NAVIGATION SOLUTIONS POWERED BY EUROPE

EUROPEAN GNSS (GALILEO) INITIAL SERVICES

OPEN SERVICE

QUARTERLY PERFORMANCE REPORT

JANUARY - MARCH 2019

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1 INTRODUCTION

This document is the *Galileo Initial Open Service (IS OS) Public Performance Report* for the period of January, February and March 2019. Following the declaration of Initial Services in December 2016, a new edition is published after each quarter, in order to provide the public with information about the Galileo Open Service measured performance statistics.

The document reports on the following performance parameters, with respect to their Minimum Performance Levels (MPLs) declared in the [OS-SDD]:

- ◊ Galileo Initial Open Service Ranging Performance;
- ◊ Galileo UTC Dissemination and GGTO Determination Performance;
- ◊ Galileo Positioning Performance;
- ◊ Timely Publication of Notice Advisory to Galileo Users (NAGUs)[1].

The document comprises the following sections:

Section 1: Provides an introduction to this report, including the status of the Galileo constellation over the quarterly reporting period.

Section 2: Provides an executive summary describing the achieved performance. Details are reported in the following chapters

Section 3: The Initial Open Service Ranging Performance comprises three subsections: "Availability of the Galileo SF/DF Ranging Service", "Per-slot Availability of HEALTHY Signal in Space" and "Galileo Signal in Space Ranging Accuracy".

Section 4: The "UTC Dissemination and GGTO Determination Performance" is presented in two subsections: the "Availability of the Galileo Time Correlation Parameters" and the "Accuracy of Galileo Time Correlation Parameters". Performance is evaluated for the Universal Time Coordinated (UTC) Time & Frequency Dissemination service and the GST-GPS Time Offset (GGTO) Determination.

Section 5: The "Galileo Positioning Performance" is illustrated in three subsections: "Availability of Global Horizontal Dilution of precision (HDOP)", "Availability of Galileo Horizontal Positioning" and "Galileo measured Positioning Performance".

Section 6: The "Timely Publication of Notice Advisory to Galileo Users (NAGUs)" is analysed.

Section 7: The cited reference documents are listed.

Section 8: The adopted terms, acronyms and abbreviations are defined.

[1] NAGUs are issued publicly by the European GNSS Service Centre (GSC)

Table 1: provides the status of the Galileo constellation for which the performance data has been measured over the reporting period.

Satellite Code	SV ID (PRN)	CCSDS ID [hex]	Orbital Slot	Status
GSAT-0101	11	3A5	B05	Available
GSAT-0102	12	3A6	B06	Available
GSAT-0103	19	3A7	C04	Available
GSAT-0203	26	263	B08	Available
GSAT-0205	24	265	A08	Available
GSAT-0206	30	266	A05	Available
GSAT-0207	7	267	C06	Available
GSAT-0208	8	268	C07	Available
GSAT-0209	9	269	C02	Available
GSAT-0210	1	26A	A02	Available
GSAT-0211	2	26B	A06	Available
GSAT-0212	3	26C	C08	Available
GSAT-0213	4	26D	C03	Available
GSAT-0214	5	26E	C01	Available
GSAT-0216	25	2C6	A07	Available
GSAT-0217	27	2C7	A04	Available
GSAT-0218	31	2C8	A01	Available
GSAT-0215	21	2C5	A03	Available
GSAT-0219	36	713	B04	Available as of February 11th, 2019[2]
GSAT-0220	13	704	B01	Available as of February 11th, 2019 [2]
GSAT-0221	15	705	B02	Available as of February 11th, 2019 [2]
GSAT-0222	33	706	B07	Available as of February 11th, 2019 [2]

Table 1: Galileo Reported Constellation Information

[2] Launch nr. 10 satellites completed the In Orbit Testing and were declared usable as per NAGUs 2019002 (GSAT-0219/E36), 2019003 (GSAT-0222/E33), 2019004 (GSAT-0220/E13), 2019005 (GSAT-0221/E15), since 11/02/2019.

For the most up-to-date information about the Galileo Constellation, please refer to the information published by the European GNSS Service Centre (GSC) on its website:

GNSS Service Centre Web Resources	
Constellation Status Information	https://www.gsc-europa.eu/system-status/Constellation-Information
Reference Constellation Orbital and Technical Parameters	https://www.gsc-europa.eu/system-status/orbital-and-technical-parameters
Incident Reporting (Galileo Incidents Report Form)	https://www.gsc-europa.eu/helpdesk/galileo-incident-report-form
Interactive support to users (Galileo Help Desk)	https://www.gsc-europa.eu/contact-us/helpdesk

Table 2: GSC main information web pages for Galileo status

The Galileo Helpdesk at GSC allows close interaction with users, both to support the exploitation of Galileo services and to collect relevant information on signal performance as observed by the users.

The GSC is also responsible for providing the timely Notice Advisory to Galileo Users (NAGU) messages, as detailed in Section 6.

