammer signal specified by IQ data file.

GNSS Simulator shall provide jamming as RF signal.

2.1.10 Spoofing simulation

, DO229-2850, 2.1.10-1, Must Have, STTE - Spoofing simulation

GNSS Simulator shall support the spoofing of GNSS receiver by means of:

- generation of 2 independent aircraft trajectories (authentic and spoofed),
- generation of multiple copies of an original constellation for manipulating orbital parameters or modification of navigation messages,
- creation of spoofing transmitters defined by their location (fixed and dynamic), antenna pattern, spoofing signals, and power levels.

GNSS Simulator shall provide spoofing as RF signal.

2.1.11 Receiver antenna modelling

, DO229-2846, 2.1.11-1, Must Have, STTE - Receiver antenna pattern

GNSS Simulator shall support modelling the receiver antenna pattern in terms of gain and phase with selectable resolution in both azimuth and elevation angles.

GNSS Simulator shall be able to load receiver antenna pattern from external file in ASCII/CSV format.

, DO229-2847, 2.1.11-2, Nice to Have, STTE - On-vehicle obscuration

GNSS Simulator shall mimic effects of the free-space reception pattern and the on-vehicle obscuration of the aircraft body.

The antenna pattern shall be fully linked to the aircraft trajectory, allowing automatic simulation of masking of satellite signals due to vehicle obscuration during manoeuvres. This shall be also supported during operation in HIL mode.

, DO229-2848, 2.1.11-3, Nice to Have, STTE - Antenna placement and orientation

GNSS Simulator shall model antenna placement (lever arm offset) in reference to the center-of-motion and antenna angular orientation with respect to the aircraft body frame

, DO229-2579, 2.1.11-4, Nice to Have, STTE - Minimum Standard Antenna Frequency Selectivity

Interfering signals shall be attenuated according to /DO229/ Appendix C.3 (DO229-1998 - C.3 Minimum Standard Antenna Frequency Selectivity). This requirement is valid for signals received by a minimum standard antenna.

2.2 Hardware specification

, DO229-2832, 2.2-1, Must Have, STTE - Standalone operation

GNSS Simulator shall be a standalone equipment, operated autonomously.

, DO229-2801, 2.2-2, Must Have, STTE - Hardware scalability/modularity

GNSS Simulator shall be extensible by additional RF/SW modules to provide RF channels and computational power.

, DO229-2857, 2.2-3, Nice to Have, STTE - Chassis type

GNSS Simulator shall be designed to be rack-mounted in 19-inch rack (fastened to the rack frame with screws using rack ears or dedicated mounting bracket).

, DO229-2859, 2.2-4, Nice to Have, STTE - Dimensions

Maximal dimensions (width x height x depth) shall not exceed:

Table 3 Maximal dimensions

Dimension	Metric [mm]	Imperial [inch]
Maximum Width	762	30
Maximum Height	762	30
Maximum Depth	762	30

, DO229-2856, 2.2-5, Nice to Have, STTE - Weight

Weight of GNSS Simulator shall not exceed 30kg.

, DO229-2854, 2.2-6, Must Have, STTE - Power input condition

GNSS Simulator shall be supplied with power input:

- Input Voltage Range: 220 to 240VAC,
- Input Frequency Range: 50 to 60Hz.

, DO229-2952, 2.2-7, Should Have, STTE - Power consumption condition

GNSS Simulator shall have power consumption less than 1 kW.

, DO229-2855, 2.2-8, Must Have, STTE - Environmental conditions

GNSS Simulator shall operate properly in following environmental conditions:

- Operating Temperature Range: +10°C to +30°C,
- Storage Temperature Range: -10°C to +50°C,
- Humidity 10% to 60% (non-condensing).

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2.3 RF front end

, DO229-2969, 2.3-1, Must Have, STTE - Integrated High-Level RF Interferer connection

If GNSS Simulator is equipped with an integrated signal combiner dedicated for external high-level RF interference signals, insertion loss from RF Interferer input to common RF equipment output shall not exceed 1 dB.

, DO229-2786, 2.3-2, Must Have, STTE - RF signal level

For GNSS Simulator **with** integrated signal combiner as specified by DO229-2969 - Integrated High-Level RF Interferer connection, GNSS Simulator shall be able to provide Nominal RF signal level between [-133.0 and -123.0] dBm.

For GNSS Simulator **without** integrated signal combiner as specified by DO229-2969 - Integrated High-Level RF Interferer connection, GNSS Simulator shall be able to provide Nominal RF signal level between [-113.0 and -103.0] dBm (see: Note 1)

Note 1: The 20 dB reserve is necessary to compensate attenuation of an external directional coupler

Note 2: Exact RF level can be achieved (shifted) by means of external elements such as RF attenuators, etc..

