# EGNOS/GALILEO ECALL CONFORMANCE TESTING IN EU COMMISSION DELEGATED REGULATION 2017/79

eCall

## Implementation guidelines for On-Board Unit manufacturers, test solution vendors and technical centres


European Global Navigation Satellite Systems Agency

GALILEO EGNOS NAVIGATION SOLUTIONS POWERED BY EUROPE

European Commission JOINT RESEARCH CENTRE

## NATURE OF THE GUIDELINES – TERMS AND CONDITIONS OF USE

- The following document provides indicative/non-binding guidelines for a possible testing configuration (i.e. definition of scenario, test set-up, etc.) implementing requirements of Commission Delegated Regulation 2017/79 (hereinafter "the Regulation").
- The GSA and JRC acknowledge that several alternative testing configurations and implementations can be compliant with the Regulation, hence the non-prescriptive non-binding nature of this document.
- The only purpose of these guidelines is to facilitate the testing implementation for the device manufacturers, test solutions vendors and technical services.
- The GSA and JRC do not provide any guarantee, expressed or implied, of the guidelines' compliance with the Regulation or their fitness for any purpose.
- The implementation of these guidelines is at the sole risk and responsibility of the user.
- The GSA and JRC disclaim any and all liability arising out of or in connection with such implementation.
- The structure of the document follows that of the Annex VI "Technical requirements for compatibility of eCall in-vehicle systems with the positioning services provided by the Galileo and the EGNOS systems" of the Commission Delegated Regulation (EU) 2017/79 in order to facilitate its readability. Nevertheless, it is not meant to integrate, complement or supersede, in whole or in part, the Regulation and its Annex VI.

**For questions and further information**

**market@gsa.europa.eu**

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# LIST OF ACRONYMS

| | |
|---|---|
| **DUT** | Device Under Test |
| **GGA (NMEA)** | GNSS System Fix Data |
| **GNSS** | Global Navigation Satellite System |
| **GPS** | Global Positioning System |
| **GSA** | European GNSS Agency |
| **GSA (NMEA)** | GNSS DOP and Active Satellites |
| **GSV (NMEA)** | GNSS Satellites in View |
| **JRC** | European Commission Joint Research Centre |
| **LNA** | Low Noise Amplifier |
| **NMEA** | National Marine Electronics Association |
| **OBU** | On-Board Unit |
| **OS** | Open Service |
| **PDOP** | Point Dilution of Precision |
| **PL** | Power Level |
| **PVT** | Position Velocity and Time |
| **RINEX** | Receiver Independent Exchange Format |
| **RMC (NMEA)** | Recommended Minimum Specific GNSS Data |
| **SBAS** | Satellite Based Augmentation System |
| **SV** | Space Vehicle |
| **TLE** | Two Line Elements |
| **TTFF** | Time To First Fix |
| **VTG (NMEA)** | Course Over Ground and Ground Speed |

# INTRODUCTION

In view of the upcoming entry into force of the Commission Delegated Regulation 2017/79 [1] on 31 March 2018, the European GNSS Agency (GSA) has launched an eCall testing campaign, inviting all interested eCall device manufacturers, such as Tier-1 suppliers, to have their eCall products that are enabled with the European Geostationary Navigation Overlay System (EGNOS) and Galileo satellite navigation systems tested with respect to their compatibility with this Regulation. This campaign is currently on-going in the EU Global Navigation Satellite System (GNSS) testing labs of the European Commission Joint Research Centre (JRC), in its Ispra (Italy) site.

In support of this activity, JRC has set-up a laboratory test bed for the eCall testing including a suite of test scenarios to evaluate the performance of the eCall Devices Under Test (DUT). The recent completion of the first batch of testing sessions on various samples of eCall devices has made it possible to fine-tune the eCall laboratory test-bed and the suite of scenarios used in the GNSS simulator.

Given the experience obtained by implementing these test scenarios and acknowledging the fact that manufacturers of both eCall devices and eCall testing solutions are going through a similar process at this stage, the GSA and JRC have agreed to make available, under the terms and conditions specified in “Nature of the guidelines – terms and conditions of use”, on page 2, a set of implementation guidelines aimed at sharing the lessons learnt so far and facilitating the implementation of the eCall testing by the technical centres in charge of issuing the EC type-approval for the eCall On-Board Units (OBU).

The implementation guidelines are provided to illustrate how the requirements stated in Annex VI of the eCall Regulation might be translated in practice into a suite of test scenarios. The proposed implementation is for illustrative/indicative purpose only. The way in which the test methods are defined in the Regulation is intentionally open to a number of correct implementations.

The core of the present report has been structured in two main sections, which strictly follow the structure of Annex VI of the Commission Delegated Regulation 2017/79 [1]. The first section facilitates the understanding of the technical requirements which are laid down in Section 1 of Annex VI. The second section provides implementing guidelines, recommendations and concrete examples of how to build one possible eCall test configuration compliant with the applicable regulation in Section 2 of Annex VI. In addition, the document includes a third section summarizing the main findings of the campaign collected so far and two annexes providing further details, the first one focusing on the algorithm to compute the statistics of the horizontal position error and the second one providing the ephemerides dataset for both Galileo and GPS constellations, as used in the tests at the JRC.

**IMPORTANT NOTE**

Since the test campaign is still on-going, the current version of this document may be subject to revision. If necessary, the GSA and JRC reserve the right to integrate additional findings in a second version of this document which will be published on the GSA website before the entry into force of the Commission Delegated Regulation 2017/79 (31 March 2018).

# 1 IMPLEMENTING GUIDELINES ON THE "TECHNICAL REQUIREMENTS"

This section provides a set of considerations regarding the technical requirements specified in Section 1 of Annex VI of the eCall Regulation [1].

## 1.1 General considerations on "Compatibility requirements"

The eCall Device Under Test (DUT) shall be compatible with the Galileo system (ref. Annex VI, Section 1.1.1) and the EGNOS system (ref. Annex VI, Section 1.1.2).

### 1.1.1 Galileo system compatibility

The Galileo system compatibility requires the eCall DUT to be able to receive and process the Galileo Open Service (OS) signals [2] transmitted over the bands **E1**, **E5a** and **E5b**. Ideally the pilot signal components shall be received and processed as well, to improve the overall performance.

| | |
|---|---|
| **Note:** | The tests defined in the eCall Regulation [1] only verify compatibility with a single frequency band (Galileo E1 and GPS L1). |
| **Verification method:** | The requirement is verified by applying the test procedure specified in Sect. 2.2.1 of Annex VI [1] and, more specifically, by parsing the GSA messages in the National Marine Electronics Association (NMEA) logs and checking that Galileo satellites are present and used in the position solution. Additionally, it is also checked that the eCall DUT logs the messages in accordance with the standard NMEA-0183 [3] [4]. |

### 1.1.2 EGNOS system compatibility

The EGNOS system compatibility requires the eCall DUT to be able to receive the corrections from the EGNOS Open Service (OS) signals [5] transmitted over the **L1** band and their actual application to the GNSS signals (GPS).

| | |
|---|---|
| **Verification method:** | The requirement is verified by applying the test procedure specified in Sect. 2.2.1 of Annex VI [1], in particular by parsing the GGA messages in the NMEA logs and checking that field #6 in the GGA messages is set to 2. |

## 1.2 General considerations on "Performance requirements"

### 1.2.1 NMEA-0183 compliance

This requirement is verified by applying the test procedure specified in Sect. 2.2.1 of Annex VI [1], in particular, parsing the NMEA logs and checking that the messages RMC, GGA, VTG, GSA and GSV are present and are formatted in accordance with the standard NMEA-0183 [3] [4].

### 1.2.2 Single GNSS operational mode

The eCall DUT capability of providing a fix when operating in single frequency (L1/E1) and single GNSS constellation mode (at least including Galileo and GPS) is verified by means of the test procedure described in Sect. 2.2.1 of Annex VI [1], parsing the NMEA logs and checking that either GPS or Galileo satellites are respectively present in the GSA messages.

### 1.2.3 Multi GNSS combined operational mode (GPS, Galileo and SBAS)

This requirement is verified by applying the test procedure specified in Sect. 2.2.1 of Annex VI [1], in particular by parsing the NMEA logs and checking that both Galileo and GPS satellites are present in the GSA messages, and that the field #6 in the GGA messages is set to 2.

### 1.2.4 Use of WGS-84 datum

This requirement is verified by applying the test procedure specified in Sect. 2.2.1 of Annex VI [1], in particular by parsing the NMEA logs and checking that the height above the geoid reported in the field #11 of the GGA messages is corresponding to the WGS-84 Datum.

### 1.2.5 Horizontal position error limits

This requirement is verified by means of the test procedures specified in Sects. 2.2.2, 2.2.3 and 2.2.4 of Annex VI [1].

This requirement sets the upper limits of the overall horizontal position error for open sky conditions and urban canyon conditions. The two operational conditions are characterized in terms of PDOP and are verified according to the table below.

| Test procedure | Open sky condition PDOP [2.0 - 2.5] | Urban canyon condition PDOP [3.5 - 4.0] |
|---|---|---|
| Sect. 2.2.1 – NMEA-0183 messages output test | ✔ | |
| Sect. 2.2.2 – Assessment of positioning accuracy in autonomous static mode | ✔ | |
| Sect. 2.2.3 – Assessment of positioning accuracy in autonomous dynamic mode | ✔ | |
| Sect. 2.2.4 – Dynamic scenario with urban canyons and intermittent reception of the navigation signals | | ✔ |
| Sect. 2.2.5 – Cold Start TTFF | ✔ | |
| Sect. 2.2.6 – Reacquisition time of tracking signals after block out of 60 seconds | ✔ | |
| Sect. 2.2.7 – Receiver sensitivity in cold start mode, tracking mode and reacquisition scenario | ✔ | |

### 1.2.6 Vehicle dynamics

This requirement is verified in the test scenarios specified in Sects. 2.2.3 and 2.2.4 of Annex VI [1].

During execution of the tests, the full range specified for both speed and linear acceleration should ideally be simulated.

The parameters defined for speed and acceleration are to be combined with the additional requirements specified in Tables 3 and 4 of Annex VI [1], for the dynamic scenario and the dynamic scenario in an urban canyon with intermittent reception of navigation signals, respectively.

### 1.2.7 Cold start time to first fix

This requirement is verified by means of the test scenario specified in Sect. 2.2.5 of Annex VI [1], where the average Time To First Fix (TTFF) of the eCall DUT is assessed at two different signal power levels to check that the TTFF does not exceed the upper limits.

### 1.2.8 GNSS signal re-acquisition time after temporary outage

This requirement is verified in the test scenario specified in Sect. 2.2.6 of Annex VI [1], where the average re-acquisition time after a 60-second temporary outage is assessed.

### 1.2.9 Sensitivity requirement

This requirement is verified in the test scenario specified in Sect. 2.2.7 of Annex VI [1], where the sensitivity of the eCall DUT is evaluated, checking that it can provide a navigation solution with the three specified signal power levels: -144 dBm, -155 dBm and -150 dBm.

# 2 IMPLEMENTING GUIDELINES ON THE "TEST CONDITIONS AND TEST PROCEDURES"

This Section provides a set of considerations and recommendations regarding both the test conditions and test procedures specified in Section 2 of Annex VI of the eCall Regulation [1].

## 2.1 Test conditions

### 2.1.1 eCall test object

According to Section 2.1.1 of Annex VI [1] *"The test objective is the eCall, which includes a GNSS receiver and a GNSS antenna, specifying navigation characteristics and features of the tested system."*

Taking into account that in most cases the eCall devices integrated into a vehicle will use an active antenna (i.e., with an LNA integrated), it is suggested to consider the eCall module under test or eCall test object (i.e. *eCall* box in Figures 2 and 5 of Annex VI [1]) as the ensemble of the OBU and an LNA, as illustrated in Figure 1 below.

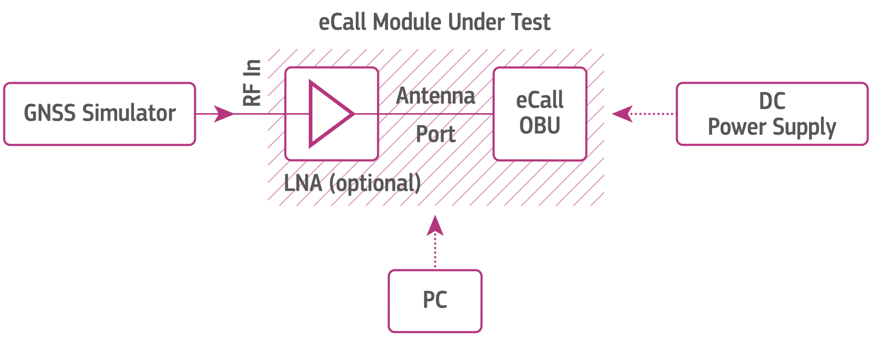


Figure 1: Breakdown of Figure 2 Annex VI [1] – eCall Module Under Test.

