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## Verification of performance levels of Galileo Enabled mass-market receivers

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## **European foreword**

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The final text of CWA 17486 was submitted to CEN/CENELEC for publication on 2019-12-18. It was developed and approved by:

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Comments or suggestions from the users of the CEN-CENELEC Workshop Agreement are welcome and should be addressed to the CEN-CENELEC Management Centre.

## **Introduction**

Galileo is European's Global Satellite Navigation System (GNSS) which aims at providing improved positioning and timing application for many services and users. Galileo comprises several components, classified into:

- Space segment: Galileo constellation will include a total of 30 Medium Earth Orbit (MEO) satellites in a 24/3/1 Walker configuration, based on 24 operational satellites and including 6 spares. Each orbit has a nominal average semi-major axis of 29600 km and an inclination of 56 degrees with reference to the equatorial plane.
- Ground segment: refers to the stations and associated infrastructure which allow that the space segment provides its functionality. It is mainly comprised of two control centres and a global network of transmitting and receiving stations.
- User segment: it is composed by all the compatible receivers and devices which collected Galileo Signal-In-Space data and use it to compute their location.

## 1 Scope

The purpose of this document is to define a technical specification and the test suite in order to perform evaluation processes to guarantee that a product can be labelled as “Galileo Enabled”.

The main goal of the Galileo labelling scheme is to assess that user equipment uses Galileo in their location services and computes a PVT solution including Galileo input data. Therefore, the essential requirement for a product is to compute the GIPVT (Galileo Improved Position Velocity Time).

The scope of the document is Galileo capable products for mass market (including non-public regulated) applications using Galileo Open Service (OS). In the context of this CWA, mass market users are understood as non-safety/non-liability critical and non-professional users. Therefore, applications with safety/legal enforcement or economic implications are excluded from the scope of this document.

The considered products in this CWA are chipsets, terminals and applications.

**NOTE** Let us remark that this version of the CWA is based on current Galileo OS features which are already available for users and implemented in the products. Future evolutions on Galileo OS such as Galileo OS-NMA are not considered in this present version of the CWA.

## 2 References

D1.1 Galileo-Improved Performance Verification Blueprint

D1.2 Mock-ups of different Galileo enabled markings

Galileo Open Service Signal-In-Space Interface Control Document (OS-SIS ICD). Issue 1 Revision 3 December 2016

Galileo Open Service - Service Definition Document (OS-SDD). Issue 1 Revision 0 December 2016

## 3 Abbreviations and definitions

### 3.1 Abbreviations

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

ACC	GIPVT Position Accuracy
API	Application Programming Interface
APP	Application
AV	Availability
DOP	Dilution Of Precision
ECAC	European Civil Aviation Conference
GDOP	Geometric Dilution Of Precision
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HDOP	Horizontal Dilution Of Precision
HERR	Horizontal Error
HW	Hardware
KPI	Key Performance Indicator
LTE	Long Term Evolution

MT	Message Type
OS	Open Service
OS API	Operating System API
PVT	Position Velocity Time
R/O	Required/Optional
RF	Radio Frequency
RM	Raw Measurements
SDD	Service Definition Document
SIS	Signal In Space
SW	Software
UTC	Universal Time Coordinated
VDOP	Vertical Dilution Of Precision

## 3.2 Definitions

### 3.2.1 Integration levels

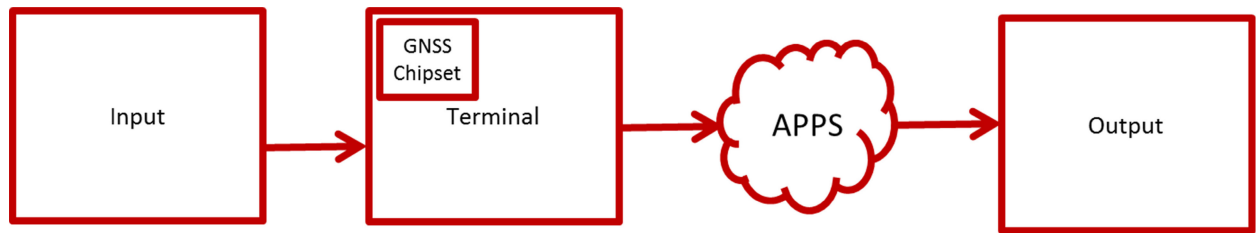
The products that can be labelled as “Galileo Enabled” may be classified into one of the following categories, or integration levels:

- GNSS chipset (first level): assumed to be the HW that receives GNSS SIS. The GNSS chipset may or may not compute the Galileo Improved PVT (GIPVT), but only those that compute it are eligible to be labelled as “Galileo Enabled”.
- Terminal (second level): assumed to the hardware with a GNSS chipset integrated, an operating system and optionally, libraries to compute the GIPVT. The terminal may or may not compute the GIPVT, but only those that compute it are eligible to be labelled as “Galileo Enabled”.
- Application (third level): assumed to be as pieces of software that are run on a terminal. The applications may or may not compute the GIPVT, but only those that compute it are eligible to be labelled as “Galileo Enabled”. The application integration level does not include the terminal, rather it interacts with the terminal through the Application Programming Interface (API).

Products may be labelled as “Galileo Enabled” at chipset level, at terminal level or at application level, depending of the kind of product they are. Additionally, a terminal that integrates a “Galileo Enabled” chipset may become “Galileo Enabled” as well by inheriting the label from the chipset it contains, as long as a simplified “Galileo Enabled” test procedure is passed by the terminal (please see 6.6.1).

A user would typically be interested in “Galileo Enabled” terminals, regardless of the level where the label was obtained (chipset or terminal level). Applications running on “Galileo Enabled” terminals will typically be using Galileo the positioning solution provided by the terminal, so they will not need to be labelled as “Galileo Enabled” as well. However, applications with specific needs may require computing their own Galileo positioning solution, and they could obtain the “Galileo Enabled” label at application level. Figure 1 represents the considered integration levels.





**Figure 1 — Integration levels**

### 3.2.2 Inputs

The main input for the integration levels are GNSS SIS received via RF by the GNSS antenna, and is used to elaborate the GNSS raw measurements and compute the PVT solution.

This input is applicable to all integration levels.

### 3.2.3 Outputs

The main output from the products is the following:

- GIPVT: is the PVT computed using Galileo information. This solution computation may be done at chipset, terminal or application level.

Additionally, the GNSS raw measurements may also be used as outputs at lower integration levels, so that the data might be processed at higher integration levels. For instance, the GNSS raw measurements may be an output at chipset level, so that the GIPVT can be computed at terminal or application level.

### 3.2.4 Interfaces

Depending on the integration level in which a product may be labelled, some of the following interfaces shall be needed:

- GNSS radio frequency antennas: the antenna that receives the radio signal from the environment. This antenna may be a patch antenna integrated in the chipset, or it may be separate and connected to the chipset for instance through a GNSS antenna port.
- GNSS antenna port: where an external antenna may be plugged in. This port may be used when the antenna is not an integrated antenna within the chipset, but an external antenna that is connected to the chip.
- Serial port: a digital serial port. It may be used to transfer data from one component to another, for instance and output from the chipset to the terminal.
- Network interface: it provides access to the internet, as for example WiFi, Ethernet, 3G, LTE and so on. It will be used mainly to retrieve Assisted GNSS data.
- Application Programming Interface (API): it specifies the way software elements interact with each other. In this case the terminal Operating System may allow general applications to receive information from the terminal.
- Dedicated files: applications may also write output files. This would be the case of application running in verbose mode, which generates a file containing GIPVT related information.

Section 6.3 includes some figures that clarify the relationship between the integration levels and the interfaces needed to be provided by the test environment.

## 4 General requirements

A series of key features have been selected to characterize the functionalities or processing capabilities of a “Galileo Enabled” device could have. These functionalities are the capabilities that the final consumer may appreciate, and are represented by a set of Key performance indicators (KPIs) which are the figures of merit than can be measured in the tests.

Section 4.1 presents the key features considered in the “Galileo Enabled” label while section 4.2 describes the corresponding KPIs. The relation between the KPIs and the key features is summarized in Table 22 in Annex B.

### 4.1 Key features

The key features that characterize the functionalities or processing capabilities of a “Galileo Enabled” device are:

- Generation of the GIPVT itself.
- Ionosphere error delay handling.
- Performance in urban environments.
- Smart processing of Galileo SIS flags sent through the Galileo navigation message.

### 4.2 Key Performance Indicators (KPI)

The defined KPIs are:

- Accuracy.
- Availability.
- Dilution of precision (DOP).

#### 4.2.1 Accuracy

GIPVT position accuracy (abbreviated as ‘ACC’) is the difference between the GIPVT position and the true position.

From the definition, several types of accuracy may be derived:

- Absolute accuracy: the distance between the GIPVT position and the true position.
- Horizontal accuracy: the horizontal distance between the GIPVT position and the true position.
- Vertical accuracy: the vertical distance between the GIPVT position and the true position.