Note 3: Spoofing and jamming simulations are not subject of this requirement.

, DO229-2968, 2.3-3, Must Have, STTE - RF signal level adjustment range and resolution

GNSS Simulator shall be able to provide Nominal RF signal adjustment in range at least +/- 20 dB.

RF signal level setting resolution shall be 0.25 dB or smaller.

, DO229-2967, 2.3-4, Must Have, STTE - RF signal level accuracy

The absolute accuracy of RF signal level shall be at least +/- 0.5 dB.

, DO229-2965, 2.3-5, Must Have, STTE - Non-Harmonic Spurious level

The Non-Harmonic Spurious level of RF signal shall be better than -45 dBc.

, DO229-2964, 2.3-6, Must Have, STTE - RF Harmonics level

The Harmonic products on RF signal output shall not exceed -40 dBc.

, DO229-2970, 2.3-7, Must Have, STTE - Phase Noise

Phase Noise shall not exceed +/- 0.02 rad RMS.

2.4 Performance

, DO229-2800, 2.4-1, Must Have, STTE - Signal simulation capability

GNSS Simulator shall able to service GPS, Galileo and SBAS signals with:

- multipath effects or
- spoofing and jamming functionality.

, DO229-2802, 2.4-2, Must Have, STTE - Computation power scalability

GNSS Simulator shall have capability to expand its computation power for increased number of simulated signals.

Note: Intention of this requirement is to provide an additional hardware capability to service a new constellation with spoofing or multipath effects without radical change of hardware base (e.g: change the setup to next generation simulator). Adding a new constellation would be done by installation a new hardware extension card or enabling

software licence in existing setup.

, DO229-2811, 2.4-3, Must Have, STTE - Simulation Iteration Rate (SIR)

Simulation Iteration Rate (SIR) of GNSS Simulator shall be not less than 100 Hz.

Note: SIR means the rate at which GNSS Simulator can update the RF signal (aircraft motion and satellites) parameters.

, DO229-2831, 2.4-4, Nice to Have, STTE - RF signal latency

GNSS Simulator shall generate the change in motion input to RF output with the latency not greater than 10ms.

Note: Important for HIL (closed loop simulation)

, DO229-2809, 2.4-5, Must Have, STTE - Pseudorange accuracy

Pseudorange Accuracy of GNSS Simulator shall be less than ±0.01m.

2.5 Scenario edition

, DO229-2963, 2.5-1, Must Have, STTE - Scenario edition

GNSS Simulator shall have capability to edit entire test scenario and set wide range of possible configuration.
The user-defined scenario shall be able to control and modify all available simulation parameters.

, DO229-2810, 2.5-2, Must Have, STTE - Simulation time

Simulation time of GNSS Simulator shall not be limited.

Note: This requirement is not applicable for IQ data recording.

, DO229-2762, 2.5-3, Should Have, STTE - Power relations of satellite in a scenario

GNSS Simulator shall be able to set and change any (in simulators's range) combination of satellite powers during running scenario.

, DO229-2838, 2.5-4, Nice to Have, STTE - Input files

GNSS Simulator shall be able to load, parse and use external defined navigation data:

- GPS Almanac File (navcen.uscg.gov)
- GPS Ephemeris Broadcast File (cddis.nasa.gov)
- SBAS WAAS NSTB File (nstb.tc.faa.gov)
- SBAS EGNOS EMS File (egnos-user-support.essp-sas.eu)

, DO229-2817, 2.5-5, Must Have, STTE - Log output files generation

GNSS Simulator shall be able to create and store:

- almanac log file as an ASCII file format complied with e.g YUMA, SEM formats (see IS-GPS-870),
- navigation message log file (e.g. in /RINEX/, /NMEA/ format),
- satellites data file.

, DO229-2947, 2.5-6, Must Have, STTE - RINEX version compatibility

GNSS Simulator shall be able to process navigation data compliant with /RINEX/ in version at least 3.00.

, DO229-2946, 2.5-7, Must Have, STTE - NMEA version compatibility

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GNSS Simulator shall be able to process navigation data compliant with /NMEA/ in version at least 4.00.

, DO229-2808, 2.5-8, Must Have, STTE - IQ files generation and playback

GNSS Simulator shall be able to stream and store IQ data in a real-time to an external file. IQ data shall be accessible in a raw form (e.g. 16-bit IQ samples in binary format) and available for numerical analysis or for feeding other RF Signal Generators.