### 2.1.2 Number of eCall test samples

According to Section 2.1.2 of Annex VI [1] *"The number of the eCall test samples shall be at least 3 pieces and can be tested in parallel."*

### 2.1.3 eCall test provisions

According to section 2.1.3 of Annex VI [1] *"The eCall is provided for the test with the installed SIM-card, operation manual and the software (provided on electronic media)."*

Considering the actual purpose of the eCall testing, we recommend the eCall object to be accompanied by:

- An installed *SIM-card*, only if the eCall object to be tested is represented by the entire unit and not just the receiver, for which the SIM is not needed. In any case, internet access should be disabled in order to avoid the use of GNSS assistance, which could be inconsistent with the simulated scenarios.
- An *operational manual*, related to the eCall unit to be tested, which provides basic information about the eCall object handling.
- The *software (provided on electronic media)*, which might be needed by the test centre to operate (e.g. Cold start commands) the eCall object.

**TABLE 1 – RECOMMENDED LIST OF MEASUREMENT INSTRUMENTS, TEST AND AUXILIARY EQUIPMENT**

The list of measurement instruments given in Table 1 of Annex VI [1] is recommended, and it is acknowledged that there are multiple variants of test equipment providing the required performance.

As regards the vector network analyser, it is suggested to select a unit that is able to characterise the RF path loss in the GPS L1 and Galileo E1 frequency bands.

## 2.2 Test procedures

This section goes through all the test procedures specified in Annex VI [1] and for each of them presents a set of implementing guidelines. In addition, some example scenarios meeting the requirements set in the test procedures specified in Annex VI [1] are described.

### 2.2.1 NMEA-0183 messages output test

The objective of the test scenario is to verify the compliance of the eCall DUT interface with the NMEA standard [3] [4]. For this test scenario, the configuration of the GNSS signal simulator is specified in Table 2 of Annex VI [1], considering the fact that the presence of the GPS, Galileo and SBAS satellites needs to be verified.

For the sake of simplicity, it is also suggested to use the requirements set for the static scenario specified in Sect. 2.2.2 of Annex VI and combine the two tests.

After having recorded the NMEA logs from the eCall DUT for the entire duration of the test scena rio, there are four main checks to be made:

- Verify that the RMC, GGA, VTG, GSA and GSV messages, are output at least at a 1 Hertz frequency for the entire duration of the test scenario.
- Parse the RMC messages and check that location of the test scenario is at a land point within the latitude range 80$^0$S – 80$^0$N (as specified in Table 2 [1]).
- Check that messages RMC, GGA, VTG, GSA and GSV are present and are formatted in accordance with the standard NMEA-0183 [3] [4], with both GPS and Galileo satellites present.
- Parse the GGA messages and check that the field #6 in the GGA messages is set to 2. This flag represents the actual usage of SBAS corrections.

An example of a NMEA GGA message setting the field no. 6 to 2 would be as follows:
$GNGGA,212930.00,6739.15127,N,02238.49558,E, **2** ,06,1.10,25.2,M,25.2,M, ,0000*79

**ACTIVATION OF THE SIMULATED CORRECTIONS**

When using a GNSS simulator that allows the configuration of a grid mask to specify the geographical region where the corrections are applicable, it is important to activate the corrections in the region where the test scenario is located. This setting is particularly relevant when the test scenario is located at high latitudes near the Polar/Antarctic Regions, where the default configuration of the test scenario may have the SBAS corrections disabled [5].

In addition, when selecting the eCall location, it is essential to consider the actual geographical coverage of the simulated SBAS system(s).

### 2.2.2 Assessment of positioning accuracy in autonomous static mode

The objective of the test scenario is to verify the positioning accuracy performance of the unit, when operating in static mode in open sky conditions.

The test procedure specified in Sect. 2.2.2 of Annex VI [1] requires the execution of three separate sub-scenarios under different test conditions regarding the satellites that are in view, namely:

i. Combined constellation with Galileo, GPS and SBAS
ii. Single constellation with Galileo (see requirement in Sect. 2.2.2.15)
iii. Single constellation with GPS/SBAS (see requirement in Sect. 2.2.2.16)

In any of the three test conditions specified above, the maximum overall horizontal position error with a 95% confidence level must be below 15 metres. A detailed procedure facilitating the calculation specified in Sects. 2.2.2.6 to 2.2.2.17 of Annex VI is given in Appendix A, along with some illustrative sample results.

The detailed specifications of the test scenario in Sect. 2.2.2 are given in Table 2 of Annex VI [1], which includes a few points that deserve some attention and that are discussed below.

## SIGNAL POWER LEVELS SETTINGS IN THE GNSS SIMULATOR

Given that the specifications on the signal power levels are common for all satellites in view for a given GNSS constellation, the signal levels of the satellites may be modelled as a constant value, not dependent on the actual distance between the satellite and the user location.

Regarding the configuration of the signal power level of the OS signal of Galileo in the E1 frequency band [2], the **power values specified for the Galileo OS** can be understood as those of the **GAL 1B** (i.e. data channel) and **GAL 1C** (i.e., pilot channel) components **separately**.

As an example, for a Power Level (PL) of -135 dBm of the Galileo OS, the GNSS simulator can be configured such that $PL_{E1C} = PL_{E1B}$ = -135 dBm.

The above consideration is particularly relevant in the test scenario specified in Sect. 2.2.7 of Annex VI [1], where the sensitivity of the eCall DUT is assessed.

**Simulated satellites by constellation**

Noting that the requirements set in Annex VI [1] clearly specify stringent constraints for the PDOP, that in all the scenarios has to be above 2.0, it is therefore advised to have a high number of satellites in the constellations so that it is possible to control the PDOP by switching off some Space Vehicles (SV) during certain time periods, while keeping the number of SVs in view as specified in the requirements (i.e., 6 GPS, 6 Galileo and 2 SBAS).

As an example, the total number of satellites in the GPS and Galileo constellations used in the test scenarios developed at the JRC is, respectively, 31 and 27. These two constellations have SVs distributed in six and three orbital planes, respectively. The detailed ephemeris data of the constellations used are provided in Annex B, both as Two Line Elements (TLE) and Receiver Independent Exchange Format (RINEX) v3.0 datasets.

## PDOP BY CONSTELLATION

Regarding the PDOP limits set in test scenarios specified in Sects. 2.2.2 to 2.2.7 of Annex VI, the actual PDOP target value can be understood as the one observed by the user when having in visibility a single GNSS constellation, which is either the GPS or Galileo constellation, separately.

SBAS satellites are assumed to be used exclusively as a communication channel to receive the corrections, therefore they are not used for ranging and are not accounted for the estimation of the PDOP.

The practical implementation of the test scenario in Sect. 2.2.2 of Annex VI [1] entails the selection of a set of 6 satellites per constellation giving a PDOP in the range between 2.0 and 2.5 during the entire duration of the scenario. A possible approach is to look for the best set of 6 satellites out of all those available from a given location. As the PDOP will vary as a function of the time, this optimal set of 6 satellites will have to be re-calculated with a certain temporal frequency (e.g., in a range of between 10 to 20 minutes). The number of possible sets of 6 satellites may be very large[1] and, for that reason, an ad-hoc optimisation tool has been developed at the JRC.

This optimisation tool uses an orbit propagator giving the precise location of the satellites in view from a given location on the ground at any given time. The orbit propagator that has been used is well-known and is based on a simplified perturbations model [6], which can ingest the satellite ephemeris data in the TLE format. Here, an open-source implementation of the SGP4 orbit propagator written in Python has been used in combination with a PDOP optimisation script written in Matlab. This optimisation script has provided as a result the optimal set of satellites in view to meet the set PDOP requirements.

As an example, the results of an optimisation to have a PDOP between 2.0 and 2.5 are shown in Figures 2 and 3. The geographical location of the vehicle that has been chosen is at 67.5° N and 22.5° E. This relatively high latitude was chosen so as to be able to find sets of 6 SVs giving a PDOP in the specified range. In this case, a test scenario with an extended duration of 3 hours has been used.

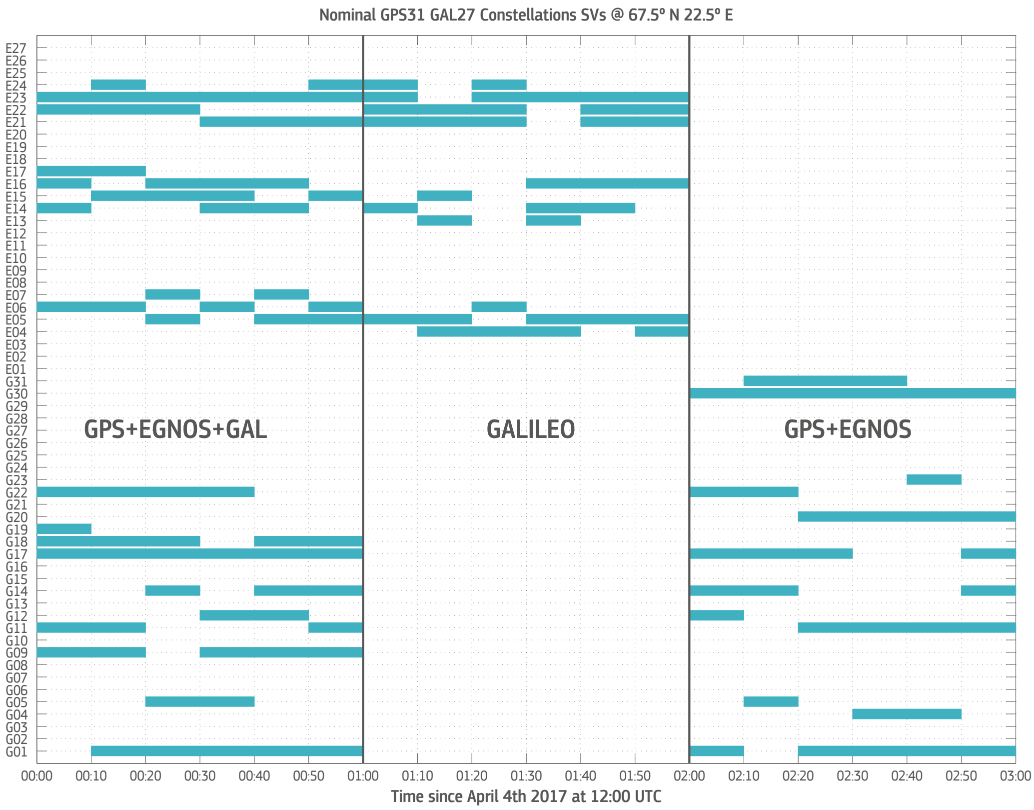


**Figure 2: Set of satellites in view giving an average PDOP in the 2.0–2.5 range for a scenario lasting 3 h, divided into three sub-scenarios of 60 min each having, respectively, 6 SVs GPS plus 6 SVs GAL, 6 SVs GAL, and 6 SVs GPS in view.**

1 If there are, say, 11 satellites of a given GNSS constellation in view at a certain location, there will be $\binom{11}{6}$ = 462 possible sets.