This KPI may be given in a statistical way, as for example, at percentile 95 %<sup>1)</sup>, mean value, maximum value...

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<sup>1)</sup> The percentile 95 % means that 95 % of the positions calculated have an error lower or equal to the accuracy value. Example: having an accuracy of 5 m (95 %) means that in 95 % of the time the positioning error will be equal or below 5 m.

In order to measure the GIPVT position accuracy, the computed position has to be compared with the true, known position, along the scenario. Then, the statistical value in which the KPI is going to be expressed (i.e.: mean, min, max, median, percentile...) is recorded in the test log.

#### 4.2.2 Availability

The availability (abbreviated as 'AV') is the portion of time that the receiver is able to compute GIPVT solution meeting certain requirements.

Availability definition depends on requirements on the service to be considered "usable". The possible definitions are defined below:

- Availability based on the existence of an GIPVT solution: the equipment/receiver is considered to be available if the GIPVT is computed.
- Availability based on position accuracy: the equipment/receiver is considered to be available if the estimate of the position accuracy is below a given threshold.

The availability used, unless otherwise is specified, is "Availability based on the existence of an GIPVT solution".

The availability is measured by counting the number of available epochs along the test. Availability is expressed as the percentage of available epochs with respect to the total number of epochs, as shown in the following expression:

$$AV = \frac{numEpochs_{available}}{numEpochs_{total}} \times 100$$

#### 4.2.3 DOP

DOP describes the error caused by the relative position of GNSS satellites.

Several types of DOP may be derived:

- Geometric DOP (GDOP): measures the total error (in terms of position and timing) caused by the relative position of GNSS satellites.
- Horizontal DOP (HDOP): measures the horizontal error caused by the relative position of GNSS satellites.
- Vertical DOP (VDOP): measures the vertical error caused by the relative position of GNSS satellites.

This KPI may be given in a statistical way, as for example, at percentile 95 %, mean value, maximum value...

In order to measure the GIPVT DOP, the position of the satellites known from navigation data and the GIPVT need to be processed to compute the DOP. Then, the statistical value in which the KPI is going to be expressed (i.e.: mean, min, max, median, percentile...) is recorded in the test log.

## 5 Labelling

This section defines the requirements for the label "Galileo Enabled" according to integration levels.

### 5.1 Chipset

The following table shows the different inputs and outputs that a GNSS chipset could present.

**Table 1 — GNSS chipsets summary**

Chipset label	Input Galileo SIS	Output GNSS raw measurements	Output Galileo Improved PVT
<b>Galileo Enabled</b>	Required	Optional	Required
<b>Not Galileo Enabled</b>	Optional	Optional	No

## 5.2 Terminal

The following table shows the different inputs and outputs that a terminal could present.

**Table 2 — Terminals summary**

Terminal label	Input Galileo SIS	Output GNSS raw measurements	Output Galileo Improved PVT
<b>Galileo Enabled</b>	Required	Optional	Required
<b>Not Galileo Enabled</b>	Optional	Optional	No

## 5.3 Application

In this integration level, any location sensitive application could make use of a GIPVT solution provided by a “Galileo Enabled” terminal. The application only has the OS API as an interface with the other integration levels. Note that the application is independent from the terminal it is running on, as long as the terminal and the application use the same API. For this reason, the test set-up used to check if an application is “Galileo Enabled” could either be a physical terminal or an emulator.

Table shows the required inputs and outputs in a “Galileo Enabled” application.

**Table 3 — Applications summary**

Application label	Input Galileo raw measurements via API	Output GNSS raw measurements	Output Galileo Improved PVT
<b>Galileo Enabled</b>	Required	Optional	Required

## 5.4 Functionality for labelling

The required functionalities or processing capabilities for a device to be labelled are shown in this section.

The information about expected functionalities shown in the following tables is:

- Functionality block: in which the different capabilities are grouped.
- R/O: the functionality is required (R) or optional (O).
- Functionality: capability brief description.

Two functionality blocks are defined:

- Connectivity: related to the input and outputs of each integration level.
- Generation of GIPVT: aspects related directly with the GIPVT computation.

### 5.4.1 Galileo Enabled

These are the required and optional functionalities of the “Galileo Enabled” product:

**Table 4 — “Galileo Enabled” functionalities**

Functionality block	R/O	Functionalities
Connectivity	R	Acquisition of GNSS raw measurements
	R	Provision or use of GIPVT
Generation of GI-PVT	R	Generation of GIPVT
	O	Ionosphere delay handling
	O	Performance in urban environments
	O	Smart processing of Galileo SIS flags

## 6 Test conditions

This chapter describes the test procedures and test cases, in order to assess whether a product complies with the requirements for the “Galileo Enabled” label.

The label is associated to a verification test procedure, which needs to be followed in order to obtain the label. This procedure will determine which test cases are executed. The available procedures are the following:

- Test procedure 1: “Galileo Enabled”.
- Reduced test procedure 1: “Galileo Enabled” terminal containing a “Galileo Enabled” chipset.

### 6.1 Operation modes and configuration

The following product operation modes are required in a test:

#### 6.1.1 GPS-only mode

The products shall be configurable to provide a GPS-only positioning solution. This will be needed in the tests to provide a reference behaviour, which will be compared with the Galileo solution.

#### 6.1.2 GPS+GLONASS mode

The products shall be configurable to provide a GPS+GLONASS positioning solution in case GLONASS is available. This will be needed in the tests to provide a reference behaviour which will be compared with the Galileo solution.

#### 6.1.3 GPS+Galileo mode

The products shall be configurable to provide a GPS+Galileo positioning solution. As the only outputs of the tests are the KPIs, no hybrid location aids (e.g. accelerometers or mobile network positioning) should be used. Only GNSS positioning is allowed. Hybrid location aids would interfere with the evaluation of the Galileo capabilities implemented in the device and therefore should not be used during the tests.

#### 6.1.4 GPS+GLONASS+Galileo mode

The products shall be configurable to provide a GPS+GLONASS+Galileo positioning solution in case GLONASS is available. As the only outputs of the tests are the KPIs, no hybrid location aids (e.g. accelerometers or mobile network positioning) should be used. Only GNSS positioning is allowed.

Hybrid location aids would interfere with the evaluation of the Galileo capabilities implemented in the device and therefore should not be used during the tests.

## **6.2 Test modes**

### **6.2.1 Test mode for terminals**

During the tests, most terminals will probably be running third party applications, and will be tested using a “test application” in charge of collecting all the required output data.

However some application-specific terminals may not be able to run such generic applications, as for example specific on-board devices. In that case, the terminal shall be able to run in ‘test mode’, which means that all the required output data should be logged into dedicated files. This data logging is equivalent to the one performed by the ‘test application’.

### **6.2.2 Verbose mode for applications**

Some applications do not have any explicit output, regarding the GIPVT solution they are using. Typically, the application uses the GIPVT for any purpose, and it provides outputs related to the specific service supplied.

A ‘verbose mode’ is required for applications, so the used GIPVT and any other related information is provided as an output. This output is a file with a standardized format.

NOTE That this additional output would only be required at application level.

## **6.3 Test environment per integration level**

The test environment in which the product shall be tested depends on the integration level, as the test environment will need to provide different interfaces.

The tests are based on simulated data sets, to be performed in a laboratory. In this environment, all the inputs available for the product are controlled by the tester.

### **6.3.1 Chipset test environment**

In order to ease the chipset testing, chipsets may be integrated into test boards that include standard interfaces, such as serial RS-232, USB, and so on. This would decouple the chipset interfaces from the test’s ones. Additionally, the test board will allow configuring the chipset according to the manufacturer’s instructions.

In the “Galileo Enabled” tests for chipsets, chipsets that contain a GNSS antenna will be tested in a faraday cage that will provide the GNSS SIS, as shown in Figure 2. Chipsets that have a GNSS antenna input port will be connected to a signal generator that will provide the GNSS SIS as shown in Figure 3.