2 EXECUTIVE SUMMARY

During this quarterly reporting period, the measured Galileo Initial Open Service performance figures generally exceed the Minimum Performance Level (MPL) targets specified in the [OS-SDD] with significant margins. The following dashboards summarise the compliance with MPLs, using the colour coding defined in the legend below:

OS MPLs		Target Value	Space Vehicle		Jan-19					Feb-19					Mar-19				
					E5a-E1	E5b-E1	E1	E5a	E5b	E5a-E1	E5b-E1	E1	E5a	E5b	E5a-E1	E5b-E1	E1	E5a	E5b
Signal In Space (SIS) Ranging	Accuracy, Any Satellite	<= 7m [95%]	GSAT-0101	E11															
			GSAT-0102	E12															
			GSAT-0103	E19															
			GSAT-0203	E26															
			GSAT-0205	E24															
			GSAT-0206	E30															
			GSAT-0207	E07															
			GSAT-0208	E08															
			GSAT-0209	E09															
			GSAT-0210	E01															
			GSAT-0211	E02															
			GSAT-0212	E03															
			GSAT-0213	E04															
			GSAT-0214	E05															
			GSAT-0215	E21															
			GSAT-0216	E25															
			GSAT-0217	E27															
			GSAT-0218	E31															
			GSAT-0219	E36															
			GSAT-0220	E13															
			GSAT-0221	E15															
			GSAT-0222	E33															

Table 3: MPL Fulfilment Status Dashboard (1/2)

Legend

- MPL measurement not available
- Target Value for MPL is fulfilled
- Target Value for MPL is NOT fulfilled (less than 10% away from the Target Value)
- Target Value for MPL is NOT fulfilled (more than 10% away from the Target Value)

OS MPLs				Target Value	Jan-19	Feb-19	Mar-19
SIS Ranging	Accuracy, Over All Satellites	E1/E5a user		≤ 2m [95%]			
		E1/E5b user					
		E1 user					
		E5a user					
		E5b user					
	Availability	Per-slot	E1/E5a	≥ 87%			
			E1/E5b				
			E1				
			E5a				
			E5b				
		Ranging Service	SF / DF Worst Case @ WUL	≥ 87%			
Timing	Accuracy	UTC Time Dissemination		≤ 30ns [95%]			
		UTC Frequency Dissemination		< 3E-13 [95%]			
		GGTO Determination		≤ 20ns [95%]			
	Availability	UTC Determination Service		≥ 87%			
		GGTO Determination Service		≥ 80%			
User Interface	NAGU	Planned Timeliness		≥ 1 day			
		Unplanned Timeliness		≤ 3 days			

Table 4: MPL Fulfilment Status Dashboard (2/2)

Availability of the Galileo Ranging Service at the Worst User Location (WUL) had a monthly value of **100**% during the entire quarterly observation period, against the MPL target of **87%**. The "per-slot" **Availability of a Healthy Signal**, with average monthly values higher than **99**% for every Single-Frequency (E1-B, E5a, E5b) and Dual-Frequency combination (E1/E5a, E1/E5b), is also significantly better than the MPL of **87%**. The figures are normalised annually, according to the MPL definition, by a moving average applied over the last 12 months.

The **Signal in Space Ranging Accuracy** shows a 95th percentile monthly accuracy between **0.24** [m] and **0.73** [m] for individual space vehicles ("Any Satellite") on Single Frequency observables.[3]

[3] Ranging measurements on the OS signals E1, E5a, E5b.

For Dual Frequency signal combinations[4], the figure is in the range from **0.18** [m] to **0.51** [m]. Compliance with the [OS-SDD] MPL, where the threshold is specified as **7** [m], is achieved with large margins.

The average **Ranging Accuracy at constellation level** (over "All Satellites") provides figures "per signal" that are better than **0.51** [m] for Single Frequency signals and **0.33** [m] for Dual Frequency signal combinations. The specified [OS-SDD] MPL threshold of **2** [m] is therefore achieved.

The **Availability of the Galileo UTC Time Determination Service**, had a monthly value of **100**% during the entire quarterly reporting period**,** comfortably exceeding the [OS-SDD] MPL target of **87%**.

The **Availability of GGTO Determination** was **98.24**% in January, **97.66**% in February and **97.33**% March. Annually normalised figures provided in §4.1 are obtained with an average applied over the last 12 months. The measured values are well above the [OS-SDD] MPL target of **80%.**

Excellent values are achieved for **UTC Time Dissemination Service Accuracy** (≤ **8.4 [ns]**), **UTC Frequency Dissemination Service Accuracy** (normalised offset ≤ $\mathbf{3.1\times10^{-14}}$) and the **GGTO Determination Accuracy** (≤ **6.5** [ns]), all computed by accumulating samples over the previous 12 months. The [OS-SDD] MPL targets, which are respectively **30** [ns], $\mathbf{3\times10^{-13}}$ and **20** [ns], are all met.