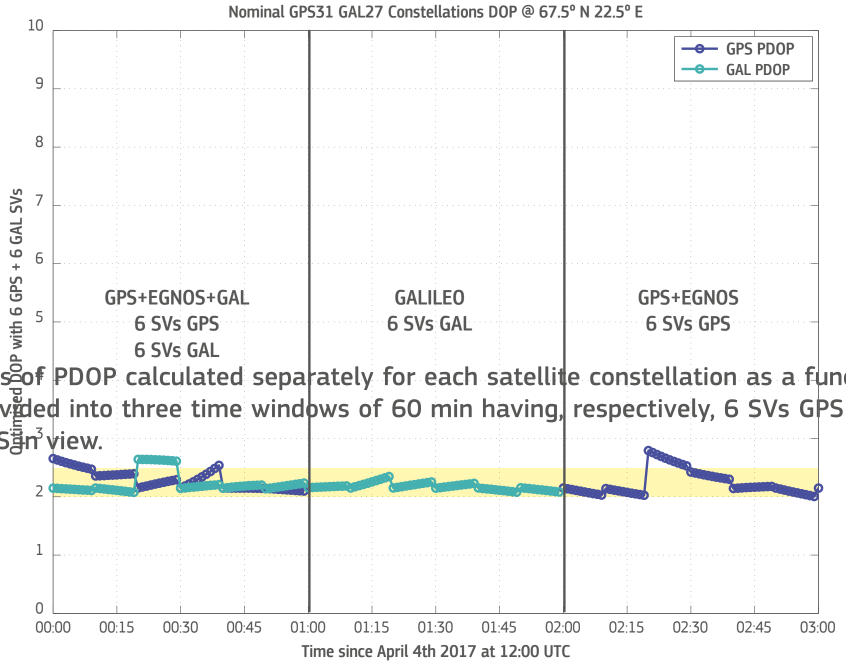


**Figure 3: Observed values of PDOP calculated separately for each satellite constellation as a function of time for a scenario lasting 3 h, divided into three time windows of 60 min having, respectively, 6 SVs GPS plus 6 SVs GAL, 6 SVs GAL, and 6 SVs GPS in view.**

This scenario consists of a sequence of three sub-scenarios, each having a different combination of constellations in view, such as specified in Table 2 of Annex VI [1]. Here, the solution of having a unique and longer scenario has been chosen to facilitate a seamless transition to the Galileo only sub-scenario, without the need to send a cold start command to the eCall DUT.

It goes without saying that another valid option would be to have three independent sub-scenarios executed separately. It can be seen that the observed PDOP values per constellation are, on average during the 60 min time window, well within the 2.0–2.5 range. The strategy adopted to keep the observed PDOP within this range for the entire duration of the scenario is to refresh the set of satellites in view regularly, once every 10 min.

### 2.2.3 Assessment of positioning accuracy in autonomous dynamic mode

The objective of the test scenario is to verify the positioning accuracy performance of the unit, when moving along a pre-defined trajectory (with specified ranges of speed and accelerations) in open sky conditions.

The test procedure specified in Sect. 2.2.3 of Annex VI [1] requires the simulation of one single test condition regarding the satellites that are in view, namely:

i. combined constellation with Galileo, GPS and SBAS

Under these test conditions, the maximum overall horizontal position error with a 95% confidence level must be below 15 meters. A detailed procedure facilitating its calculation is given in Appendix A, showing some illustrative sample results.

**Vehicle trajectory:**

The performance requirements in Sect. 1.2.6 and the additional requirements on the vehicle trajectory in the dynamic scenarios specified in Sects. 2.2.3 and 2.2.4 of Annex VI [1] can be summarised as follows:

- Maximum linear velocity of 140 km/h
- Maximum linear acceleration of 2G, with G being the gravitational constant
- Inclusion of a turn along a circular path of radius 500 meters and a turning acceleration of 0.2 $m/s^2$, which implies a velocity of 10 m/s
- Inclusion of a section in the trajectory with a halt period at zero velocity
- Inclusion of a section in the trajectory with constant velocity at zero acceleration.

An example of a vehicle trajectory meeting the above requirements is shown in Figure 4.

The proposed trajectory consists of two turns along an elongated oval aligned in the North/South direction. The trajectory is split into four sectors, with the last one ending with a sudden 2G deceleration event (i.e., reducing the speed from 140 km/h to 0 in 2.0 seconds). The specifications of the length, velocity, acceleration, and travel time of each section of this trajectory are summarised in Table 1.

For the sake of illustration, the observations of the heading angle and velocity of the vehicle extracted from the VTG messages of the NMEA logs of the GNSS simulator are shown in Figure 5.

Excluding the halt periods at the beginning and end of the trajectory, the overall travel time and distance along this vehicle trajectory are, respectively, 49.3 minutes and 53665.2 meters. Needless to say that there are a number of alternative trajectories that may differ significantly from this example while still being fit for purpose.

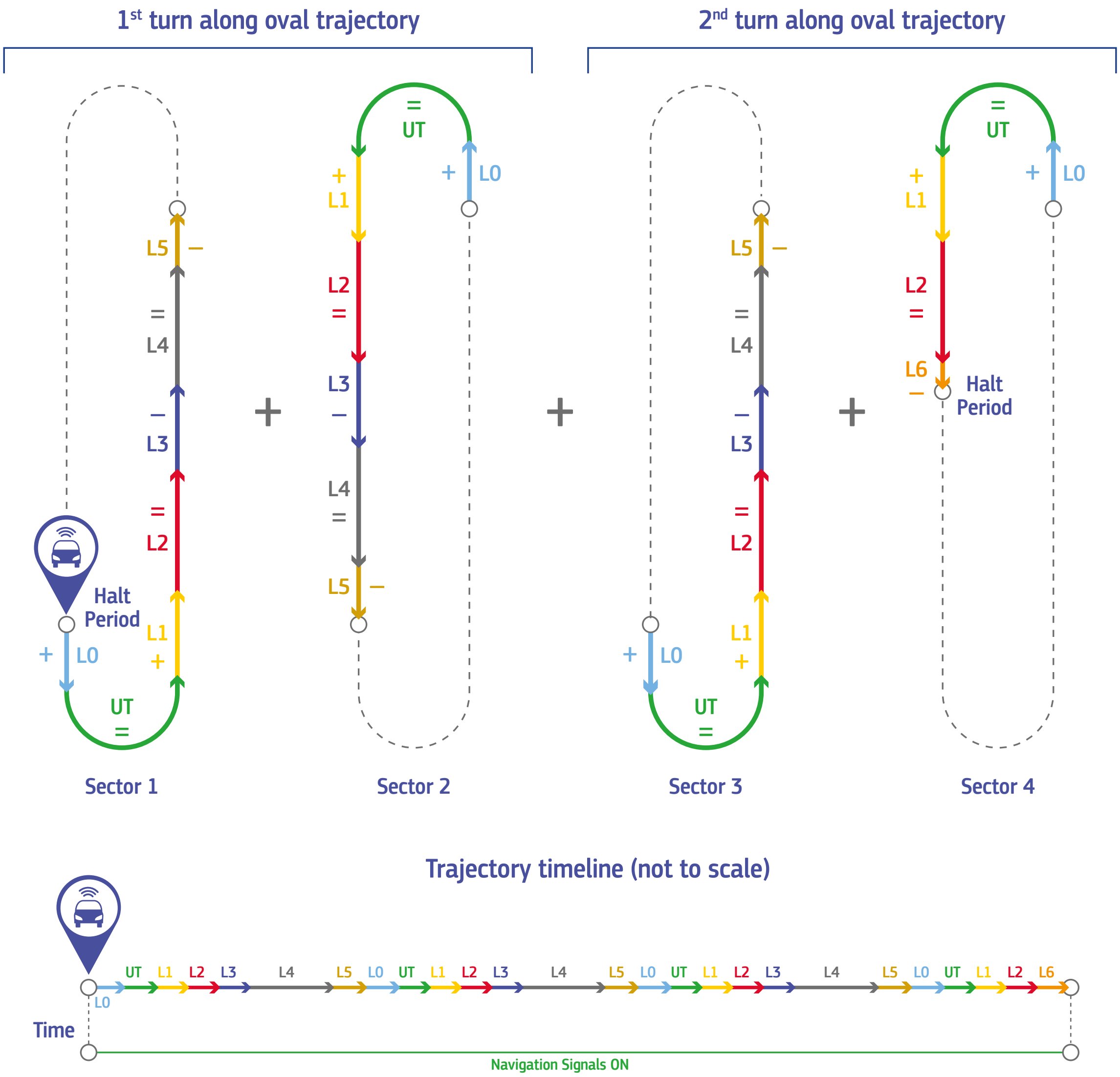


Figure 4: Sketch of a possible open sky vehicle trajectory to be used in the dynamic scenario specified in Sect. 2.2.3 of Annex VI [1], and the associated timeline indicating the time series of all the trajectory sectors involved.

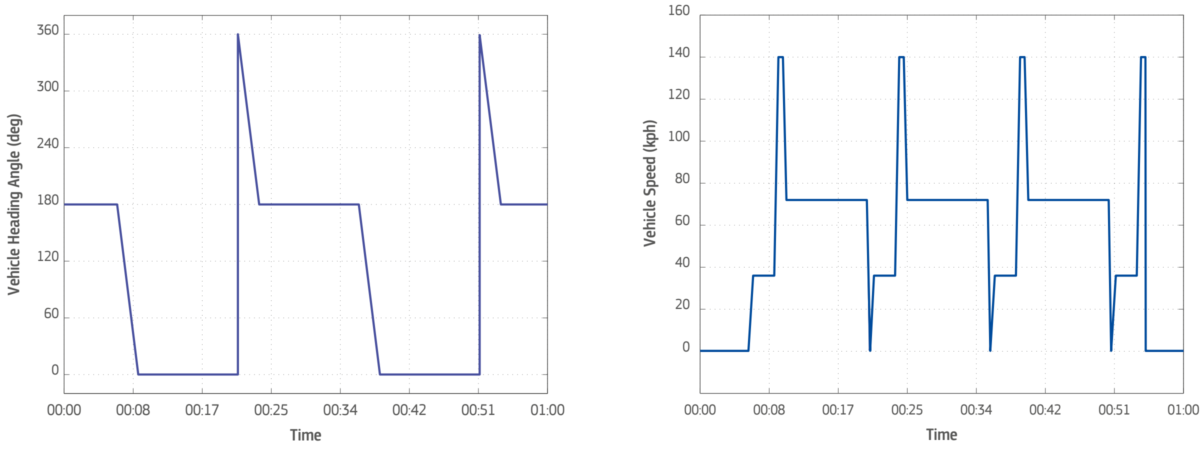


**Figure 5: True heading angle (left) and vehicle speed (right) extracted from the VTG messages in the NMEA logs created by the GNSS simulator for the dynamic scenario in open sky.**

**PDOP optimisation**

This test scenario does not include any sub-scenario with a single GNSS constellation in view, like the previous one in Sect. 2.2.2. Therefore, it is possible to simply re-use the results of the PDOP optimisation with the combined constellations in view (i.e., 6 GPS, plus 6 Galileo, plus 2 EGNOS satellites) corresponding to the first sub-scenario of Figure 2.

### 2.2.4 Movement in shadow areas, areas of intermittent reception of navigation signals and urban canyons

The objective of the test scenario is to verify the positioning accuracy performance of the unit, when moving along a pre-defined trajectory (with specified ranges of speed and accelerations) in an urban canyon characterised by shadow areas and intermittent signal reception.

The test procedure specified in Sect. 2.2.4 of Annex VI [1] requires the simulation of one single test condition regarding the satellites that are in view, namely:

i. Combined constellation with Galileo, GPS and SBAS

The test procedure presents four main differences with respect to the previous dynamic scenario in open sky conditions:

[1] The enforced PDOP range is higher, from 3.5 to 4.0.

[2] The vehicle is driving in an urban canyon that is simulated with the antenna mask specified in Sect. 2.2.4.2 of Annex VI [1].

[3] The satellite visibility in this scenario has to include sequences of intervals where navigation signals are visible and absent for, respectively, 300 and 600 seconds. This requirement is set to emulate the presence of long tunnels in the vehicle's trajectory.

Under these test conditions, the maximum overall horizontal position error with a 95% confidence level must be below 40 metres. A detailed procedure facilitating its calculation is given in Appendix A, with some illustrative sample results.

**Vehicle trajectory:**

The requirements on the turning acceleration, linear acceleration range, and velocity range remain unchanged with respect to the previous scenario, therefore the trajectory specified in Section 2.2.3 can be reused.

In addition, sectors lasting 600 seconds characterised by a complete navigation signal outage should be included, which alternate with signal visibility intervals lasting 300 seconds. This is illustrated in Figure 6, where a dynamic trajectory with three outages of the navigation signals lasting exactly 600 seconds is shown. These three sectors are labelled as L4, where the vehicle is driving a distance of 12 km at a constant speed of 20 m/s.