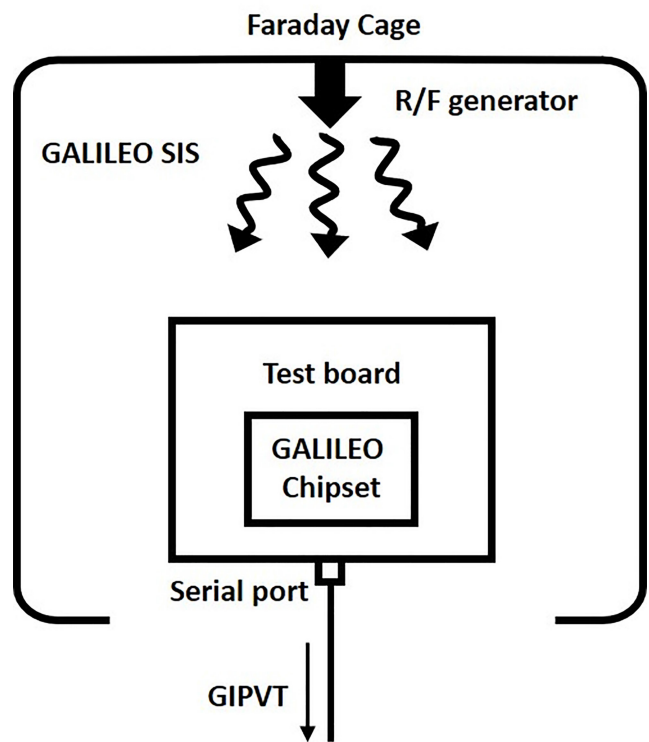


Figure 2 — Test environment for chipsets with GNSS antenna

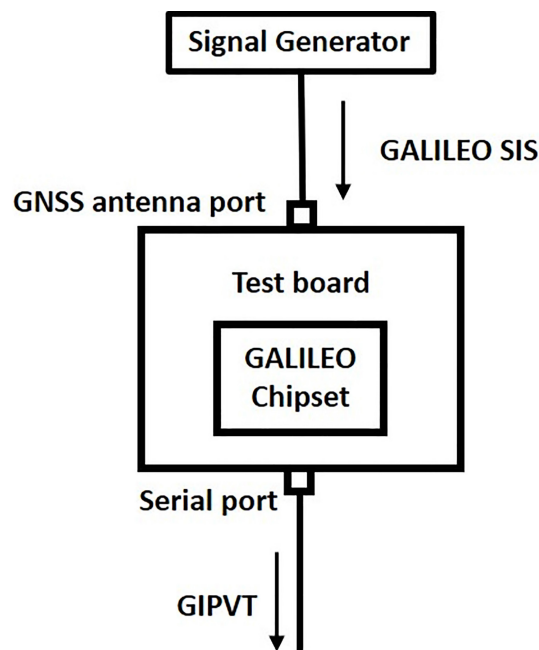


Figure 3 — Test environment for chipsets with GNSS antenna port

The test environment for chipsets is summarized in Table 5. Please note that, when a data flow that has several interfaces is marked as “Required”, it means that at least one of the interfaces needs to be used.

**Table 5 — Input/output interfaces in “Galileo Enabled” tests for GNSS chipset**

In / Out	Data flow	Required / Optional	Chipset Interface	Test set-ups
Input	GNSS SIS	Required	GNSS antenna	Faraday cage and R/F signal generator.
			GNSS antenna port	Signal generator with output in RF connector for the antenna port. Chipset for test installed in printed circuit with standardized antenna connector.
Output	GIPVT	Required	Serial port	Chipset for test installed in printed circuit with standardized antenna connector and protocols.

### 6.3.2 Terminal test environment

Most terminals will probably be running third party applications, as any smartphone would do. However, specific applications may implement an embedded solution where the application is inherent to the terminal, and running any other applications may not be feasible, for instance, on-board GNSS systems such as eCall. Therefore, two types of tests will be considered:

- Terminal running a test application: terminal testing would include a test application being run in the terminal, extracting all the needed data through the API and logging it, so that the test process will be transparent to the terminal.
- Terminal running in test mode: the terminal would be configured to run in test mode (see Section 6.2.1) so that logs by itself all the needed information, as the test application would have done in the previous case.

In the “Galileo Enabled” tests for terminals, the terminals must acquire the GNSS raw measurements and provide the GIPVT as output. These outputs are collected by the test application through the API and used for the performance analyses. Terminals that contain a GNSS antenna will be tested in a faraday cage that will provide the GNSS SIS, as shown in Figure 4. Terminals that have a GNSS antenna input port will be connected to a signal generator that will provide the GNSS SIS, as shown in Figure 5.



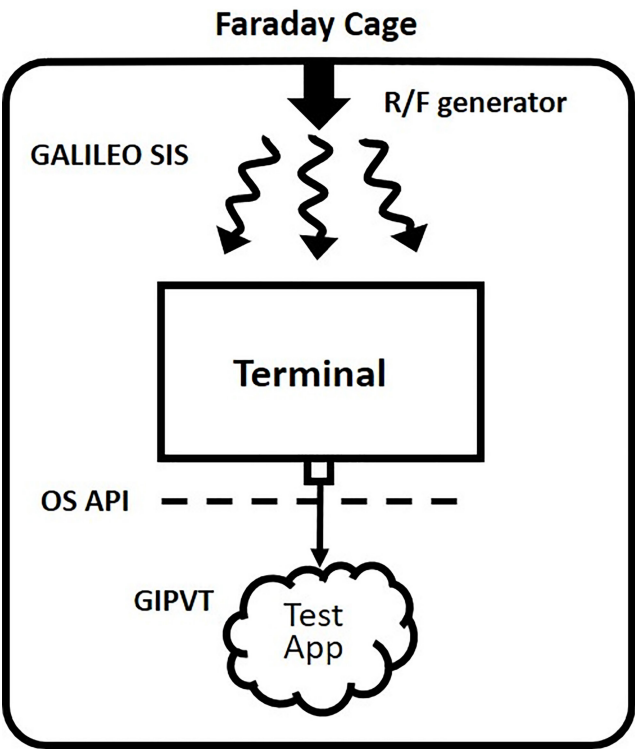


Figure 4 — Test environment for terminals with GNSS antenna

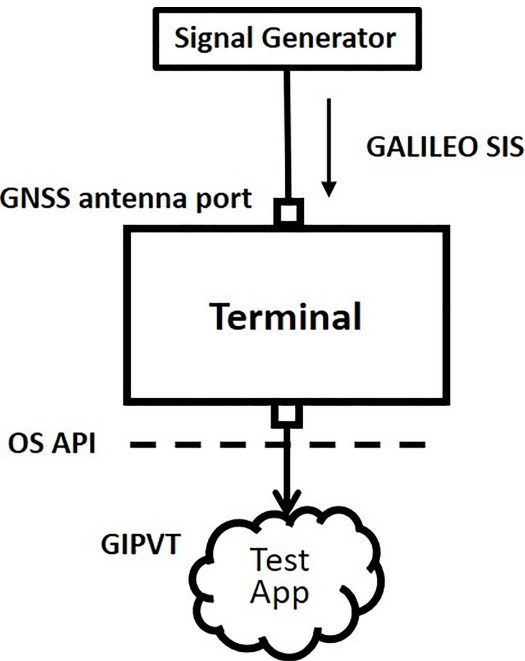


Figure 5 — Test environment for terminals with GNSS antenna port

The test environment for chipsets is summarized in Table 6. Please note that, when a data flow that has several interfaces is marked as “Required”, it means that at least one of the interfaces needs to be used.

**Table 6 — Input/output interfaces in “Galileo Enabled” tests for terminal**

In / Out	Data flow	Required / Optional	Interface	Test set-ups
Input	GNSS SIS	Required	GNSS antenna	Faraday cage and R/F signal generator.
			GNSS antenna port	Signal generator with output in RF connector for the antenna port. If the terminal does not include an antenna connector, a test terminal adapted for the test is needed.
Output	GIPVT	Required	API	Test application collecting output data and storing it in standardized file for later analysis.
			Dedicated File	Terminal running in test mode logs all the output data needed in standardized file for later analysis.

### 6.3.3 Application test environment

When the application is the one computing the GIPVT, instead of the terminal, it must be provided with the GNSS raw measurements. The application should run in “test mode” or “verbose mode”. This will record all the information relative to the used GIPVT, so that the performance analyses can be performed.

Please note that, when a data flow that has several interfaces is marked as “Required”, it means that at least one of the interfaces needs to be used.

**Table 7 — Input/output interfaces in “Galileo Enabled” tests for the application**

In / Out	Data flow	Required / Optional	Interface	Test set-ups
Input	GNSS raw measurements	Required	API	SW environment or terminal providing API mock-ups.
Output	GIPVT	Required	Dedicated file	The application must run in test mode (verbose mode, see Section 7.2.2).

### 6.4 Test cases

A set of test cases is defined in this section, in order to assess and evaluate the use of Galileo. These test cases follow the ‘black-box’ paradigm. They are based on simulated data sets that will reproduce specific stress conditions, and they will allow the tester to observe the product’s behaviour. Please note that the configuration settings considered in these tests may not occur frequently in real scenarios, as they are designed to reproduce specific stress conditions<sup>2)</sup>.

The following types of tests are defined:

- Galileo assessment and reference tests (AS): to ensure the use of Galileo and to be used as reference for the analysis of performances of degraded scenarios, used for the “Galileo Enabled” labelling procedure. Some of these tests have several requirements that must be fulfilled in order to obtain the “Galileo Enabled” label, regardless of the results in the performance tests.
- Galileo performance tests (PERFO): to analyse the level of performances achieved when using Galileo information, used for the “Galileo Enabled” labelling procedure.