The monthly **Availability of HDOP ≤ 5** is better than **92.33**%, achieving **100**% within some geographic areas in all three months and reaching a minimum value close to **100%** over the entire service area in March. The monthly **Availability of Galileo Horizontal Positioning better than 10 [m]** is better than **97.01**%**,** achieving **100**% in some areas of the world in January and February, and **100**% over the entire service area in March. These figures are in line with the deployment status of the Galileo constellation during the reporting period (18 operational satellites at the beginning of the reporting period, then 22 since February 11th, 2019) and greatly exceed the expected minimum threshold for Initial Services, defined in the [OS-SDD] as **50%** in both cases.

Availability figures are complemented with measured "Galileo-only" 3D positioning performance, attainable when PDOP ≤ 6. For Dual-Frequency combinations (E1/E5a and E1/E5b), the 95th percentile of **Horizontal and Vertical 3D Positioning Errors** (HPE and VPE, correspondingly) did not exceed **2.18** [m] and **3.60** [m] respectively during the reporting period, as measured by the GSA network of reference receivers. The corresponding RMS values are **1.19** [m] and **1.79** [m]. In line with the [OS-SDD], no MPL is presently applicable to HPE and VPE values.

Regarding **Publication of NAGUs**, [OS-SDD] MPLs are met during the whole period for both Planned and Unplanned events. The target of at least **24** hours before the start of a scheduled event, as well as not more than **72** hours after an unscheduled one, is achieved in all cases. Additional details about NAGU timeliness are presented in § 6.

[4] Ranging measurements on OS signal combinations E1/E5a, E1/E5b.

3 INITIAL OPEN SERVICE RANGING PERFORMANCE

In this section of the report the following performance figures for the Galileo Initial Open Service are provided:

- ◊ Availability of the Galileo SF/DF Ranging Service.
- ◊ Per-slot Availability of HEALTHY Signal in Space.
- ◊ Galileo Signal in Space Ranging Accuracy.

3.1 AVAILABILITY OF THE GALILEO SF/DF RANGING SERVICE

The Availability of the Galileo SF/DF Ranging Service is computed at any user location as the percentage of time that the user is provided with at least one HEALTHY [5] Galileo Open Service (OS) Signal in Space (SiS).

The following figure shows the monthly availabilities of the Galileo Single Frequency (SF) and Dual Frequency (DF) Ranging Services at the Worst User Location (WUL). WUL is selected among the nodes of an equally spaced geographic grid, within the Navigation Service coverage area.

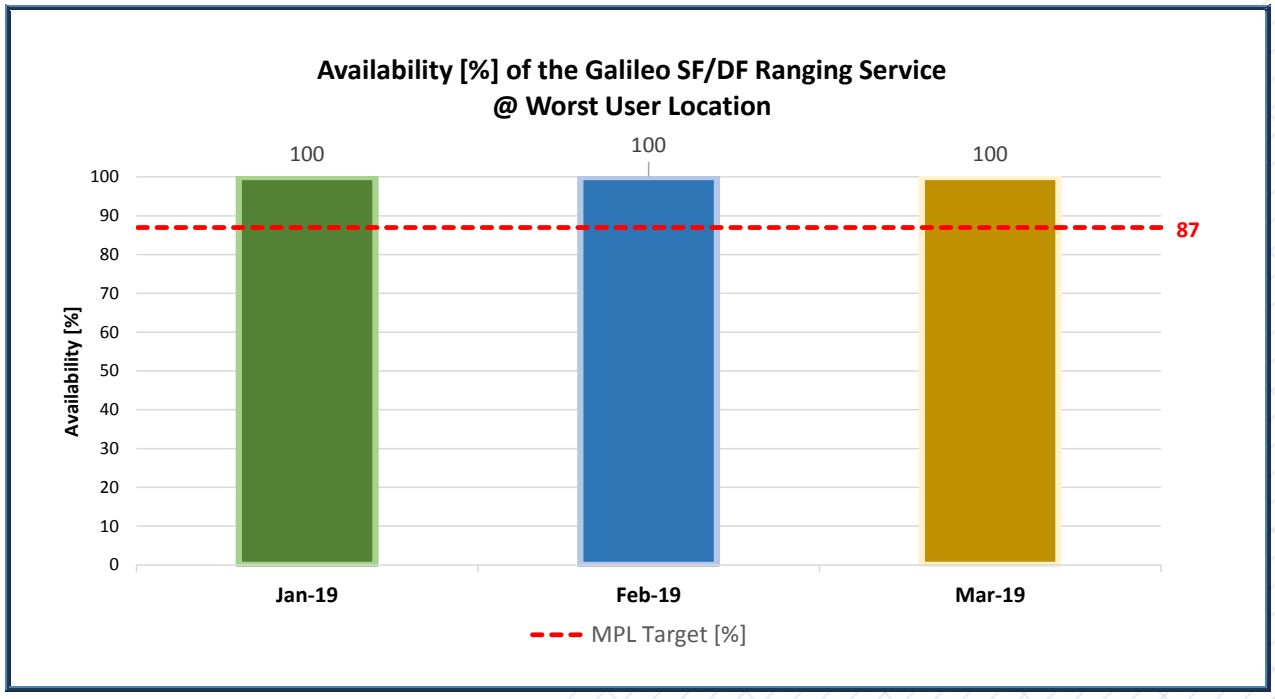

Figure 1: Monthly Availability of the Galileo SF/DF Ranging Service

[5] HEALTHY Galileo Open Signal in Space is defined in [OS-SDD] .