**PDOP optimisation:**

It is important to note that the orientation of this trajectory is not casual and has been chosen so that 84% of the time the vehicle is moving in a North/South direction either upwards or downwards. This facilitates the analysis of the observed PDOP in the dynamic scenario with the vehicle in an urban canyon, with the antenna mask specified in Sect. 2.2.4.2 of Annex VI [1]. Indeed the PDOP optimisation for the dynamic scenario in shadow areas should also take into account the impact of the antenna mask.

| | Trajectory Section | Length (m) | Speed (km/h) | Acceleration ($m/s^2$) | | Travel Time (s) |
|---|---|---|---|---|---|---|
| | | | | Linear | Radial | |
| | Halt Period | 0 | 0 | 0 | 0 | 320 |
| Sector 1 | L0 | 174 | Increase | +0.29 | 0 | 34.70 |
| | UT | 1570.8 | 36 | 0 | 0.2 | 157.08 |
| | L1 | 750 | Increase | +0.94 | 0 | 30.68 |
| | L2 | 1350 | 140 | 0 | 0 | 34.71 |
| | L3 | 750 | Decrease | -0.74 | 0 | 25.47 |
| | L4 | 12000 | 72 | 0 | 0 | 600 |
| | L5 | 174 | Decrease | -1.15 | 0 | 17.35 |
| Sector 2 | L0 | 174 | Increase | +0.29 | 0 | 34.70 |
| | UT | 1570.8 | 36 | 0 | 0.2 | 157.08 |
| | L1 | 750 | Increase | +0.94 | 0 | 30.68 |
| | L2 | 1350 | 140 | 0 | 0 | 34.71 |
| | L3 | 750 | Decrease | -0.74 | 0 | 25.47 |
| | L4 | 12000 | 72 | 0 | 0 | 600 |
| | L5 | 174 | Decrease | -1.15 | 0 | 17.35 |
| Sector 3 | L0 | 174 | Increase | +0.29 | 0 | 34.70 |
| | UT | 1570.8 | 36 | 0 | 0.2 | 157.08 |
| | L1 | 750 | Increase | +0.94 | 0 | 30.68 |
| | L2 | 1350 | 140 | 0 | 0 | 34.71 |
| | L3 | 750 | Decrease | -0.74 | 0 | 25.47 |
| | L4 | 12000 | 72 | 0 | 0 | 600 |
| | L5 | 174 | Decrease | -1.15 | 0 | 17.35 |
| Sector 4 | L0 | 174 | Increase | +0.29 | 0 | 34.70 |
| | UT | 1570.8 | 36 | 0 | 0.2 | 157.08 |
| | L1 | 750 | Increase | +0.94 | 0 | 30.68 |
| | L2 | 1350 | 140 | 0 | 0 | 34.71 |
| | L6 | 38.0 | Decrease | -19.90 [2G] | 0 | 1.95 |
| | Halt Period | 0 | 0 | 0 | 0 | 320 |
| | Total | 53665.2 | | | | 3600 |

300 seconds (Sector 1 L5 to Sector 2 L3)

300 seconds (Sector 2 L5 to Sector 3 L3)

**Table 1: Length, velocity, acceleration and travel times of a dynamic trajectory in open sky meeting the requirements set in Annex VI.**

*Note: red numbers are required to be compliant with the main parameters specified in Table 3 of Annex VI [1], whereas numbers in blue are required for compliance with the additional parameters for satellite visibility specified in Table 4 of Annex VI [1].*

The adopted strategy is to keep the number of satellites in view fixed to 6 like in the static scenario, keeping 5 SVs out of the B and C antenna mask regions (see Sect. 2.2.4.2 of Annex VI [1]) and 1 SV in view within those mask regions. Optimising this set of satellites in view makes it possible to meet the requirement to observe a PDOP within the range 3.5–4.0.

The results of the PDOP optimisation for this scenario are summarised in Figures 7 and 8. As in the previous case, it can be seen that the observed PDOP values per constellation for this scenario are again, on average during the 60 min time window, well within the range 3.5–4.0.

The sky plot associated with this scenario is shown in Figure 9, where it is clearly visible that most of the satellites in view are outside the antenna mask regions B and C. More precisely, the optimisation has been made in such a way that only one SV from each constellation at a time is within the antenna mask regions B and C, and the remaining 5 are all outside those regions.

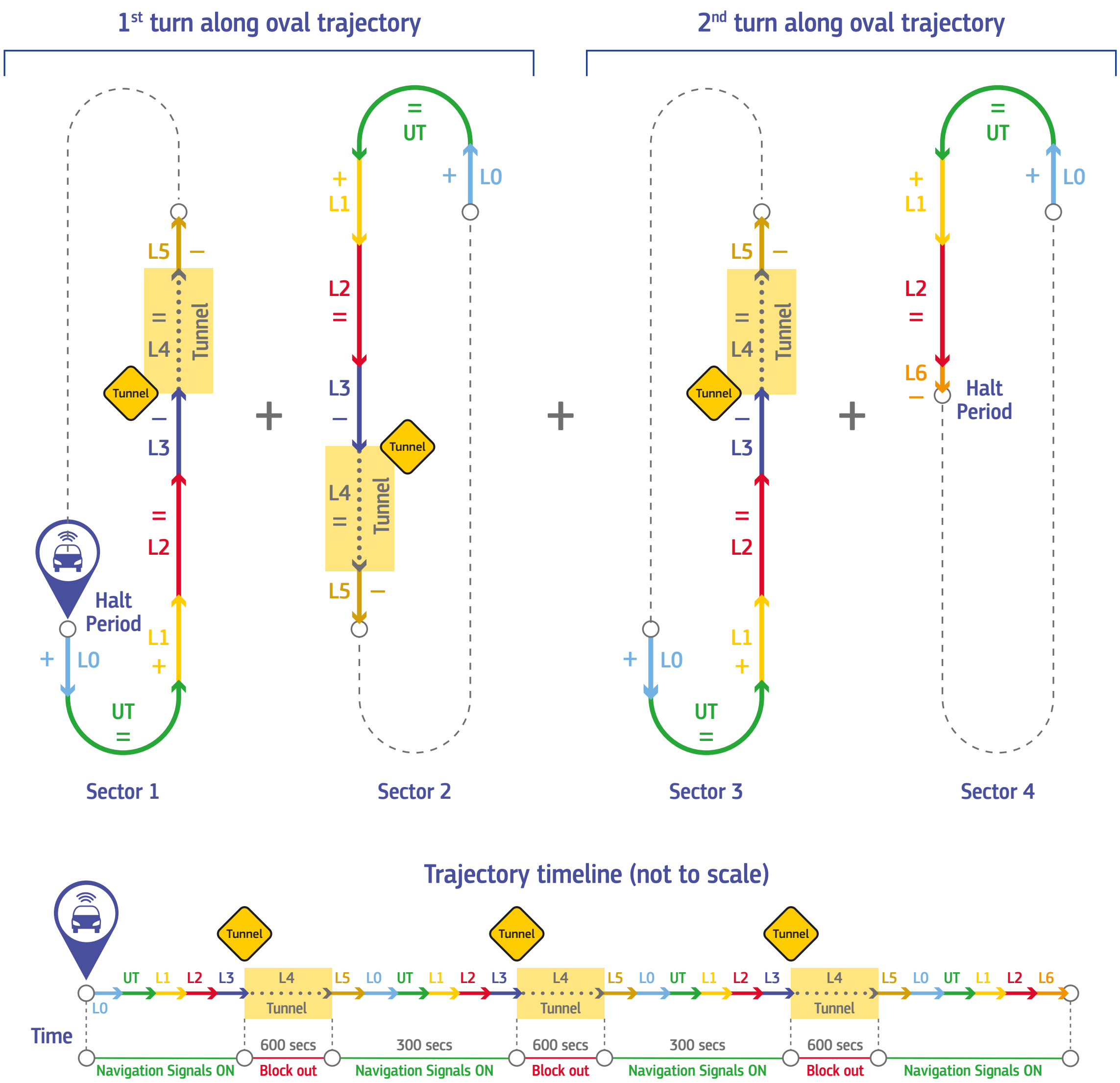


Figure 6: Sketch of a possible open sky vehicle trajectory to be used in the dynamic scenario specified in Sect. 2.2.4 of Annex VI [1], including three intervals with a complete outage of navigation signals, and the associated timeline indicating the time series of all the trajectory sectors involved.

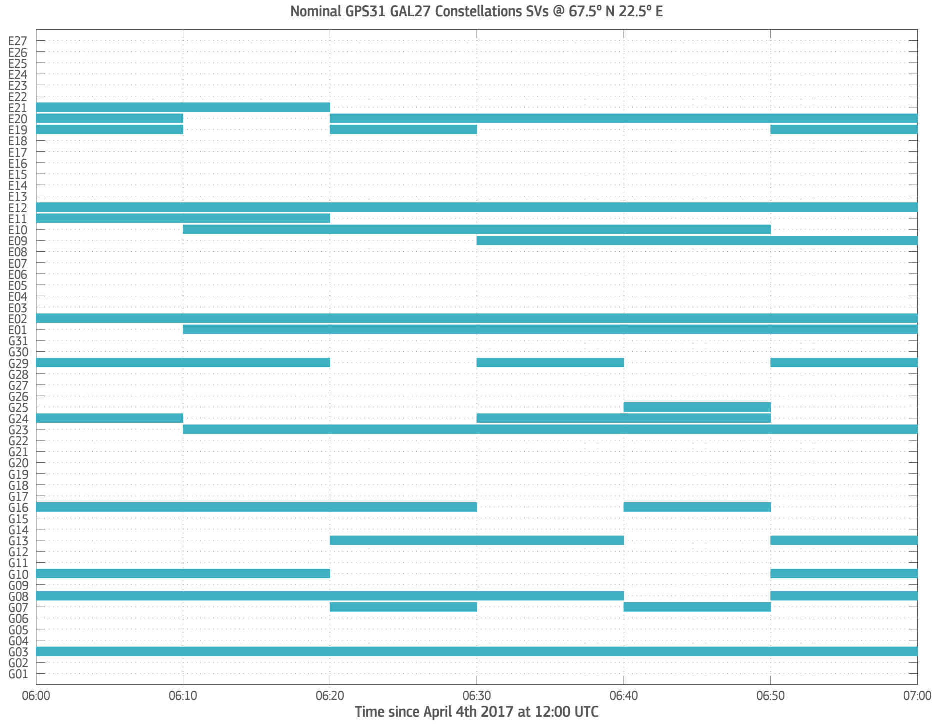


Figure 7: Set of satellites in view giving an average PDOP in the 3.5–4.0 range for a scenario lasting 60 min, with 6 SVs GPS, 6 SVs GAL, and 2 SBAS in view.

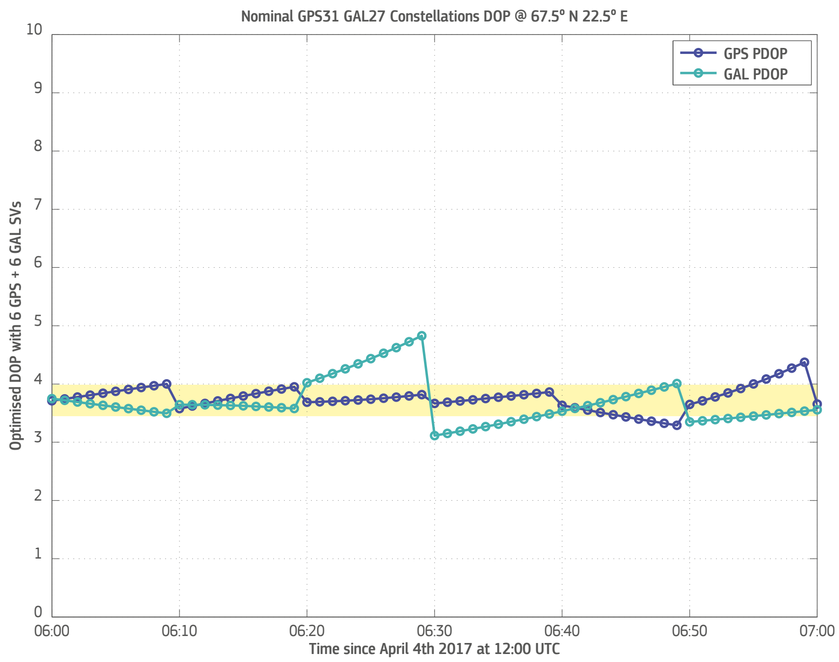


Figure 8: Observed values of PDOP calculated separately for each satellite constellation as a function of time for a scenario lasting 60 min, having 6 SVs GPS, 6 SVs GAL, and 2 SBAS in view.