<sup>2)</sup> Please let us note that these tests were defined using commercial GNSS simulation tools in the frame of a European Commission project carried out before the preparation of this CWA.

- Interface tests (IF): to assess the correct usage of the interface between the different components, only used in the “Reduced test procedure” for a terminal containing a “Galileo Enabled” chipset.

The tests will be named according to the type of tests (AS for assessment and reference tests; PERFO for performance tests, etc.) For each of the ‘assessment and reference’ and ‘performance’ test cases, the KPI values are evaluated and rated into a set of performance levels which depend on the goal for each test. Some tests may have only a performance level, but others may range from 1 (the lowest) to 3 (the highest), (see Annex A: Label). For a summary of the relation between KPI rating and tests, please refer to Table 22 in Annex B.

#### 6.4.1 Nominal conditions

This section details the nominal test conditions common to all scenarios, unless otherwise specified in the test. This configuration will be modified in the performance tests in order to reproduce specific stress conditions.

NOTE The nominal conditions for the tests were selected assuming a European scenario.

##### 6.4.1.1 GPS constellation

The GPS baseline constellation corresponds to the 24 satellites configuration as described in GPS SPS PS. Slots for the baseline 24-slot constellation are specified in terms of the Right Ascension of the Ascending Node (RAAN) and the Argument of Latitude for a defined epoch in Table 8. The corresponding Groundtrack Equatorial Crossing (GEC) values (also known as the Geographic Longitude of the Ascending Node [GLAN] values) are also provided in Table 8.

**Table 8 — Baseline 24-Slot GPS constellation slot assignments as of defined epoch (00:00:00 UTC, 1st July 1993)**

Slot	RAAN	Argument of Latitude	GEC (GLAN)
A1	272.847°	268.126°	127.85°
A2	272.847°	161.786°	74.68°
A3	272.847°	11.676°	179.63°
A4	272.847°	41.806°	14.69°
B1	332.846°	80.956°	94.27°
B2	332.846°	173.336°	140.46°
B3	332.846°	309.976°	28.78°
B4	332.846°	204.376°	155.98°
C1	32.847°	111.876°	169.73°
C2	32.847°	11.796°	119.69°
C3	32.847°	339.666°	103.62°
C4	32.847°	241.556°	54.57°
D1	92.847°	135.226°	135.226°
D2	92.847°	265.446°	126.51°
D3	92.847°	35.156°	11.37°
D4	92.847°	167.356°	77.47°
E1	152.847°	197.046°	152.31°

Slot	RAAN	Argument of Latitude	GEC (GLAN)
E2	152.847°	302.596°	25.09°
E3	152.847°	66.066°	86.82°
E4	152.847°	333.686°	40.63°
F1	212.847°	238.886°	53.23°
F2	212.847°	345.226°	106.40°
F3	212.847°	105.206°	166.39°
F4	212.847°	135.346°	1.46°

#### 6.4.1.2 GLONASS constellation

The GLONASS baseline constellation corresponds to the 24 satellites configuration as described in GLONASS ICD:

Satellites are placed in three orbital planes, with 8 satellites per plane. Longitudes of ascending nodes of orbit planes are discriminated on 120°. The orbital planes have ordinal numbers 1, 2 and 3 counting towards Earth rotation. The 1st orbital plane has slot numbers 1...8, the 2nd orbital plane – slots 9...16, and the 3rd orbital plane – slots 17...24. Slot numbers within orbital plane are increased backward satellite rotation around the Earth.

Nominal values of absolute longitudes of ascending nodes for ideal orbital planes fixed at 00 h 00 minutes 00 s MT (UTC + 03 h 00 min 00 s) on January 1st, 1983 are equal to:

$$251^{\circ} 15' 00'' + 120^{\circ} (i - 1),$$

where

“i” is orbital plane number (i = 1, 2, 3).

Nominal spacing between adjacent satellites within single orbital plane, according to argument of latitude, is equal to 45°.

Mean rate of orbital plane precession is equal to  $(-0.59251 \cdot 10^{-3})$  radian/day.

Ideal values of argument of latitude for satellites located in slots  $j = N+8$  and  $j = N+16$  differ from arguments of latitude for satellites located in slots  $j = N$  and  $j = N + 8$  by 15° correspondingly, where  $N = 1, \dots, 8$  also make on 0h00m00s on January 1st, 1983 and are equal to:

$$145^{\circ} 26' 37'' + 15^{\circ} (27 - 3j + 25j^*),$$

where

“j” is slot number (j = 1, 2, ..., 24);

$$j^* = E \left\{ \frac{j-1}{8} \right\} - \text{integer part of } \frac{j-1}{8} j$$

An interval of repetition for satellite tracks and visibility zones as observed on the ground is equal to 17 orbital periods (7 days 23 h 27 min 28 s). Nominal orbit parameters of the GLONASS system satellites are as follows:

Draconian period - 11 h 15 min 44 s;

Orbit altitude - 19100 km;

Inclination - 64.8°;

Eccentricity - 0.

Maximum deviation of a satellite position relative to ideal slot position does not exceed 5° on the period of lifetime.

#### 6.4.1.3 Galileo constellation

The Galileo constellation is composed of 24 satellites in Medium Earth Orbit (MEO) around the Earth, as defined in Galileo Open Service SDD.

The orbital parameters of the Galileo satellites are summarized in Table 9.

**Table 9 — Baseline 24-Slot Galileo constellation**

SV ID	Semi-major Axis (m)	Eccentricity	Inclination Angle	Right Ascension of ascending node	Argument of perigee	Mean anomaly
1	29599.801 m	0	56	317.632	0	180.153
2	29599.801 m	0	56	317.632	0	225.153
3	29599.801 m	0	56	317.632	0	270.153
4	29599.801 m	0	56	317.632	0	315.153
5	29599.801 m	0	56	317.632	0	0.153
6	29599.801 m	0	56	317.632	0	45.153
7	29599.801 m	0	56	317.632	0	90.153
8	29599.801 m	0	56	317.632	0	135.153
9	29599.801 m	0	56	77.632	0	195.153
10	29599.801 m	0	56	77.632	0	240.153
11	29599.801 m	0	56	77.632	0	285.153
12	29599.801 m	0	56	77.632	0	330.153
13	29599.801 m	0	56	77.632	0	15.153
14	29599.801 m	0	56	77.632	0	60.153
15	29599.801 m	0	56	77.632	0	105.153
16	29599.801 m	0	56	77.632	0	150.153
17	29599.801 m	0	56	197.632	0	210.153
18	29599.801 m	0	56	197.632	0	255.153
19	29599.801 m	0	56	197.632	0	300.153
20	29599.801 m	0	56	197.632	0	345.153
21	29599.801 m	0	56	197.632	0	30.153
22	29599.801 m	0	56	197.632	0	75.153
23	29599.801 m	0	56	197.632	0	120.153
24	29599.801 m	0	56	197.632	0	165.153

#### 6.4.1.4 Satellite information (ephemeris)

The satellites broadcast ephemeris information, which may be modified in some tests to artificially introduce errors and reproduce specific stress conditions. In the nominal conditions the following key information is provided:

- Clock errors in ephemeris approximately correspond to the clock errors in the satellites.
- Galileo navigation message contains the NeQuick parameters to help to compute the ionospheric delay corrections for single frequency users.

#### **6.4.1.5 User (receiver)**

The nominal conditions regarding the user conditions are:

- Static (not in movement).
- Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### **6.4.1.6 RF signal conditions**

The test signals presented to the equipment under test shall ensure that there are no message losses. In order to do so, the maximum signal-in-space power of  $-119.5$  dBm, as defined in specific professional standards, could be used. The aim of the tests is to reproduce certain stress conditions, in which the RF power and the interferences are not a key factor.

The RF signals are available to the user equipment with a  $5^\circ$  mask angle clearance, as in an open sky environment.

### **6.4.2 Galileo Assessment and reference test cases**

#### **6.4.2.1 Test case TC-AS-01: Nominal No-Galileo**

This test obtains the values for each KPI under nominal conditions using the device under test removing Galileo from its configuration mode. These values are used as a reference.

By nominal conditions it is understood that ephemeris, interference, multipath, ionospheric and tropospheric conditions at all user site are assumed to be nominal.

The KPI values obtained in this test will be used as a reference in other tests, and they will be referred to as 'SC-AS-01'.

##### **6.4.2.1.1 Test case conditions**

Input for this test case is SC-AS-01 scenario, which is defined as follow:

- Duration: 6 h.
- Constellation (2):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: Nominal (open sky).
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:

- Type: Static.
- Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### 6.4.2.1.2 KPI rating

The following KPI is measured in this test:

- Position accuracy (ACC) by measuring the Horizontal Error (HERR percentile 95th) in meters.

Please note that the KPI values obtained in this test will be used as a reference in other tests, and they will be referred to as 'SC-AS-01'. The KPIs may additionally be used in the assessment verification of this test.