The availability of the Galileo Single Frequency and Dual Frequency Ranging Service is **100**% during all three months, exceeding the Minimum Performance Level from [OS-SDD], which is specified as **87**% [6] .

3.2 PER-SLOT AVAILABILITY OF HEALTHY SIGNAL IN SPACE

The "Availability of HEALTHY Signal in Space" is defined, for each Galileo operational satellite, as the percentage of time that the specific satellite broadcasts HEALTHY [5] Galileo Open Service Signals in Space.

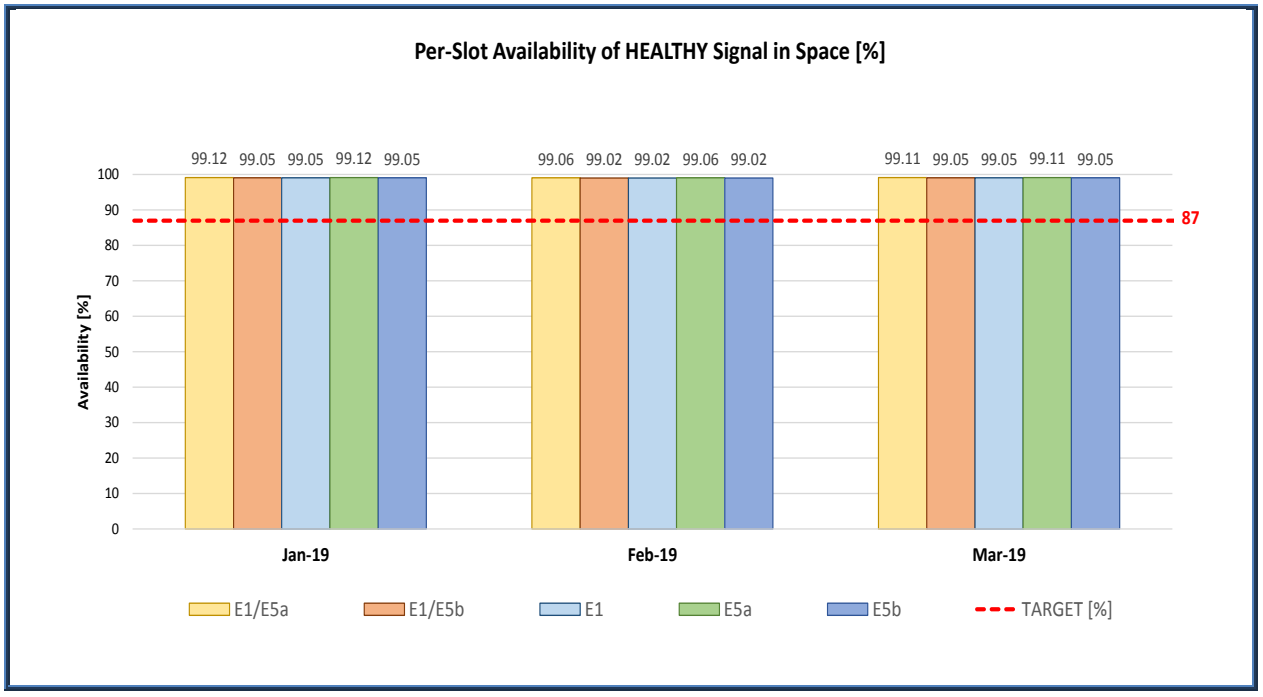

Figure 2: "Per-Slot" availability of HEALTHY Signal in Space for the reporting period

Figure 2 provides the Signal in Space "per slot" availability of Galileo HEALTHY Signals in Space, averaged over the entire constellation during the reporting period and normalised annually.[7]

The [OS-SDD] Minimum Performance Level (MPL) specifies **87%** [8] as the target value for this constellation metric.

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6 Ref.: [OS-SDD] , §3.5.2 (Table 15) and §3.5.3 (Table 16)

7 The [OS-SDD] foresees an "annual normalisation", which is implemented with an incremental averaging process, accumulating data over the previous 12 months. Data for each month takes into account only those space vehicles that are declared active members of the constellation during the whole month.

8 Ref.: [OS-SDD] , §3.5.1 (Table 14)

The achieved performance is between **99.02**% (I/NAV SIS, February) and **99.12**% (F/NAV SIS, January).

The availability of Galileo HEALTHY SIS, evaluated individually per frequency combination, satellite and month (without annual normalisation), was between **87.66**% and **100**%, where the lower value was due to an unplanned event affecting GSAT-0103 (E19) in March.