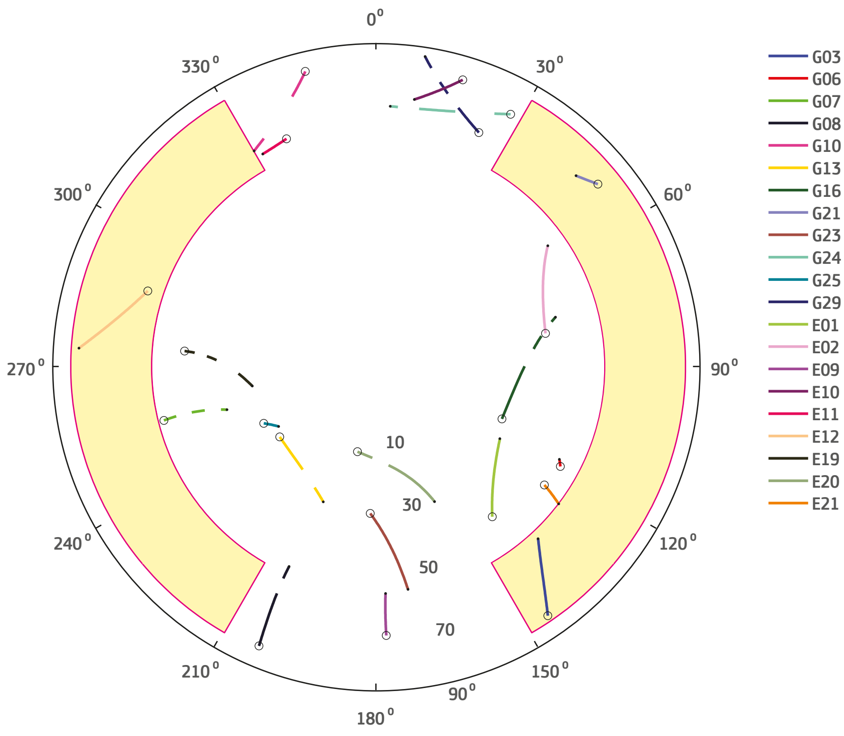


**Figure 9: Skyplot for a 60 min scenario, showing that the number of SVs within the antenna mask regions B and C is kept to a minimum.**

### 2.2.5 Cold start time to first fix test

The objective of the test scenario is to verify the cold start TTFF performance.

The test procedure specified in Sect. 2.2.5 of Annex VI [1] includes two sub-scenarios where the average cold start TTFF of the eCall DUT is assessed, respectively, at the signal power levels of minus 130dBm and minus 140dBm. These power levels are common for the GPS, Galileo and SBAS (EGNOS) satellites in view during the tests.

This test scenario has to be carried out exclusively with the combined GPS/Galileo/SBAS constellations in view (i.e. no single constellation sub-scenario is requested). The PDOP limits set are those specified in Sects. 2.2.2 and 2.2.3, in the range between 2.0 and 2.5.

The average TTFF has to be calculated using a minimum of 10 measurements in the two sub-scenarios. The pass/fail criteria on the average TTFF are different depending on the signal power level used:

- Average TTFF at minus 130 dBm must be below 60 seconds
- Average TTFF at minus 140 dBm must be below 300 seconds

The TTFF can be measured using a stopwatch, as indicated in Sect. 2.2.5 of Annex VI. Additionally, it is also possible to record the time-stamps of each cold start event and the associated first position solution in the NMEA logs. This approach would also allow for a fully automated tool by using simple control software that interfaces with both the eCall DUT and the GNSS signal simulator.

### 2.2.6 Test of re-acquisition time of tracking signals after block out of 60 seconds

The objective of the test scenario is to verify the time the eCall unit takes to provide a solution after being disconnected from any satellite for 60 seconds.

The test procedure specified in Sect. 2.2.6 of Annex VI [1] basically consists of the following steps:

- At the beginning of the scenario, wait 15 minutes to make sure that a valid position solution is calculated.
- Run a sequence of at least 10 intervals of signal outages (GNSS antenna disconnected) each of them lasting 60 seconds.
- Compute the average of the associated re-acquisition times: it must be below 20 seconds.

Note: This test scenario needs to be carried out at the signal power level of minus 130 dBm, for all satellites in view.

As in the previous scenario, with no single constellation sub-scenarios are needed and the combined GPS/Galileo/SBAS constellations are always in view. Again, the PDOP limits set are those specified in Sects. 2.2.2 and 2.2.3 of Annex VI [1], in the range between 2.0 and 2.5.

Similarly to the calculation of the TTFF, the reacquisition times can be measured using a stopwatch, as indicated in Sect. 2.2.6 of Annex VI [1]. Additionally, it is also possible to record the time stamp of (i) the signal block out events and (ii) those of the relevant next position solution in the NMEA logs, and build fully automated control software that interfaces with the eCall DUT and the GNSS signal simulator and subsequently computes the average re-acquisition time.

Two solutions are possible to provoke a signal block out: the first one remotely interfacing with the GNSS simulator to power off the satellites, and the second one making use of a remotely-controlled radio-frequency electromechanical switch in between the GNSS simulator and the eCall DUT.

### 2.2.7 Test of GNSS receiver sensitivity in cold start mode, tracking mode, and re-acquisition scenario

The objective of the test scenario is to verify the eCall DUT sensitivity when fed with very low signal power levels. The test procedure is specified in Sect. 2.2.7 of Annex VI [1] and it is meant to check that the eCall DUT is able, step by step, to:

- Provide a valid position solution when fed with a signal power level of minus 144dBm within 3600 seconds after a cold start event,
- Keep on providing a valid position solution for at least 600 seconds after reducing the signal power level down to minus 155 dBm, assuming that the position solution was available before the power drop, and
- Re-acquire the position in no more than 60 seconds, when the signal power level is first increased up to minus 150dBm and afterwards a 20-second navigation signal outage is introduced.

Apart from this sequence of operations in the signal power levels of the GNSS simulator, the rest of the test parameters remain unchanged with respect to those in Sects. 2.2.5 or 2.2.6 of Annex VI [1].

#### POWER CALIBRATION OF THE eCall TEST BED

Noting that the signal power levels specified in this scenario are very low, it is very important that the eCall test-bed used to execute the test procedure is well calibrated.

The requirements listed in Sects. 1.2.7, 1.2.8, and 1.2.9 of Annex VI [1] specify power levels on the GNSS simulator assuming that there are no losses between the RF output port of the simulator and the RF input port of the eCall DUT. The assumption made is that the signal power level set at the GNSS simulator output coincides with the actual signal power level at the antenna port of the eCall DUT.

Therefore it is recommended to carry out a calibration of the test set-up by measuring the insertion loss of the RF cables and any other passive RF components (e.g. bias tee, electromechanical RF switch, RF attenuators, etc.) in between the RF output port of the GNSS simulator and the RF input port of the eCall module, as shown in Figure 1. If these insertion losses are not negligible (e.g. they are above 1.5-2.0 dB), the power levels set to be the output of the GNSS simulator should be adjusted so that the measured insertion losses are compensated and nulled out.

As regards the eCall DUT design, keeping a safety margin in the power of 1.5-2.0 dB is desirable as it will minimize the variability of the test results.

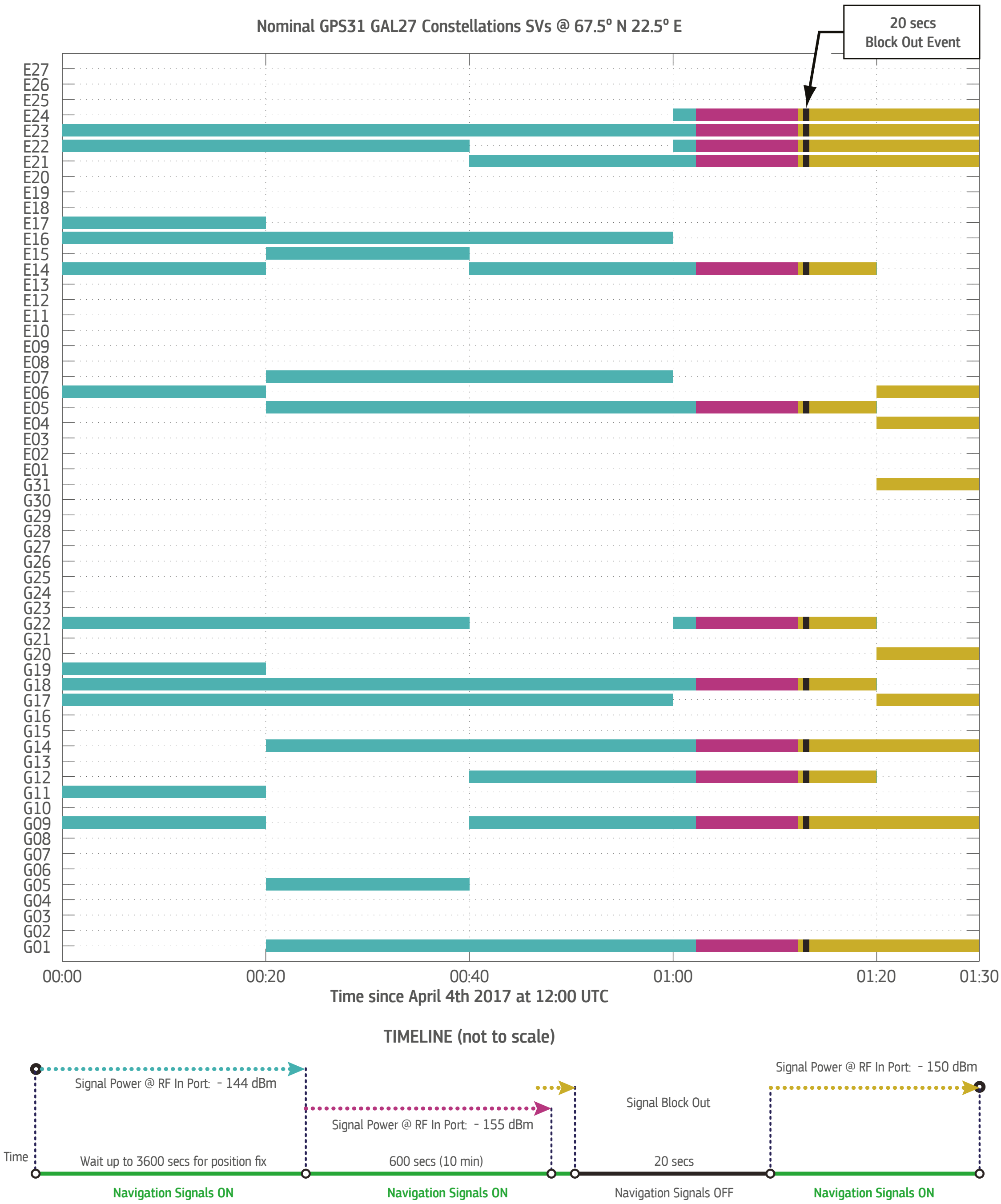


**Figure 10: Top: set of satellites in view giving an average PDOP in the 2.0–2.5 range for the sensitivity test scenario lasting 90 min, with 6 GPS, plus 6 GAL, plus 2 EGNOS in view; bottom: timeline illustrating the sequence of different power levels to be used in the scenario and the presence of a block out of 20 secs.**

The PDOP optimisation in this test scenario has been made by refreshing the set of 6 satellites in view for each constellation once every 20 minutes, as shown in Figure 10. An extended duration of the refresh period was chosen to avoid any change of the satellites in view during the 10 minute period where the power level is set to minus 155 dBm, the subsequent time period of the signal block out and the initial period when the power level is increased to minus -150 dBm. The overall duration of this test scenario has been set to 90 minutes, in order to let the eCall DUT provide the first solution (which can take up to 3600 seconds in accordance with the requirement in Sect. 1.2.9 of Annex VI [1]) and afterwards the operator executes the remaining steps.

As in the previous test scenarios of the TTFF and re-acquisition measurements, it is again recommended to record the time stamps of the end of the block out period programmed in the GNSS simulator or the electromechanical switch, and also those of the first position solution in the NMEA logs of the eCall DUT.

# 3 SUMMARY OF THE MAIN LESSONS LEARNT

The objective of this report is to provide a set of implementation guidelines aimed at facilitating the development of the test procedures specified in the Commission Delegated Regulation 2017/79 [1]. The testing campaign, started back in March 2017, has given us the opportunity to thoroughly review the requirements and the test procedures, assessing a wide range of different testing implementation options.