#### 6.4.2.1.3 Assessment requirements

The following assessment requirement must be fulfilled for the "Galileo Enabled" label:

- HERR (95 %) must be **lower than 20 m**.

#### 6.4.2.2 Test case TC-AS-02: Nominal No-Galileo for dynamic user

This test obtains the values for each KPI for a dynamic user using the device under test without considering Galileo. These values will be used as reference.

The KPI values obtained in this test will be used as a reference in other tests, and they will be referred to as 'SC-AS-02'.

##### 6.4.2.2.1 Test case conditions

Input for this test case is SC-AS-02 scenario, which is defined as follows (same as SC-AS-01 but in dynamic mode):

- Duration: 6 h.
- Constellation (2):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: Nominal (open sky).
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Dynamic with velocity 40 km/h in north direction.
  - Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### **6.4.2.2.2 KPI rating**

The following KPIs are measured in this test:

- Position accuracy (ACC) by measuring the Horizontal Error (HERR percentile 95th) in meters.
- DOP by measuring the Horizontal DOP (HDOP percentile 95th).

Please note that some of the KPI's performances achieved by executing this test will be used as reference for some of the following tests and will be referred as 'SC-AS-02' These KPIs may additionally be used in the assessment verification of this test.

#### **6.4.2.2.3 Assessment requirements**

The following assessment requirements must be fulfilled to "Galileo Enabled" label:

- HERR (percentile 95th) must **be lower than 20 m**.

#### **6.4.2.3 Test case TC-AS-03: Basic Galileo performance**

This test obtains, using the device under test in Galileo mode, the values for each KPI under nominal conditions. These values will be used:

- To ensure the use of Galileo by the device under test, by comparing the level of performances achieved with those obtained in the same scenario (nominal conditions) but without using Galileo (TC-AS-01: Nominal No-Galileo).
- As a reference (referred to as 'SC-AS-03'), in order to be later compared with the ones obtained under degraded conditions and to evaluate the observed degradation, of any.

##### **6.4.2.3.1 Test case conditions**

Input for this test case is SC-AS-03 scenario, which is defined as follows (the main difference with respect SC-AS-01 is the inclusion of Galileo):

- Duration: 6 h.
- Constellation (3):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: Nominal (open sky).
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Static.



- Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### 6.4.2.3.2 KPI rating

The following KPI are measured in this test, although only the DOP is rated as part of this test:

- Position accuracy (ACC) by measuring the Horizontal Error (HERR percentile 95th) in meters.
- DOP by measuring the Horizontal DOP (HDOP percentile 95th).

Some of the KPI's performances achieved by executing this test will be used as reference in other tests, and they will be referred to as 'SC-AS-03'. The KPIs may also be compared to the performance levels distribution provided below, compared against the performances (HDOP\_95 %) achieved in TC-AS-01: Nominal No-Galileo. The KPI ratings will depend whether the reference scenario processes GLONASS or not.

**Table 10 — KPI ratings in TC-AS-03: Basic Galileo performance:  
GPS-only reference**

KPI	Level 1	Level 2	Level 3
DOP	$\leq \text{SC-AS-01}$	$\leq 0.8 * \text{SC-AS-01}$	$\leq 0.7 * \text{SC-AS-01}$

**Table 11 — KPI ratings in TC-AS-03: Basic Galileo performance:  
GPS+GLONASS reference**

KPI	Level 1	Level 2	Level 3
DOP	$\leq \text{SC-AS-01}$	$\leq 0.9 * \text{SC-AS-01}$	$\leq 0.8 * \text{SC-AS-01}$

#### 6.4.2.3.3 Assessment requirement

The following assessment requirement must be fulfilled to "Galileo Enabled" label:

- At least the **position accuracy Level 1 performance must be reached**.

#### 6.4.2.4 Test case TC-AS-04: No Galileo Ionosphere error correction

This test obtains using the device under test in Galileo mode, the values for each KPI under nominal conditions. These values will be used as a reference for the ionosphere delay errors, to ensure some kind of Galileo ionosphere error delay processing.

The KPI values obtained in this test will be used as a reference in other tests, and they will be referred to as 'SC-AS-04'.

##### 6.4.2.4.1 Test case conditions

Input for this test case is SC-AS-04 scenario, which is defined as follows (same as SC-AS-03 but with a specific configuration on Galileo ionosphere and ensuring GLONASS is not included):

- Duration: 6 h.
- Constellation (2):
  - Full GPS constellation (24 satellites).
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions: Nominal.

- Environmental conditions:
  - Multipath conditions: Nominal (open sky).
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday), but NeQuick parameters in the Galileo navigation messages are set to 0 to force worse accuracies on Galileo (equivalent to not ionosphere correction). Also, inclusion of measurements from one single frequency for the Galileo satellites.
- Additional connectivity: Not available.
- User information:
  - Type: Static.
  - Initial location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### **6.4.2.4.2 KPI rating**

The following KPI is measured in this test:

- Position accuracy (ACC) by measuring the Horizontal Error (HERR percentile 95th) in meters.

This test is only to obtain the reference values to be used later in the TC-PERFO-01: Galileo ionosphere error handling test. Therefore, no rating will be done as part of this test.

#### **6.4.2.4.3 Assessment requirements**

No assessment requirements are needed in this test.

#### **6.4.2.5 TC-AS-05: No Galileo urban conditions**

This test obtains the values for each KPI for a user under urban conditions without considering Galileo. These values will be used as reference, in order to be later compared with the ones obtained with the same scenario using Galileo, to evaluate the observed degradation.

The KPI values obtained in this test will be used as a reference in other tests, and they will be referred to as 'SC-AS-05'.

##### **6.4.2.5.1 Test case conditions**

Input for this test case is SC-AS-05 scenario, which is defined as follows (same as SC-AS-01 but with a specific configuration on the multipath):

- Duration: 6 h.
- Constellation (2):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: degraded (urban canyon) conditions represented with a 30° mask angle.

- Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- Additional connectivity: Not available.
- User information:
  - Type: Static.
  - Initial location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### 6.4.2.5.2 KPI rating

The following KPIs are measured in this test:

- Position accuracy (ACC) by measuring the Horizontal Error (HERR percentile 95th) in meters.
- Availability (AV), understood in this context as the percentage of time when it is feasible to compute a PVT solution.

KPI's performances achieved by executing this test will be used as reference for some of the following tests and referred to as 'SC-AS-05'. The KPIs may additionally be used in the assessment verification of this test.

#### 6.4.2.5.3 Assessment requirements

The following assessment requirement must be fulfilled to "Galileo Enabled" label:

- Availability must be **greater than the 10 %**.

### 6.4.3 Galileo Performance test cases

#### 6.4.3.1 Test case TC-PERFO-01: Galileo ionosphere error handling

This test analyses the ability of the Galileo processing implemented in the device under test to implement any kind of ionosphere error delay modelling (e.g. Klobuchar, NeQuick or Dual frequency). The achieved values for the KPIs under analysis in this test will be used to analyse the level of performances achieved by the device, by comparing the KPI values with those obtained by the device in reference conditions (no Galileo ionosphere corrections).

##### 6.4.3.1.1 Test case conditions

Input for this test case is SC-PERFO-01 scenario, which is defined as follows (the main difference with respect SC-AS-04 are the configurability of the ionosphere conditions for Galileo):

- Duration: 6 h.
- Constellation (2):
  - Full GPS constellation (24 satellites).
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: Nominal (open sky).

- Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- Additional connectivity: Not available.
- User information:
  - Type: Static.
  - Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### 6.4.3.1.2 KPI rating

The following KPI is evaluated in this test:

- Position accuracy (ACC) by measuring the Horizontal Error (HERR percentile 95th) in meters.

**Table 12 — KPI ratings in TC-PERFO-01: Galileo ionosphere error handling**

KPI	Level 1	Level 2	Level 3
ACC	$\leq 0.8 \cdot \text{SC-AS-04}$	$\leq 0.5 \cdot \text{SC-AS-04}$	$\leq 0.1 \cdot \text{SC-AS-04}$

#### 6.4.3.2 Test case TC-PERFO-02: Dynamic user processing Galileo

This test analyses the performances achieved by the device under test in dynamic conditions. The objective is achieved by evaluating the values for each KPI under analysis and their possible degradation from the performances achieved by a dynamic receiver using the same scenario, but without Galileo.

##### 6.4.3.2.1 Test case conditions

Input for this test case is SC-PERFO-02 scenario, which is defined as follows (same as SC-AS-02 but including Galileo):

- Duration: 6 h.
- Constellation (3):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: Nominal (open sky).
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Dynamic with velocity 40 km/h in north direction.
  - Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

### 6.4.3.2.2 KPI rating

The following KPI is evaluated in this test:

- DOP by measuring the Horizontal DOP (HDOP percentile 95th).