3.3 GALILEO SIGNAL IN SPACE RANGING ACCURACY

The Galileo Signal In Space Error (SISE) vector provides the instantaneous difference between the Galileo satellite position/clock offset as obtained from the broadcast Navigation message, and the "true" satellite position/clock offset. The true orbit path and clock performance are precisely reconstructed using sophisticated tools. When projecting SISE to the user location, the obtained scalar value is also named Ranging Accuracy and represents the ranging error affecting a user receiver. The following figures show the 95th percentile of the monthly global average of the instantaneous Ranging Accuracy, achieved for each Galileo operational satellite and Single Frequency/Dual Frequency combinations. Projection of SISE is implemented at the nodes of a virtual grid, representing all user locations within the Navigation Service coverage area. Any signals carrying Navigation message information with Age of Time of Ephemeris beyond the validity period of 4 hours are filtered out, as per [OS-SDD] and explained in §5.3.

As shown in the following Figure 3 and Figure 4, the 95% metric applied to the Galileo Signal in Space Ranging Accuracy "for any space vehicle", over all satellites[9] and frequency combinations, is:

- for individual space vehicles in **January**, between **0.18 [m]** and **0.27** [m] for Dual Frequency, and between **0.24** [m] and **0.66** [m] for Single Frequency;
- for individual space vehicles in **February**, between **0.20** [m] and **0.51** [m] for Dual Frequency, and between **0.27** [m] and **0.74** [m] for Single Frequency;
- for individual space vehicles in **March**, between **0.18** [m] and **0.32** [m] for Dual Frequency, and between **0.26** [m] and **0.73** [m] for Single Frequency.

[9] Data for each month takes into account only those space vehicles that are declared active members of the constellation during the whole month.

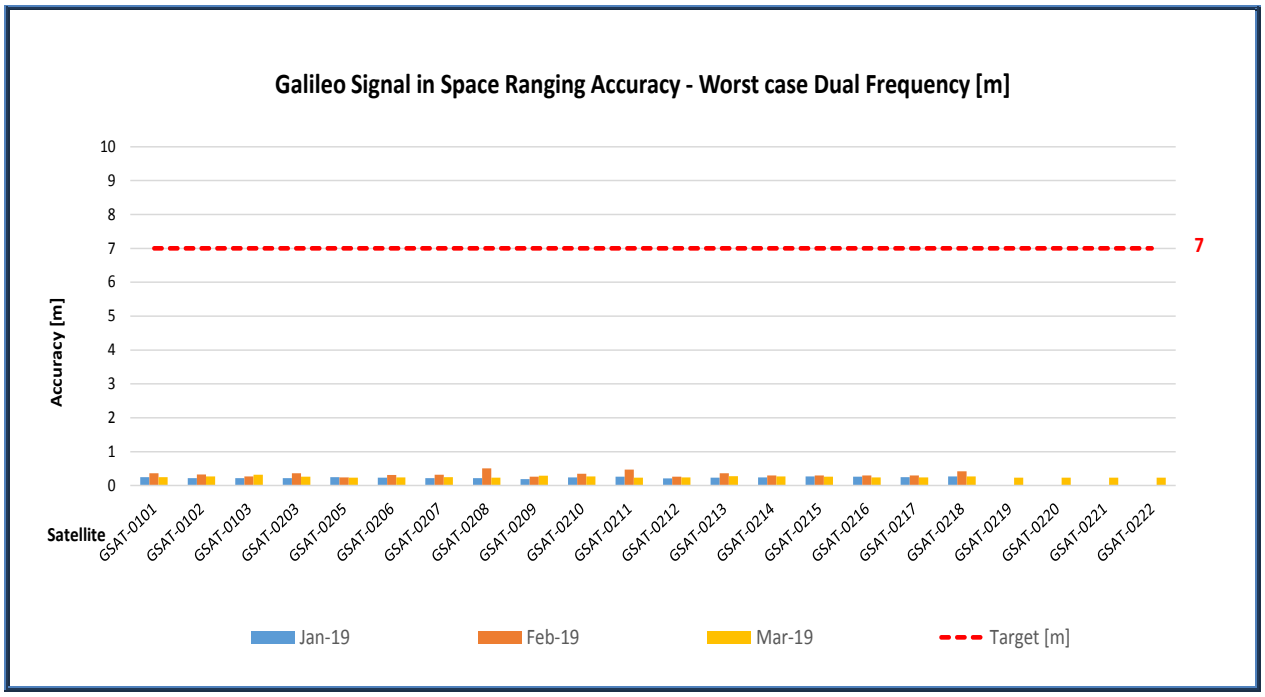

Figure 3: Monthly Galileo SIS Ranging Accuracy (95th percentile) "for any satellite", measured during reporting period for worst-case, Dual-Frequency (DF)