Sharing of the know-how gathered over the last few months is deemed valuable for the community of eCall OBU manufacturers, test solution vendors, and technical centres. This potential interest has led to a coordinated undertaking by the GSA and the JRC to publish this document.

A number of recommendations were provided, which are relevant to one or more test procedures. Among others, the following are considered to be of particular importance as they might substantially affect the final result of the testing:

1. The **"test object"**, which is defined as the eCall item under test, **may or may not include an LNA**. It is up to the eCall manufacturer to decide what is the configuration to be tested (and therefore type approved), depending on the actual commercial configuration of the eCall OBU.
2. The eCall DUT has to output the data logs in accordance with the NMEA Standard 0183.
3. The eCall DUT has to output the RMC, GGA, VTG, GSA and GSV messages, at least once every second (1 Hertz) during the entire duration of the test scenario.
4. The eCall DUT has to demonstrate the capability of using the **SBAS corrections**, therefore it is important that the GNSS simulator be set in such a way that the corrections are enabled in the region where the test scenario is located.
5. The relative geometry of the GNSS satellites with respect to the user location is very important to perform most of the tests, and it is constrained in terms of PDOP. The **PDOP** can be calculated as the one observed simulating a single GNSS constellation, which is either the GPS or Galileo constellation, separately. Both GPS PDOP and Galileo PDOP have to respect the limits set in the regulation individually, while the SBAS satellites are assumed to be used exclusively as a communication channel to receive the corrections (i.e. they are not used for ranging) and therefore are not accounted for in the estimation of the PDOP.
6. Each test procedure is characterised in terms of **signal power level** for each satellite. Regarding the configuration of the signal power level of the Galileo E1 OS signals, the power level values specified in Annex VI [1] are to be set to each of the two components (GAL 1B – data channel and GAL 1C – pilot channel), separately. This point is particularly relevant in the test scenario where the sensitivity of the eCall DUT is assessed.
7. The calibration of the eCall test bed cannot be neglected. The test procedures are designed under the assumption that the signal power level set at the output of the GNSS simulator coincides with the actual signal power level at the antenna port of the eCall DUT. A lack of calibration can significantly affect the test results in a number of test cases.

# 4 REFERENCE DOCUMENTS

[1] COMMISSION DELEGATED REGULATION (EU) 2017/79, 12 September 2016.

[2] European GNSS (Galileo) Open Service, Signal in Space Interface Control Document, Issue 2.1, 2011.

[3] NMEA 0183 Version 4.1 Standard Specification, June 2012.

[4] NMEA 0183 Version 4.0 Standard Specification, November 2008.

[5] RTCA DO-229 Minimum Operational Performance Standards for Global Positioning System/Satellite-based Augmentation System Airborne Equipment – rev. E, December 2016

[6] Vallado, David A. and Crawford, Paul. SGP4 orbit determination. In Proceedings of AIAA/AAS Astrodynamics Specialist Conference and Exhibit, pages 18–21. AIAA Reston, VA, 2008

# ANNEX A – CALCULATION OF THE OVERALL HORIZONTAL POSITION ERROR

The procedure to calculate the horizontal position errors is specified in Annex VI, from points 2.2.2.3 to 2.2.2.14.

The pass/fail criteria on the horizontal position errors have been set with a confidence interval of 95%. A procedure to enforce this confidence interval on the horizontal position errors obtained in generic scenario is as follows.

- Extract latitude and longitude fields from the RMC messages in the NMEA logs of the GNSS simulator, which should contain the reference or true trajectory, and from the NMEA logs of the eCall DUT. The differences between the reference coordinates and those of the eCall DUT should give us these two sets of position errors, as specified in Equation (1) in Sect. 2.2.2.7 of Annex VI of the eCall Regulation, i.e.:

$$\{\Delta \mathrm{B}(\mathrm{j}),\ \Delta \mathrm{L}(\mathrm{j})\}, \quad \text{with} \quad \mathrm{j} = 1, 2, \ldots \mathrm{N} \tag{1}$$

where $\Delta \mathrm{B}(\mathrm{j})$ and $\Delta \mathrm{L}(\mathrm{j})$ denote, respectively the latitude (B) and longitude (L) error in arc-seconds at each epoch where a position solution has been given, i.e.:

$$\begin{aligned} \Delta \mathrm{B}(\mathrm{j})\ \text{[arc-sec]} &= \mathrm{B}(\mathrm{j}) - \mathrm{B}_{\mathrm{true}}(\mathrm{j}) \\ \Delta \mathrm{L}(\mathrm{j})\ \text{[arc-sec]} &= \mathrm{L}(\mathrm{j}) - \mathrm{L}_{\mathrm{true}}(\mathrm{j}), \quad \text{with} \quad \mathrm{j} = 1, 2, \ldots \mathrm{N} \end{aligned} \tag{2}$$

where $\mathrm{B}_{\mathrm{true}}(\mathrm{j})$ and $\mathrm{L}_{\mathrm{true}}(\mathrm{j})$ denote, respectively, the true or reference latitude and longitude at the $\mathrm{j}\,th$ epoch, which shall be available from the GNSS simulator logs. The total number of valid observations or GGA/RMC messages logged in the test scenario is $\mathrm{N}$.

- At this point, since the position error limit has been set in meters, the latitude and longitude position errors have to be converted from arc-seconds to meters as follows:

$$\begin{aligned} \Delta \mathrm{B}(\mathrm{j})\ \text{[m]} &= \frac{\mathrm{a} \cdot (1 - \mathrm{e}^2)}{\left\{1 - \mathrm{e}^2 \sin^2[\mathrm{B}_{\mathrm{true}}(\mathrm{j})]\right\}^{3/2}} \quad \frac{\pi}{180 \cdot 3600} \quad \Delta \mathrm{B}(\mathrm{j})\ \text{[arc-sec]} \\ \Delta \mathrm{L}(\mathrm{j})\ \text{[m]} &= \frac{\mathrm{a} \cdot \cos[\mathrm{B}_{\mathrm{true}}(\mathrm{j})]}{\sqrt{1 - \mathrm{e}^2 \sin^2[\mathrm{B}_{\mathrm{true}}(\mathrm{j})]}} \quad \frac{\pi}{180 \cdot 3600} \quad \Delta \mathrm{L}(\mathrm{j})\ \text{[arc-sec]} \end{aligned} \tag{3}$$

where a denotes the semi-major axis of the WGS-84 ellipsoid†, $\mathrm{e}$ is the first eccentricity‡, and $\mathrm{B}_{\mathrm{true}}(\mathrm{j})$ is the true latitude in radians. Noting the fact that $\mathrm{e}^2$ is a very tiny number, the expressions of the latitude and longitude position error can be simplified and approximated as:

$$\begin{aligned} \Delta \mathrm{B}(\mathrm{j})\ \text{[m]} &\simeq \mathrm{a} \cdot \frac{\pi}{180 \cdot 3600} \cdot \Delta \mathrm{B}(\mathrm{j})\ \text{[arc-sec]} \\ \Delta \mathrm{L}(\mathrm{j})\ \text{[m]} &\simeq \mathrm{a} \cdot \cos[\mathrm{B}_{\mathrm{true}}(\mathrm{j})] \cdot \frac{\pi}{180 \cdot 3600} \cdot \Delta \mathrm{L}(\mathrm{j})\ \text{[arc-sec]} \end{aligned} \tag{4}$$

- The subsets of the position errors within a 95% confidence interval can be now expressed as:

$$\frac{\#\left\{\sqrt{\left(\Delta \mathrm{B}(\mathrm{i})\ \text{[m]}\right)^2 + \left(\Delta \mathrm{L}(\mathrm{i})\ \text{[m]}\right)^2} \le \mathrm{H}_{95}\right\}}{\mathrm{N}} = 0.95 \quad \text{with} \quad \mathrm{i} = 1, 2, \ldots, \mathrm{N}_{95} \tag{5}$$

† Semi-major axis in WGS-84 datum is a =6356752.3142 m
‡ First eccentricity in WGS-84 datum is e =0.081819190843

where $\Pi_{95}$ denotes the upper bound of the horizontal position error with the 95% confidence level, and $N_{95}$ is the number of observations used to estimate the overall horizontal position error, which shall be roughly 0.95×N. The operator $\#\{\cdot\}$ denotes the number of elements in a given set. **Note that epochs where the position solution is non-compliant with the requirements set in Tables 2, 3 and 4 of Annex VI (e.g., a PDOP temporarily outside the specified range) should be excluded from the initial set of N position solutions considered here.**

- Once the upper bound giving a 95% confidence level $\Pi_{95}$ is known, the subset of $N_{95}$ observations needed to estimate the overall position error can be easily obtained.
- The overall horizontal position error $\Pi$ with a 95% confidence level can be simply calculated following the next steps:

$$\Pi_{95}\ [\text{m}] = \sqrt{(dB_{95}\ [\text{m}])^2 + (dL_{95}\ [\text{m}])^2} + 2 \cdot \sqrt{(\sigma_{B95}\ [\text{m}])^2 + (\sigma_{L95}\ [\text{m}])^2} \tag{6}$$

with

$$\begin{aligned} dB_{95}\ [\text{m}] &= \frac{1}{N_{95}} \sum_{i=1}^{N_{95}} \Delta B(i)\ [\text{m}] \\ dL_{95}\ [\text{m}] &= \frac{1}{N_{95}} \sum_{i=1}^{N_{95}} L(i)\ [\text{m}] \\ \sigma_{B95}\ [\text{m}] &= \sqrt{\frac{\sum_{i=1}^{N_{95}} (\Delta B(i)\ [\text{m}] - dB_{95}\ [\text{m}])^2}{N_{95}}} \\ \sigma_{L95}\ [\text{m}] &= \sqrt{\frac{\sum_{i=1}^{N_{95}} (\Delta L(i)\ [\text{m}] - dL_{95}\ [\text{m}])^2}{N_{95}}} \end{aligned} \tag{7}$$

Some example results obtained with an eCall device illustrating the use of the above procedure are given next. The test scenario that has been selected is one with the dynamic trajectory given in Table 1. The number of epochs where the position estimates from the eCall DUT is $N$=3600, which corresponds to a time window lasting exactly 1 hour.

The horizontal position errors extracted from the NMEA logs of the eCall DUT and those of the GNSS simulator are shown in Figure 11(a). This time series includes an entire set of position estimates with $N$=3600 points. A two-dimensional scatter plot of the position errors $\{\Delta B(j)\,[\text{m}], \Delta L(j)\,[\text{m}]\}$, distinguishing the points that are inside and outside the 95% confidence interval, is shown in Figure 11(b). This result illustrates the fact that the 5% of position estimates with the largest error are discarded from the calculation of the overall horizontal position error limit set in Annex VI of the eCall Regulation.

The histogram of the distribution of the set of $N$ positions of this dynamic scenario is also useful to understand what are the points that are excluded from the estimation of the overall horizontal position error. The identification of the points that are within and outside the 95% confidence interval is shown in Figure 12. In this particular example, the overall horizontal position errors without extracting any samples (i.e., with a confidence level of 100%) was $\Pi$ =2.30 m, and that with a 95% confidence level was $\Pi_{95}$ =1.69 m, which is significantly smaller.

One last point that deserves special attention is that of the time basis of the trajectories recorded with the GNSS simulator (i.e., the true or reference trajectory) and that from the eCall DUT. They are generally fully synchronous (i.e., the epochs of NMEA logs with the trajectory are exactly the same), however the eCall Regulation [1] does not include any requirement forcing the two trajectories to be perfectly aligned in time.

Therefore, before starting the test session, it is important to check whether the eCall DUT is recording the position solutions with a fixed time offset with respect to the reference trajectory. This time offset will be within a range −0.5 to +0.5 seconds. **The calculation of the overall horizontal position error when there is such a time offset requires a proper interpolation of the reference trajectory such that it gets perfectly aligned with that of the eCall DUT.**

An assessment of the impact of the interpolation errors on the overall horizontal position error $\Pi$ has been made for the dynamic trajectory described in Table 1. It has been observed that a polynomial interpolation applied separately to the latitude and longitude coordinates introduces an error term in the overall horizontal position error $\Pi$. The bounds of this error term are dependent on the value of the time offset, the degree of the polynomial interpolation function, the shape and kinematics of the trajectory, and the extent of the confidence interval enforced in the calculation of the overall horizontal position error $\Pi$.