Duration of IQ recording shall not be limited in time (only limited by capacity of local storage).

Additionally IQ file metadata could be generated according to GNSS SDR Metadata Standard.

2.6 Connectors and interfaces

, DO229-2858, 2.6-1, Must Have, STTE - RF connector

GNSS Simulator shall provide a composite signal of all simulated satellites to one RF output connector.

, DO229-2943, 2.6-2, Must Have, STTE - Pulse Per Second connectors

GNSS Simulator shall provide Pulse Per Second signal to separate PPS output connector. PPS signal shall be synchronized with 1 seconds epochs in simulated time.

GNSS Simulator shall be also equipped with PPS input connector to supply external pulse synchronization.

Note: Period 1 s, TTL Level.

, DO229-2944, 2.6-3, Should Have, STTE - Synchronization connectors

GNSS Simulator shall provide internal frequency reference to separate Synchronization output connector.

GNSS Simulator shall be also equipped with Synchronization input connector to connect an external frequency reference.

Note: Impedance 50 Ohm, 10MHz sine/square wave.

, DO229-2942, 2.6-4, Nice to Have, STTE - Trigger connector

GNSS Simulator shall be equipped with Trigger input connector to start a simulation from an external trigger signal.

Note: Impedance 50 Ohm, TTL Level

, DO229-2852, 2.6-5, Must Have, STTE - LAN connection

GNSS Simulator shall include LAN connection interface used to remote control operation.

, DO229-2849, 2.6-6, Must Have, STTE - Receiver data input

GNSS Simulator shall include a communication port that inputs navigation and other performance data from a receiver via series of messages in the /NMEA/ standard. Port properties (baud rate, stop bits, parity) shall be settable.

Receiver's data shall be presented and processed by GNSS Simulator.

2.7 Control

, DO229-2837, 2.7-1, Must Have, STTE - Local control

GNSS Simulator shall be controlled locally via Graphical User Interface by means of combinations of data editing/entry/display windows, graphs, plots and tables. Local Control shall be separated from the simulation engine.

, DO229-2835, 2.7-2, Must Have, STTE - Script

It shall be possible to run test scenario by means of script file from the local or remote location. Script file shall allow the same GUI actions to be replayed in a specified sequence.

, DO229-2836, 2.7-3, Must Have, STTE - Remote control

It shall be able to control the GNSS Simulator remotely. Remote Control shall be available via flexible Application Programming Interface (API) commands prepared for software/script developers. Preferred languages such as Python, C#, C++, or dedicated internal script language.

, DO229-2833, 2.7-4, Must Have, STTE - Remote Desktop Connection

It shall be possible to connect with GNSS Simulator by Remote Desktop Connection via e.g. RDP, VNC etc. (in local area network).

, DO229-2834, 2.7-5, Should Have, STTE - Software only mode - no hardware

It shall be possible to operate GNSS Simulator in software only mode (without hardware access, for IQ generation).
Note: In software only mode, RF signal is not generated and IQ or raw logging data is saved (also in in real time, useful when developing automation scripts).

, DO229-2839, 2.7-6, Should Have, STTE - Multi-instance run

GNSS Simulator shall be provided with a license(s) permitting two engineers to work simultaneously (at the same time): first at GNSS Simulator, second at local workstation (using Software only version).

2.8 Technical support, documentation and trainings

, DO229-2828, 2.8-1, Must Have, STTE - Technical support

GNSS Simulator shall be supplied with a two years technical support including software updates, e-mail and phone software/application support.

, DO229-2853, 2.8-2, Must Have, STTE - Documentation

GNSS Simulator shall be provided with:

- User Guide,
- Interface Control Document (ICD) (Offline documentation database is strongly welcome),
- Script Examples (Examples, good programming practices).

, DO229-2827, 2.8-3, Nice to Have, STTE - Technical trainings

GNSS Simulator shall be provided with a technical trainings including:

1. Getting Started with GNSS Simulator (setup and configure).
2. Hands-on training for setting up and using GNSS Simulator.
3. Typical and advanced test scenario configuration.

2.9 Calibration, warranty and licenses

, DO229-2830, 2.9-1, Must Have, STTE - Calibration service

GNSS Simulator shall be delivered with calibrated hardware to ensure quality measurements and traceability. Calibration certificate/authentication shall be available. Terms and re-calibration period/cost shall be specified.

, DO229-2829, 2.9-2, Must Have, STTE - Warranty

GNSS Simulator shall be supplied with a two years hardware and software warranty.

, DO229-2851, 2.9-3, Must Have, STTE - License(s) expiration

GNSS Simulator shall be supplied with perpetual license(s).