KPI's performances achieved by executing this test will be compared to the performance levels distribution provided below, compared against the performances (HERR\_95 %) achieved in TC-AS-02: Nominal No-Galileo for dynamic user:

**Table 13 — KPI ratings in TC-PERFO-02: Dynamic user processing Galileo:  
GPS-only reference**

KPI	Level 1	Level 2	Level 3
DOP	$\leq \text{SC-AS-02}$	$\leq 0.8 * \text{SC-AS-02}$	$\leq 0.7 * \text{SC-AS-02}$

**Table 14 — KPI ratings in TC-PERFO-02: Dynamic user processing Galileo:  
GPS+GLONASS reference**

KPI	Level 1	Level 2	Level 3
DOP	$\leq \text{SC-AS-02}$	$\leq 0.9 * \text{SC-AS-02}$	$\leq 0.8 * \text{SC-AS-02}$

### 6.4.3.3 Test case TC-PERFO-03: Urban

This test analyses the ability of the Galileo to improve the user performance under degraded conditions. The achieved values for the KPIs under analysis in this test will be used to analyse the level of performances achieved by the device, by comparing the KPI values with those obtained by the device in nominal conditions.

#### 6.4.3.3.1 Test case conditions

Input for this test case is SC-PERFO-03 scenario, which is defined as follows (let us remark that the main difference with respect SC-AS-05 is the inclusion of Galileo):

- Duration: 6 h.
- Constellation (3):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
  - Full Galileo constellation: (24 satellites).
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: Degraded (urban canyon) conditions represented with a 30° mask angle.
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Static.

- Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### 6.4.3.3.2 KPI rating

The following KPI is evaluated in this test:

- Position accuracy (ACC) by measuring the Horizontal Error (HERR percentile 95th) in meters.
- Availability (AV), understood in this context as the percentage of time when it is feasible to compute a GIPVT solution.

KPI's performances achieved by executing this test will be compared to the performance levels distribution provided below, compared against the performances achieved in TC-AS-05: No Galileo urban conditions:

**Table 15 — KPI ratings in TC-PERFO-03: Urban in GPS+Galileo**

KPI	Level 1	Level 2
ACC		$\leq 0.5 \cdot \text{SC-AS-05}$
AV	$\leq \text{SC-AS-05}$	

**Table 16 — KPI ratings in TC-PERFO-03: Urban in GPS+GLONASS+Galileo**

KPI	Level 1	Level 2
ACC		$\leq 0.5 \cdot \text{SC-AS-05}$
AV	$\leq \text{SC-AS-05}$	

The availability performance is only used to assess Level 1 performance, whereas accuracy aspects are only taken into account for Level 2 rating.

#### 6.4.3.4 Test case TC-PERFO-04: Galileo SHS SIS flags processing

This test analyses the ability of the receiver to process correctly the SHS SIS status flags from Galileo navigation message. The achieved values for the KPIs under analysis in this test will be used to analyse the level of performances achieved by the device, by comparing the KPI values with those obtained by the device in nominal conditions.

##### 6.4.3.4.1 Test case conditions

Input for this test case is SC-PERFO-04 scenario, which is defined as follows (let us remark that the main difference with respect SC-AS-03 are the multipath environmental conditions):

- Duration: 6 h.
- Constellation (3):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions:
  - Galileo configuration:

- In four satellites, random integer values in the SHS value ranging from 1 to 3.
- Environmental conditions:
  - Multipath conditions: Nominal (open sky).
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Static.
  - Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### 6.4.3.4.2 KPI rating

The following KPI is evaluated in this test:

- DOP by measuring the Horizontal DOP (HDOP percentile 95th).

KPI's performances achieved by executing this test will be compared to the performance levels distribution provided below, compared against the performances achieved in TC-AS-03: Basic Galileo performance:

**Table 17 — KPI ratings in TC-PERFO-04: Galileo SHS SIS flags processing**

KPI	Level 1
DOP	$\geq$ SC-AS-03

#### 6.4.3.5 Test case TC-PERFO-05: Galileo DVS SIS flags processing

This test analyses the ability of the receiver to process correctly the DVS SIS status flags from Galileo navigation message. The achieved values for the KPIs under analysis in this test will be used to analyse the level of performances achieved by the device, by comparing the KPI values with those obtained by the device in nominal conditions.

##### 6.4.3.5.1 Test case conditions

Input for this test case is SC-PERFO-05 scenario, which is defined as follows (let us remark that the main difference with respect SC-AS-03 are the multipath environmental conditions):

- Duration: 6 h.
- Constellation (3):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions:
  - Galileo configuration:
    - In different four satellites, DVS value set to 1.

- Environmental conditions:
  - Multipath conditions: Nominal (open sky).
  - Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Static.
  - Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### **6.4.3.5.2 KPI rating**

The following KPI is evaluated in this test:

- DOP by measuring the Horizontal DOP (HDOP percentile 95th).

KPI's performances achieved by executing this test will be compared to the performance levels distribution provided below, compared against the performances achieved in TC-AS-03: Basic Galileo performance:

**Table 18 — KPI ratings in TC-PERFO-05: Galileo DVS SIS flags processing**

KPI	Level 1
DOP	≥ SC-AS-03

#### **6.4.3.6 Test case TC-PERFO-06: Galileo SISA SIS flags processing**

This test analyses the ability of the receiver to process correctly the SISA SIS status flags from Galileo navigation message. The achieved values for the KPIs under analysis in this test will be used to analyse the level of performances achieved by the device, by comparing the KPI values with those obtained by the device in nominal conditions.

##### **6.4.3.6.1 Test case conditions**

Input for this test case is SC-PERFO-06 scenario, which is defined as follows (let us remark that the main difference with respect SC-AS-03 are the multipath environmental conditions):

- Duration: 6 h.
- Constellation (3):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions:
  - Galileo configuration:
    - In different four satellites, SISA set to 255.
- Environmental conditions:



- Multipath conditions: Nominal (open sky).
- Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Static.
  - Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### 6.4.3.6.2 KPI rating

The following KPI is evaluated in this test:

- DOP by measuring the Horizontal DOP (HDOP percentile 95th).

KPI's performances achieved by executing this test will be compared to the performance levels distribution provided below, compared against the performances achieved in TC-AS-03: Basic Galileo performance:

**Table 19 — KPI ratings in TC-PERFO-06: Galileo SISA SIS flags processing**

KPI	Level 1
DOP	$\geq$ SC-AS-03

#### 6.4.4 Interface tests

##### 6.4.4.1 Test Case TC-IF-01: Interface test

This test is only used to assess that the product's interfaces are properly implemented, generating a GIPVT as an output.

The configurability of the GNSS constellations for this scenario depends on whether the product under test processes GLONASS or not. Therefore, two possible configurations are considered depending on such feature.

##### 6.4.4.1.1 Input scenario

Input for this test case is SC-IF-01 scenario, which is defined as follows (same as SC-AS-03 but with reduced duration):

- Duration: 30 min.
- Constellation (3):
  - Full GPS constellation (24 satellites).
  - Full GLONASS constellation (24 satellites). This will only be included if the product under test processes GLONASS.
  - Full Galileo constellation (24 satellites).
- Satellites information (ephemeris) conditions: Nominal.
- Environmental conditions:
  - Multipath conditions: Nominal (open sky).

- Ionosphere conditions: Nominal ECAC ionosphere conditions (midday).
- User information:
  - Type: Static.
  - Location: Central zone of the ECAC (longitude = 10°E, latitude = 50°N).

#### **6.4.4.1.2 KPI rating**

As stated before, this scenario is conceived only for interface tests. Thus, KPIs are not evaluated in order to determine performance levels.

#### **6.4.4.1.3 Interface requirements**

The functional verification that needs to be done is:

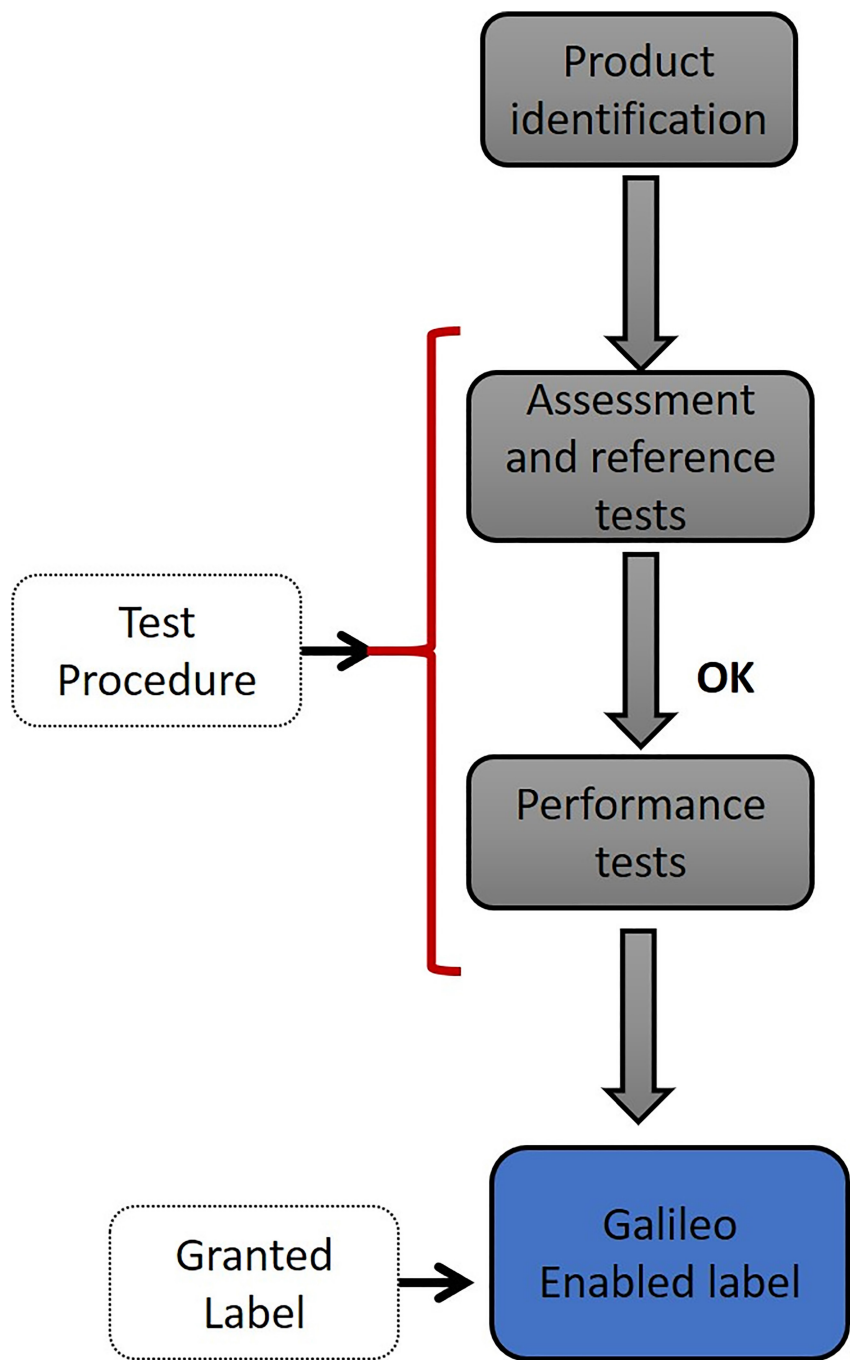
- Check that a GIPVT is provided as an output.

### **6.5 General test procedures**

This chapter describes the general test procedure. An additional test procedure for specific cases is described in section 7.6.

The overview of the general procedure is:

- i) Product identification.
- ii) Test cases:
  - a) Assessment and reference tests.
  - b) Performance tests.
- iii) Label granted.



**Figure 6 — Labelling process diagram**

The applicability of these test procedures to the different integration levels is traced in Table 20, where it is shown that the reduced test procedure is only applicable to terminals.

**Table 20 — Trace of test procedures to integration levels**

Label	Test procedure	Applicable to chipset	Applicable to terminal	Applicable to application
Galileo Enabled	Test procedure: “Galileo Enabled”	X	X	X
	Reduced test procedure “Galileo Enabled” terminal containing an “Galileo Enabled” chipset		X	

**6.5.1 Identification of Product Under test**

In order to test a device or application, the supplier must provide the following information:

- To document the kind of device/application, and which of the three integration levels it corresponds to (chipset, terminal or application). This step shall also document whether the product processes GLONASS or not so that products eligible to be granted with a “Galileo Enabled” label are not penalized in case GLONASS is not processed by such products.
- To state that all the requested operating modes (see Clause 6.1) are implemented, and document the configuration steps if any.
- To specify all the input/output interfaces of the product, in order to conclude that the device/application is suitable to be tested in one of the test environments (see Clause 6.3).
- To specify if there is any “Galileo Enabled” element integrated in the device, and provide related documentation.

**6.5.2 Test Procedure 1: “Galileo Enabled”**

The procedure steps are the following:

- 1) Identification of the product under test (see Clause 6.5.1). Assess whether GLONASS is processed or not by the product under test to consider such information during the test procedure.
- 2) Prepare the test environment (see Clause 6.3).
- 3) Run the following Galileo assessment and reference test cases:
  - a) Test Case TC-AS-01: Nominal No-Galileo.
  - b) Test Case TC-AS-02: Nominal No-Galileo for dynamic user.
  - c) Test Case TC-AS-03: Basic Galileo performance.
  - d) Test Case TC-AS-04: No Galileo Ionosphere error correction.
  - e) Test Case TC-AS-05: No Galileo urban conditions.
- 4) Verify that the assessment requirements detailed in the tests are met. If not, the procedure ends and the product is not labelled as “Galileo Enabled”.
  - a) Optionally, a declaration of conformity (understood as the statement of conformity issued by a first party) could be provided by the manufacturer in order to prove that Galileo is used in the computation of the GIPVT. Then these assessment requirements, included in the tests in the previous step, would be considered to be satisfied.

- 5) Run the performance tests:
  - a) Test Case TC-PERFO-01: Galileo ionosphere error handling.
  - b) Test Case TC-PERFO-02: Dynamic user processing Galileo.
  - c) Test Case TC-PERFO-03: Urban.
  - d) Test Case TC-PERFO-04: Galileo SHS SIS flags processing.
  - e) Test Case TC-PERFO-05: Galileo DVS SIS flags processing.
  - f) Test Case TC-PERFO-06: Galileo SISA SIS flags processing
- 6) In each scenario, measure all the KPIs identified in Clause 4.2, and evaluate them following “KPI ratings” specified in each scenario, when applicable.
- 7) Based on the rated KPIs per scenario, determine the “Galileo Enabled” label achieved, according to the labelling scheme.

For a summarized view of the relation between rated KPIs and test cases, please refer to Table 22 in Annex B.

## **6.6 Reduced test procedure in case of integration with other labelled items**

A simplified test procedure, instead of the general procedure, is only applicable to specific products: terminal testing when an “Galileo Enabled” chipset is integrated in the device. Therefore, this procedure is not applicable to chipsets or applications.

### **6.6.1 Reduced Test Procedure 1: “Galileo Enabled” Terminal containing a “Galileo Enabled” GNSS Chipset**

This reduction applies specifically where an “Galileo Enabled” GNSS chipset is integrated within the terminal. Chipset computes internally the GIPVT and provides it to the terminal level.

The chipset performances must have been evaluated at the chipset’s labelling tests.

The test reduction consists on a simplification of the “Test Procedure 1: Galileo Enabled” (see Clause 6.5.2).

This procedure is reduced to an interface and documentation inspection. The steps are the following:

- 1) Identification of the product under test (see Clause 6.5.1). Assess whether GLONASS is processed or not by the product under test to consider such information during the test procedure.
- 2) Prepare the test environment (see Clause 6.3).
- 3) Run the following test cases:
  - a) Test Case TC-IF-01: Interface test.
- 4) Verify that the interface requirements detailed in the test are met. If not, the procedure ends and the product is not labelled as “Galileo Enabled”.
- 5) The supplier must provide a declaration of conformity (understood as the statement of conformity issued by a first party), stating that the output GIPVT is the one obtained directly from the chipset.

- 6) Performances are assumed to be the same ones obtained by the chipset. Therefore, the terminal shall “inherit” the same “Galileo Enabled” label obtained by the chipset.

## Annex A

### Label

This section explains the labelling system. The only label considered in this document is “Galileo Enabled”, suitable for any product (chipset, terminal or application) that computes the GIPVT.

The terminology used in the labelling system is:

- **Level:** is related to performance achievement, regarding a specific KPI or a more general aspect, like the overall product's performance. It is an indicator in range from 1 to 5.
- **Level 1:** The labelling system is intended to be simple and easy to be compliant with, for the least restrictive levels. This first should be achievable by any receiver that uses the Galileo information for the computation of an GIPVT, and thus, minimum level of performances is requested.
- **Level 2:** This is intermediate low-end rate is intended to represent the current state of art receiver performances. This level of performance should be achieved by most of the already existing Galileo receivers. Therefore the performance requirements are not too restrictive.
- **Level 3:** This intermediate label is intended to represent the high-end receivers in current state of art. For this level, the performance requirements are quite demanding.
- **Level 4:** This is the intermediate high-end level, which provides advanced performances. This level should only be achieved by products that implement further processing, improved algorithms, smart managing of information, and similar innovations. This level should be a reachable goal that would foster innovation among manufacturers.
- **Level 5:** The highest level of “Galileo Enabled” devices should excel in performances, even under the most demanding and adverse conditions. The required capabilities and performances may not be achievable by today's devices, but should serve as a goal, as a motivation that would foster further innovation, competition and excellence among manufacturers.
- **Label:** is the final “Galileo Enabled” tag that will be granted to the product, which reflects the level of performance.