In our case, when a linear interpolation of the reference dynamic trajectory is used, the bound of the error term in the overall horizontal position error, with a 95% confidence level $\Pi_{95}$ in the dynamic scenario of section 2.2.3 of Annex VI, has been found to be of 4 cm, which occurs for a time offset of half a second (i.e., the worst possible case). It is important to note that the major contribution to this error term is coincident with the high acceleration/deceleration sectors of the trajectory (i.e., the 2G deceleration sector in the dynamic trajectory used).

In summary, for the reference trajectory described in Table 1, noting that a linear interpolation introduces an error term that is negligible when compared to the limits set on the overall horizontal position error $\Pi_{95}$ (i.e., 15 and 40 meters, respectively in the two dynamic scenarios of sections 2.2.3 and 2.2.4 of Annex VI), it can be concluded that there is no need to use a higher order interpolation function. On the other hand, a zero-order or nearest neighbour interpolation function may produce an error term as high as 18 meter, and therefore its use has been totally discarded. However, this conclusion might not be valid for a reference trajectory different from the one proposed and an in-depth assessment on the impact of the interpolation error might be needed. This assessment should be done using a reference trajectory recorded at a high sampling rate (e.g., in our evaluation a value of 100 Hz was used) with the GNSS simulator.

## TIME OFFSET BETWEEN TRAJECTORIES

It is important to verify the presence of a time offset between the trajectories recorded by the eCall DUT and the GNSS simulator before starting the test sessions. In case the test scenarios implement the trajectory described in Table 1 of this document, a simple linear interpolation is sufficient to calculate precisely the overall horizontal position error. **However, if the dynamic trajectory used differs from the one recommended in this document, a linear interpolation might not suffice and an in-depth assessment of the actual impact of the interpolation on the overall horizontal position error is required.**

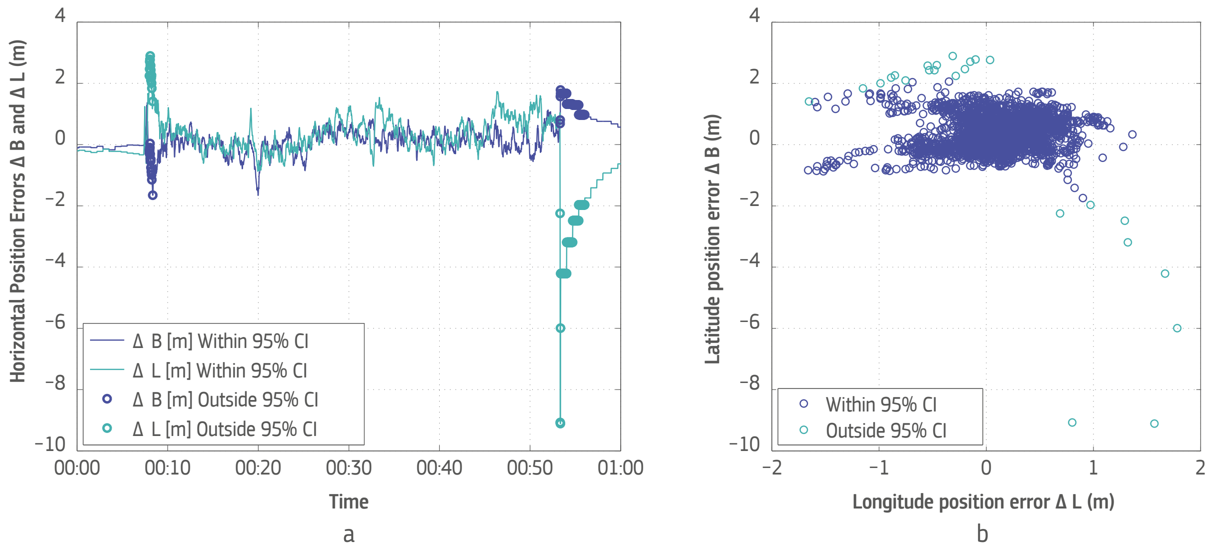


Figure 11: (a): Horizontal position error versus the observation time highlighting the points outside the 95% confidence interval (CI) , and (b): scatter plot of the horizontal position error highlighting in red those outside the 95% CI.

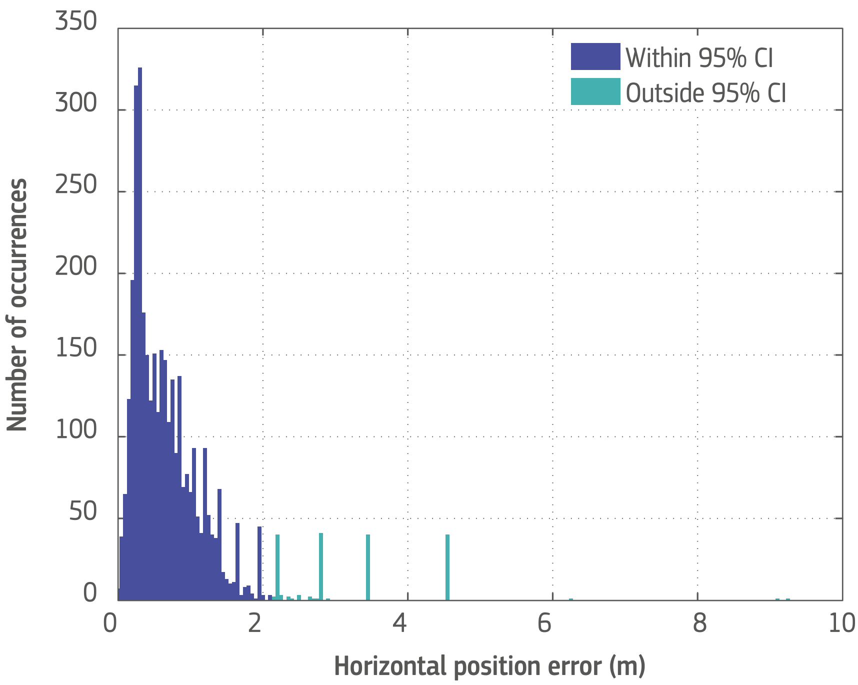


Figure 12: Histogram of the horizontal position errors observed on an eCall DUT: histogram bins inside the 95% confidence interval (CI) are coloured in blue, and those outside, in red.

# ANNEX B – SAMPLE EPHEMERIS DATASETS OF GPS AND GALILEO

The satellite ephemeris data given in this Annex have been uploaded to a JRC cloud server and are available in electronic format here.

## B.1 Galileo TLE dataset

The ephemeris data of the selected Galileo constellation of 27 SVs in the TLE format is as follows.

```
GSAT (PRN E1)
1 99901U 00000    17094.69332176  .00000000  00000+0  00000+0 0    07
2 99901  56.0000 131.0000 0000000    .0000    .0000  1.70476777    02
GSAT (PRN E2)
1 99902U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 99902  56.0000 131.0000 0000000    .0000  40.0000  1.70476777    07
GSAT (PRN E3)
1 99903U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 99903  56.0000 131.0000 0000000    .0000  80.0000  1.70476777    02
GSAT (PRN E4)
1 99904U 00000    17094.69332176  .00000000  00000+0  00000+0 0    00
2 99904  56.0000 131.0000 0000000    .0000 120.0000  1.70476777    08
GSAT (PRN E5)
1 99905U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 99905  56.0000 131.0000 0000000    .0000 160.0000  1.70476777    03
GSAT (PRN E6)
1 99906U 00000    17094.69332176  .00000000  00000+0  00000+0 0    02
2 99906  56.0000 131.0000 0000000    .0000 200.0000  1.70476777    09
GSAT (PRN E7)
1 99907U 00000    17094.69332176  .00000000  00000+0  00000+0 0    03
2 99907  56.0000 131.0000 0000000    .0000 240.0000  1.70476777    04
GSAT (PRN E8)
1 99908U 00000    17094.69332176  .00000000  00000+0  00000+0 0    04
2 99908  56.0000 131.0000 0000000    .0000 280.0000  1.70476777    09
GSAT (PRN E9)
1 99909U 00000    17094.69332176  .00000000  00000+0  00000+0 0    05
2 99909  56.0000 131.0000 0000000    .0000 320.0000  1.70476777    05
GSAT (PRN E10)
1 99910U 00000    17094.69332176  .00000000  00000+0  00000+0 0    07
2 99910  56.0000 251.0000 0000000    .0000  13.3300  1.70476777    05
GSAT (PRN E11)
1 37846U 00000    17094.69332176  .00000000  00000+0  00000+0 0    07
2 37846  56.0000 251.0000 0000000    .0000  53.3300  1.70476777    09
GSAT (PRN E12)
1 37847U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 37847  56.0000 251.0000 0000000    .0000  93.3300  1.70476777    04
GSAT (PRN E13)
1 99913U 00000    17094.69332176  .00000000  00000+0  00000+0 0    00
2 99913  56.0000 251.0000 0000000    .0000 133.3300  1.70476777    01
```

```
GSAT (PRN E14)
1 99914U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 99914  56.0000 251.0000 0000000    .0000 173.3300  1.70476777    06
GSAT (PRN E15)
1 99915U 00000    17094.69332176  .00000000  00000+0  00000+0 0    02
2 99915  56.0000 251.0000 0000000    .0000 213.3300  1.70476777    02
GSAT (PRN E16)
1 99916U 00000    17094.69332176  .00000000  00000+0  00000+0 0    03
2 99916  56.0000 251.0000 0000000    .0000 253.3300  1.70476777    07
GSAT (PRN E17)
1 99917U 00000    17094.69332176  .00000000  00000+0  00000+0 0    04
2 99917  56.0000 251.0000 0000000    .0000 293.3300  1.70476777    02
GSAT (PRN E18)
1 99918U 00000    17094.69332176  .00000000  00000+0  00000+0 0    05
2 99918  56.0000 251.0000 0000000    .0000 333.3300  1.70476777    08
GSAT (PRN E19)
1 38857U 00000    17094.69332176  .00000000  00000+0  00000+0 0    00
2 38857  56.0000  11.0000 0000000    .0000  26.6600  1.70476777    02
GSAT (PRN E20)
1 38858U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 38858  56.0000  11.0000 0000000    .0000  66.6600  1.70476777    07
GSAT (PRN E21)
1 99921U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 99921  56.0000  11.0000 0000000    .0000 106.6600  1.70476777    00
GSAT (PRN E22)
1 99922U 00000    17094.69332176  .00000000  00000+0  00000+0 0    00
2 99922  56.0000  11.0000 0000000    .0000 146.6600  1.70476777    05
GSAT (PRN E23)
1 99923U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 99923  56.0000  11.0000 0000000    .0000 186.6600  1.70476777    00
GSAT (PRN E24)
1 99924U 00000    17094.69332176  .00000000  00000+0  00000+0 0    02
2 99924  56.0000  11.0000 0000000    .0000 226.6600  1.70476777    06
GSAT (PRN E25)
1 99925U 00000    17094.69332176  .00000000  00000+0  00000+0 0    03
2 99925  56.0000  11.0000 0000000    .0000 266.6600  1.70476777    01
GSAT (PRN E26)
1 99926U 00000    17094.69332176  .00000000  00000+0  00000+0 0    04
2 99926  56.0000  11.0000 0000000    .0000 306.6600  1.70476777    07
GSAT (PRN E27)
1 99927U 00000    17094.69332176  .00000000  00000+0  00000+0 0    05
2 99927  56.0000  11.0000 0000000    .0000 346.6600  1.70476777    02
```