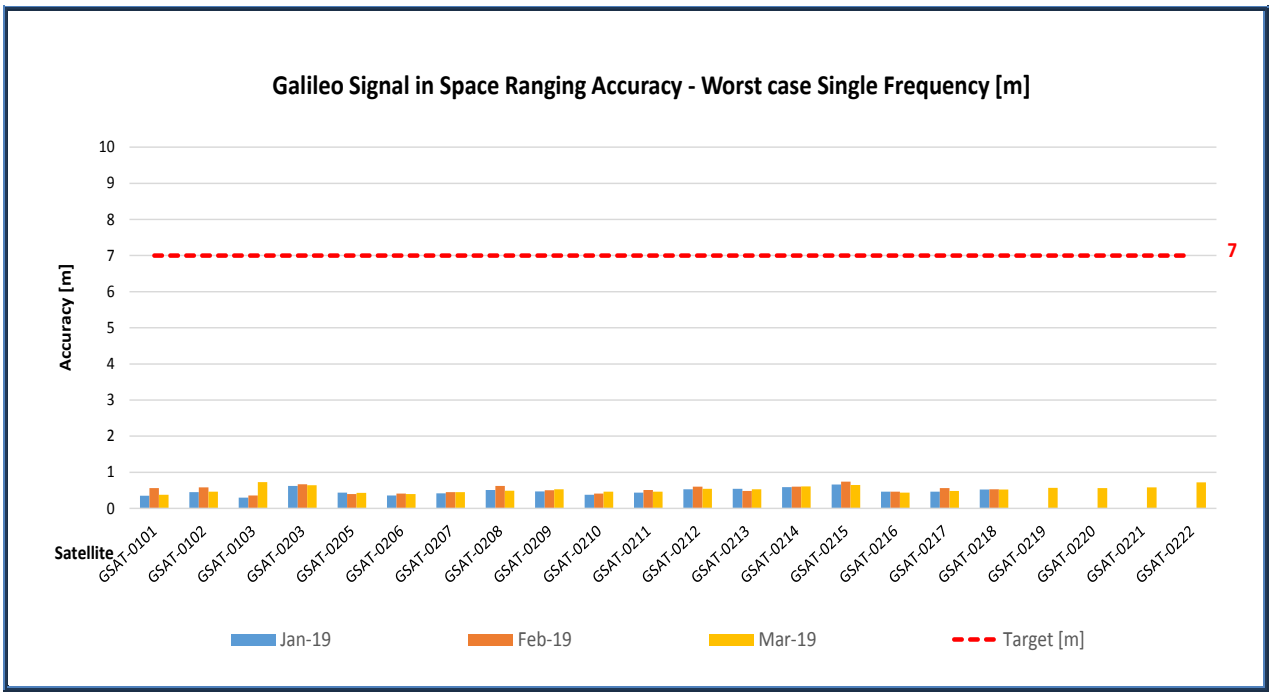

Figure 4: Monthly Galileo SIS Ranging Accuracy (95th percentile) "for any satellite", measured during the reporting period for worst-case, Single-Frequency (SF)

Compliance with the MPL in [OS-SDD] is always achieved, with a specified maximum threshold of **7** [m] [10] for the monthly performance of each individual satellite.

Figure 5 depicts the average "over all satellites" (constellation mean). Again, the [OS-SDD] MPL target of **2** [m] is met by the Constellation average value.

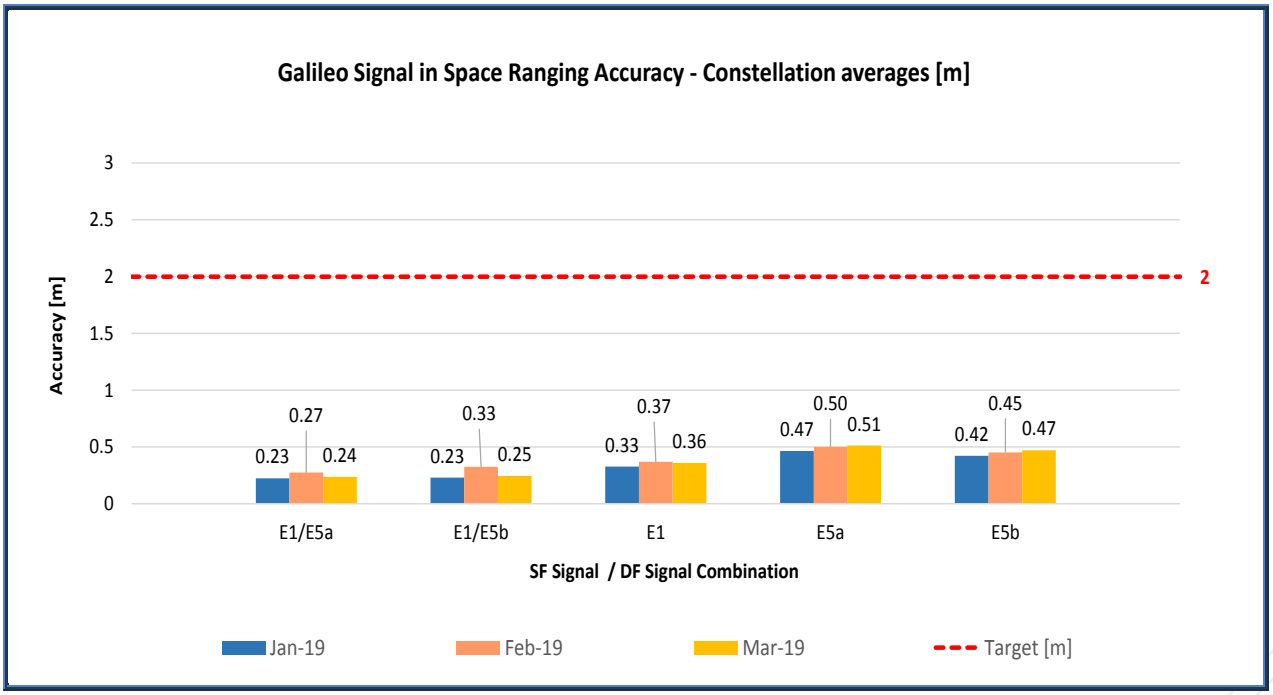

Figure 5: Monthly Galileo SIS Ranging Accuracy (95th percentile) "over all satellites" (constellation average), measured during the reporting period