## Annex B

### Labelling Scheme: 2-step global labelling





In the frame of ECCAPS SC8 project, several labelling schemes have been proposed. In this document the recommended scheme is presented: “2-step global labelling”.

In the “2-step global labelling” scheme, in a first step, from the KPI ratings in each scenario, a global KPI is derived using the lowest value, the average. Then, from the scores of each KPI, a global label is selected.

In the Galileo Enabled a weighted approach is used, taking into account different weights depending on the level of importance given to each of the key features.

The “Galileo Enabled” labelling process consists on the analysis of the different key features individually, in which a score over 1 would be given. The analysis on how each key feature is scored individually is described in Sections B.1, B.2, B.3, B.4, B.5.

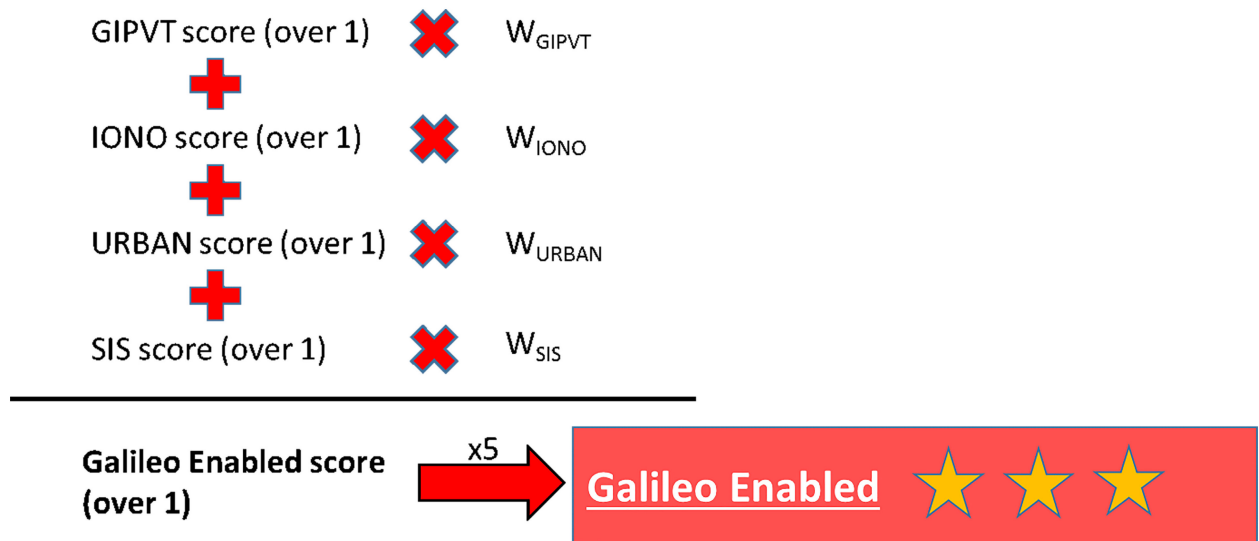
An example of this scheme is shown hereafter:

	Level 1	Level 2	Level 3	
<b>Provision/Generation of GIPVT</b>	✗	✗		 GIPVT score (over 1)
<b>Ionosphere delay handling</b>	✗			 IONO score (over 1)
<b>Performance in urban environment</b>				 URBAN score (over 1)
<b>Smart processing of Galileo SIS flags</b>	✗			 SIS score (over 1)

**Figure 7 — Example of Labelling Scheme (1)**

After that, the score of each key factor will be weighted according to a pre-defined weighting factors which are described below, to obtain a global score over 5. The integer resulting number (round down) will determine the type of label (e.g. number of stars) to be granted.





**Figure 8 — Example of Labelling Scheme (2)**

The selection of the weighting factors has been driven to foster those key features that are considered to be very relevant for mass-market receivers. For this reason, the following weighting factors between 1 (the lowest) and 4 (the largest) have been chosen for the “Galileo Enabled” label:

- Provision/generation of GIPVT: this is considered a relevant feature to be implemented by “Galileo Enabled” products, so a value of 2 over 10 has been selected.
- Ionosphere delay handling: an advanced ionosphere delay processing is considered one of the advanced improvements to be rewarded by the Galileo labelling. For this reason, it is set more weight (3 over 10) on this feature rather in comparison to the previous one.
- Performance in urban environment: this is one of the most demanded key features for mass-market users. Therefore, this key feature has been assigned with also the largest weighting factor, a total of 3 over 10.
- Smart processing of Galileo SIS flags sent through the Galileo navigation message, this is not considered a driver feature as ionosphere or urban processing, a value of 2 over 10 is assumed for this aspect.

**Table 21 — Weighting factors per key feature**

Key feature	Weighting factor
Provision/generation of GIPVT	0.2
Ionosphere delay handling	0.3
Performance in urban environment	0.3
Smart processing of Galileo SIS flags	0.2

A summary of the relation between the tests, the KPIs and the key features is provided in Table 22.

**Table 22 — Trace of features to KPI and tests**

Key feature	KPI	Tests
Provision/generation of GIPVT	DOP ACC	TC-AS-03: Basic Galileo performance (DOP) TC-PERFO-02: Dynamic user processing Galileo
Ionosphere delay handling	ACC	TC-PERFO-01: Galileo ionosphere error handling (ACC)
Performance in urban environment	AV ACC	TC-PERFO-03: Urban (AV+ACC)
Smart processing of Galileo SIS flags	DOP	TC-PERFO-04: Galileo SIS flags processing (DOP)

The following subsections provide, for each identified key feature, the test's level requirements that should be complied by the device under test to achieve a certain level of performance.

### B.1 Provision/generation of GIPVT

This key feature considers three different levels of performance.

The following table provides the test results taking into account to measure this key feature, including the levels of performances identified for each of them.

**Table 23 — Trace of tests to measure Provision/generation of GIPVT**

Test Case	Level 1	Level 2	Level 3
TC-AS-03	Level 1 GIPVT	Level 2 GIPVT	Level 3 GIPVT
TC-PERFO-02	Level 1 GIPVT	Level 2 GIPVT	Level 3 GIPVT

In order to compute the GIPVT score (over 1), a maximum of two levels are considered:

- A score of 1/2 is given if Level 1 is achieved in TC-AS-03 and TC-PERFO-02 tests.
- A score of 1 is obtained if at least Level 2 is achieved in TC-PERFO-02 test.

### B.2 Ionosphere delay handling

This key feature considers three different levels of performance.

The following table provides the test results taking into account to measure this key feature, including the levels of performances identified for each of them:

**Table 24 — Trace of tests to measure Ionosphere delay handling**

Test Case	Level 1	Level 2	Level 3
TC-PERFO-01	Level 1 IONO	Level 2 IONO	Level 3 IONO

In order to compute the IONO score (over 1), a maximum of three levels are considered:

- A score of 1/3 is given if Level 1 is achieved in TC-PERFO-01 test.
- A score of 2/3 is given if Level 2 is achieved in TC-PERFO-01 test.
- A score of 1 is obtained only if Level 3 is achieved in TC-PERFO-01 test.

### B.3 Performance in urban environment

This key feature considers two different levels of performance.

The following table provides the test results taking into account to measure this key feature, including the levels of performances identified for each of them:

**Table 25 — Trace of tests to measure Performance in urban environment**

Test Case	Level 1	Level 2
TC-PERFO-03	Level 1 URBAN	Level 2 URBAN

In order to compute the GIPVT score (over 1), a maximum of three levels are considered:

- A score of 0.5 is given if Level 1 is achieved in TC-PERFO-03 tests.
- A score of 1 is obtained only if Level 3 is achieved in TC-PERFO-03 test.

#### B.4 Smart processing of Galileo SIS flags sent through the Galileo navigation message

This key feature considers only a performance level.

The following table provides the test results taking into account to measure this key feature, including the levels of performances identified for each of them:

**Table 26 — Trace of tests to measure Galileo SIS flags**

Test Case	Level 1
TC-PERFO-04	Level 1 SIS*
TC-PERFO-05	Level 1 SIS*
TC-PERFO-06	Level 1 SIS*
(*) The only way to obtain SIS score is to achieve Level 1 in the three Galileo SIS flags tests: TC-PERFO-04, TC-PERFO-05 and TC-PERFO-06 tests.	

#### B.5 Global “Galileo Enabled” label

The formula to determine the performance level obtained in the test is as follows:

$$GAL_{score} = round \left[ 5 \cdot \left( score_{GIPVT} \cdot w_{GIPVT} + score_{IONO} \cdot w_{IONO} + score_{URBAN} \cdot w_{URBAN} + score_{SIS} \cdot w_{SIS} \right) \right]$$

where

round indicates that the weighted average shall be rounded down to an integer number, which indicates the performance level achieved by the device.