## B.2 GPS TLE dataset

The ephemeris data of the selected GPS constellation of 31 SVs in the TLE format is as follows.

```
GPS (PRN 1)
1 37753U 00000    17094.69332176  .00000000  00000+0  00000+0 0    04
2 37753  55.0000 288.0000 0000000 291.1317 230.9161  2.00560399    05
GPS (PRN 2)
1 28474U 00000    17094.69332176  .00000000  00000+0  00000+0 0    04
2 28474  55.0000 222.0000 0000000 155.5065 290.3526  2.00560399    01
GPS (PRN 3)
1 40294U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 40294  55.0000 157.0000 0000000  50.9900 269.8111  2.00560399    09
GPS (PRN 4)
1 22877U 00000    17094.69332176  .00000000  00000+0  00000+0 0    05
2 22877  55.0000 223.0000 0000000  27.1176  92.8439  2.00560399    08
GPS (PRN 5)
1 35752U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 35752  55.0000  98.0000 0000000  74.1972  70.3424  2.00560399    05
GPS (PRN 6)
1 39741U 00000    17094.69332176  .00000000  00000+0  00000+0 0    03
2 39741  55.0000 160.0000 0000000 276.1758  54.4845  2.00560399    03
GPS (PRN 7)
1 32711U 00000    17094.69332176  .00000000  00000+0  00000+0 0    03
2 32711  55.0000  43.0000 0000000 167.5072 186.1219  2.00560399    03
GPS (PRN 8)
1 00000U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 00000  55.0000 105.0000 0000000 170.5420 147.7286  2.00560399    06
GPS (PRN 9)
1 40105U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 40105  55.0000  41.0000 0000000  83.6181 133.0295  2.00560399    01
GPS (PRN 10)
1 23953U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 23953  55.0000 284.0000 0000000  33.8524 339.6730  2.00560399    08
GPS (PRN 11)
1 25933U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 25933  55.0000 211.0000 0000000  39.1942 178.2079  2.00560399    04
GPS (PRN 12)
1 29601U 00000    17094.69332176  .00000000  00000+0  00000+0 0    07
2 29601  55.0000 103.0000 0000000 313.4319 197.0616  2.00560399    02
GPS (PRN 13)
1 24876U 00000    17094.69332176  .00000000  00000+0  00000+0 0    06
2 24876  55.0000 346.0000 0000000  86.2980 329.3430  2.00560399    03
GPS (PRN 14)
1 26605U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 26605  55.0000 345.0000 0000000 239.7076 306.4524  2.00560399    05
GPS (PRN 15)
1 32260U 00000    17094.69332176  .00000000  00000+0  00000+0 0    02
2 32260  55.0000 342.0000 0000000 317.4867 335.4014  2.00560399    04
GPS (PRN 16)
1 27663U 00000    17094.69332176  .00000000  00000+0  00000+0 0    03
2 27663  55.0000 104.0000 0000000 337.8851  52.7235  2.00560399    04
```

```
GPS (PRN 17)
1 28874U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 28874  55.0000 164.0000 0000000 202.4351 350.5007  2.00560399    03
GPS (PRN 18)
1 26690U 00000    17094.69332176  .00000000  00000+0  00000+0 0    02
2 26690  55.0000 285.0000 0000000 220.2981  60.0550  2.00560399    04
GPS (PRN 19)
1 28190U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 28190  55.0000 167.0000 0000000 337.5810 308.0058  2.00560399    01
GPS (PRN 20)
1 26360U 00000    17094.69332176  .00000000  00000+0  00000+0 0    06
2 26360  55.0000 282.0000 0000000  75.3215  68.4883  2.00560399    05
GPS (PRN 21)
1 27704U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 27704  55.0000 224.0000 0000000 208.2293 133.1787  2.00560399    00
GPS (PRN 22)
1 28129U 00000    17094.69332176  .00000000  00000+0  00000+0 0    01
2 28129  55.0000 285.0000 0000000 255.5271 355.6114  2.00560399    05
GPS (PRN 23)
1 28361U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 28361  55.0000 343.0000 0000000 165.1495 277.1153  2.00560399    03
GPS (PRN 24)
1 38833U 00000    17094.69332176  .00000000  00000+0  00000+0 0    04
2 38833  55.0000 226.0000 0000000 323.3580  54.2294  2.00560399    01
GPS (PRN 25)
1 36585U 00000    17094.69332176  .00000000  00000+0  00000+0 0    06
2 36585  55.0000  38.0000 0000000 289.5599  84.0995  2.00560399    06
GPS (PRN 26)
1 22014U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 22014  55.0000 346.0000 0000000  55.4435 251.9533  2.00560399    02
GPS (PRN 27)
1 39166U 00000    17094.69332176  .00000000  00000+0  00000+0 0    04
2 39166  55.0000  40.0000 0000000 265.3948  30.9184  2.00560399    07
GPS (PRN 28)
1 26407U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 26407  55.0000 105.0000 0000000 242.1347  14.8077  2.00560399    01
GPS (PRN 29)
1 32384U 00000    17094.69332176  .00000000  00000+0  00000+0 0    09
2 32384  55.0000 164.0000 0000000 283.0269 136.1980  2.00560399    05
GPS (PRN 30)
1 39533U 00000    17094.69332176  .00000000  00000+0  00000+0 0    02
2 39533  55.0000 101.0000 0000000  80.9690  39.5616  2.00560399    03
GPS (PRN 31)
1 29486U 00000    17094.69332176  .00000000  00000+0  00000+0 0    08
2 29486  55.0000  43.0000 0000000 291.5986 181.9226  2.00560399    01
```

## B.3 Galileo RINEX v3.0 dataset

The ephemeris data of the selected Galileo constellation of 27 SVs in RINEX v3.0 format is as follows.

```
     3.00           N: NAVIGATION DATA  E: GALILEO          RINEX VERSION / TYPE
                                        20170404 120000 UTC PGM / RUN BY / DATE
GAL    1.0000D+02  0.0000D+00  0.0000D+00  0.0000D+00       IONOSPHERIC CORR
GAUT  0.0000000000D+00 0.000000000D+00 216000 1943          TIME SYSTEM CORR
    17                                                      LEAP SECONDS
                                                            END OF HEADER
E03 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00-6.744776885778D-01
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-1.038693008215D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E04 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 2.365401221990D-02
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-1.038693008215D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E05 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 7.217857130176D-01
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-1.038693008215D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E06 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 1.419917413815D+00
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-1.038693008215D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E07 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 2.118049114613D+00
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-1.038693008215D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E13 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 2.563064015107D-01
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00 1.055702094178D+00 0.000000000000D+00
```

```
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E14 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 9.544381023085D-01
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00 1.055702094178D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E15 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 1.652569803106D+00
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00 1.055702094178D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E16 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 2.350701503904D+00
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00 1.055702094178D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E17 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 3.048833204702D+00
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00 1.055702094178D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E21 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00-2.091729099961D-01
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-3.133088110608D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E22 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 4.889587908016D-01
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-3.133088110608D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
```

```
E23 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 1.187090491599D+00
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-3.133088110608D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
E24 2017 04 04 12 00 00 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.000000000000D+00 0.000000000000D+00 0.000000000000D+00 1.885222192397D+00
     0.000000000000D+00 0.000000000000D+00 0.000000000000D+00 5.440588207683D+03
     2.160000000000D+05 0.000000000000D+00-3.133088110608D+00 0.000000000000D+00
     9.773843811168D-01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     0.000000000000D+00 2.630000000000D+02 9.190000000000D+02 0.000000000000D+00
     2.500000000000D+01 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
     2.160000000000D+05 0.000000000000D+00 0.000000000000D+00 0.000000000000D+00
```

## B.4 GPS RINEX v3.0 dataset

The ephemeris data of the selected GPS constellation of 31 SVs in RINEX v3.0 format is as follows.

```
     3.00           N: NAVIGATION DATA  G: GPS              RINEX VERSION / TYPE
                                        20170404 120000 UTC PGM / RUN BY / DATE
GPSA   4.6566D-09  1.4901D-08 -5.9605D-08 -5.9605D-08       IONOSPHERIC CORR
GPSB   7.9872D+04  6.5536D+04 -6.5536D+04 -3.9322D+05       IONOSPHERIC CORR
GPUT  0.0000000000D+00 0.000000000D+00 466944 1943          TIME SYSTEM CORR
    17                                                      LEAP SECONDS
                                                            END OF HEADER
G01 2017 04 04 12 00 00 5.268258973956D-05 7.958078640513D-13 0.000000000000D+00
     5.700000000000D+01-6.418750000000D+01 0.000000000000D+00 1.594086331585D+00
    -3.207474946976D-06 0.000000000000D+00 9.721145033836D-06 5.153700812979D+03
     2.160000000000D+05-5.587935447693D-09 1.701473917416D+00 1.098960638046D-07
     9.599310885969D-01 1.910000000000D+02-1.201978585251D+00 0.000000000000D+00
     0.000000000000D+00 1.000000000000D+00 1.943000000000D+03 0.000000000000D+00
     1.200000000000D+00 0.000000000000D+00 5.122270000000D-09 5.700000000000D+01
     2.160000000000D+05 4.000000000000D+00 0.000000000000D+00 0.000000000000D+00
G04 2017 04 04 12 00 00 1.383479684591D-06 5.684341886081D-13 0.000000000000D+00
     7.500000000000D+01 5.271875000000D+01 0.000000000000D+00-8.157281638875D-01
     2.630054950714D-06 0.000000000000D+00 5.355104804039D-06 5.153700812979D+03
     2.160000000000D+05 4.284083843231D-08 5.670099036195D-01-1.471489667892D-07
     9.599310885969D-01 2.883437500000D+02 4.732914052388D-01 0.000000000000D+00
     0.000000000000D+00 1.000000000000D+00 1.943000000000D+03 0.000000000000D+00
     2.900000000000D+00 3.100000000000D+01-1.955777406693D-08 7.500000000000D+01
     2.160000000000D+05 4.000000000000D+00 0.000000000000D+00 0.000000000000D+00
G05 2017 04 04 12 00 00-5.247024819255D-05 1.932676241267D-12 0.000000000000D+00
     6.100000000000D+01 8.125000000000D+00 0.000000000000D+00-1.208453425525D+00
     4.898756742477D-07 0.000000000000D+00 8.270144462585D-06 5.153700812979D+03
     2.160000000000D+05-6.332993507385D-08-1.614651661373D+00 3.725290298462D-08
     9.599310885969D-01 2.140000000000D+02 1.294985435761D+00 0.000000000000D+00
     0.000000000000D+00 1.000000000000D+00 1.943000000000D+03 0.000000000000D+00
     1.200000000000D+00 0.000000000000D+00-1.071020960808D-08 6.100000000000D+01
     2.160000000000D+05 4.000000000000D+00 0.000000000000D+00 0.000000000000D+00
```

```
G09 2017 04 04 12 00 00 3.351904451847D-04 7.730704965070D-12 0.000000000000D+00
     3.300000000000D+01 8.562500000000D+00 0.000000000000D+00-1.143571319980D-01
     2.849847078323D-07 0.000000000000D+00 7.918104529381D-06 5.153700812979D+03
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```

## How does EGNOS work?

EGNOS, the European Geostationary Navigation Overlay Service, uses geostationary satellites and a network of ground stations to increase the accuracy of existing satellite positioning signals while providing a crucial 'integrity message' that informs users in the event of signal problems.

The EGNOS reference stations pick up signals from GPS satellites, which are processed in Mission Control Centres (MCC). The accuracy of the original signals is determined and confounding factors are corrected.

This data is then incorporated into EGNOS signals and sent to its three geostationary satellites. The satellites relay these signals back to users on the ground, providing greater positioning accuracy than would be achieved through GPS alone.

## Galileo Initial Services

With the declaration of Initial Services in December 2016, Galileo - the European Global Satellite Navigation System (GNSS) - has moved from testing to the provision of live services. Users around the world can now be guided using the positioning, navigation and timing information provided by Galileo's global satellite constellation.

By working together with GPS, Galileo satellites provide better positioning and navigation for users, particularly in cities, where satellite signals can often be blocked by buildings. Plus, Galileo's excellent timing accuracy helps make the synchronisation of banking and financial transactions and telecommunication and energy distribution networks more resilient, allowing them to operate more efficiently.

Galileo's Search and Rescue service reduces the time it takes to detect emergency distress beacon signals from up to three hours to just ten minutes, potentially saving many more lives. The additional resiliency provided by Galileo is expected to help drive economic growth in Europe and beyond by enabling a range of new applications and services.

## useGALILEO.eu

Mass-market devices containing a Galileo-enabled chipset, such as smartphones or vehicle navigation devices, can use Galileo signals for positioning, navigation and timing. The www.useGALILEO.eu tool helps you keep track of Galileo-enabled in-vehicle, portable, road tolling and fleet management systems, serving a variety of needs, as they become available.

## GSA: linking space to user needs

The GSA is the European Union Agency in charge of managing operations and service provision of Galileo and EGNOS, ensuring that European citizens get the most out of Europe's satellite navigation programmes in terms of innovation, competitiveness, economic growth, and benefit to users.

As Europe's link between space technology and user needs, GSA keeps users at the centre of Galileo and EGNOS.


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European Global Navigation Satellite Systems Agency

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