[10] Ref.: [OS-SDD] , §3.4.1 (Table 9)

4 UTC DISSEMINATION AND GGTO DETERMINATION PERFORMANCE

In this section of the report the following performance figures are provided:

- ◊ Availability of the Galileo Time Correlation Parameters;
- ◊ Accuracy of Galileo Time Correlation Parameters.

4.1 AVAILABILITY OF THE GALILEO TIME CORRELATION PARAMETERS

The *Availability of the Galileo Universal Time Coordinated (UTC) Time Determination Service* is defined as the percentage of time that the system provides at least one HEALTHY [5] ranging/timing Signal in Space above a minimum elevation angle of 5 degrees. Figure 6 provides the Worst User Location (WUL) Availability of the UTC Determination service, computed for a virtual grid of user positions over the service coverage area.

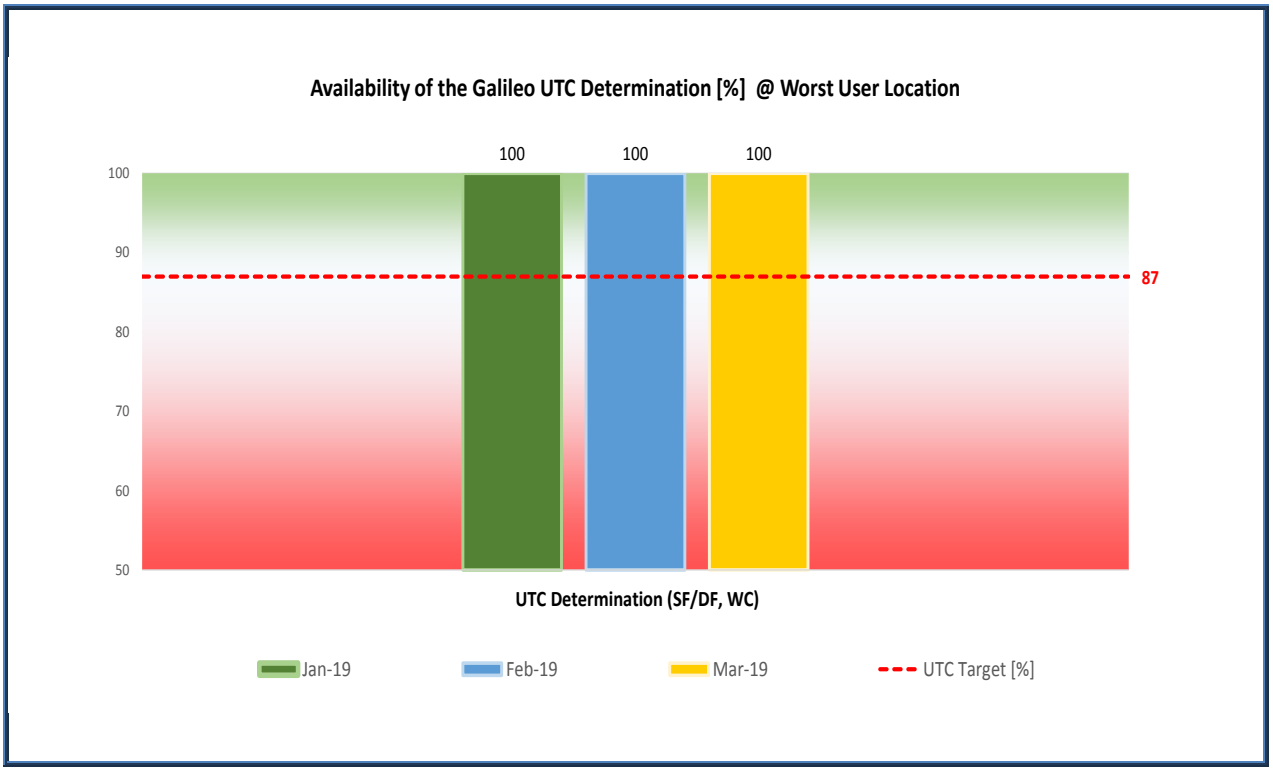

Figure 6: Monthly availability of the UTC Determination Service during the reporting period

As shown in Fig. 6, the monthly (short-term) availability of the Galileo UTC Determination Service achieved **100**% during the entire quarterly reporting period.

The MPL of **87%** [11] specified by [OS-SDD] for the long term is therefore fully achieved.

The *Availability of Galileo to GPS Time Offset (GGTO) Determination* is the percentage of time that the system provides at least one non-dummy GGTO[12] set of coefficients within the Navigation message, acquiring SiS from a space vehicle seen above a minimum elevation angle of 5 degrees. Figure 7 gives the availability of the GGTO Determination for Worst User Location (WUL), computed for a virtual grid of user positions over the service coverage area. Values are normalised annually by accumulating data over the previous 12 months.

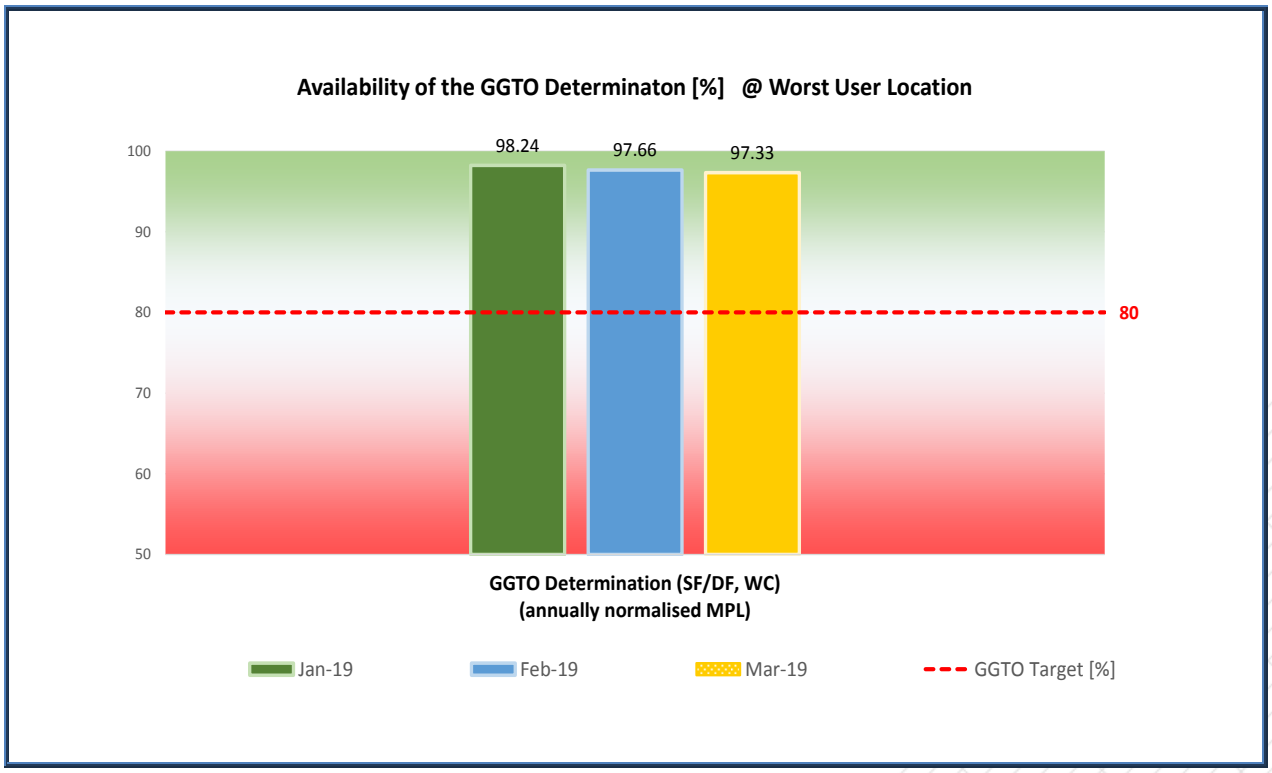

Figure 7: Annually normalised availability of the GGTO Determination, during the reporting period

The MPL of **80%** [13] specified by [OS-SDD] for the long-term is fully achieved.

The monthly (short-term) Galileo user GGTO Determination capability, which is not shown in the figures, was **100**% in January, **93.01**% in February (ref.: NAGUs 2019006, 2019007) and **95.31**% in March (ref.: NAGU 2019011, 2019012).

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11 Ref.: [OS-SDD] , §3.5.4 (Table 17)

12 "Dummy" GGTO is defined in [OS-SDD] and in Galileo SiS ICD in terms of "all 1's" appearing in the GGTO parameters binary slot(s) carried by the Navigation message.

13 Ref.: [OS-SDD] , §3.6.1.2 (Table 19)

4.2 ACCURACY OF GALILEO TIME CORRELATION PARAMETERS

The Galileo Signal in Space *Universal Time Coordinated (UTC) Time Dissemination Accuracy* and the Galileo Signal in Space *Universal Time Coordinated (UTC) Frequency Dissemination Accuracy* are computed as the daily average error of the normalised time and frequency offset relative to UTC for a user equipped with a Standard Timing / Calibration Laboratory Receiver [14].

The *Galileo to GPS Time Offset (GGTO) Determination Accuracy* is computed as the daily average of the difference between the GST-GPS Time Offset computed using the Galileo navigation message and the true GST-GPS Time Offset.

Figure 8 shows the 95th percentile of the daily average of the UTC Dissemination Accuracy, observed and normalised over a period of 12 months.

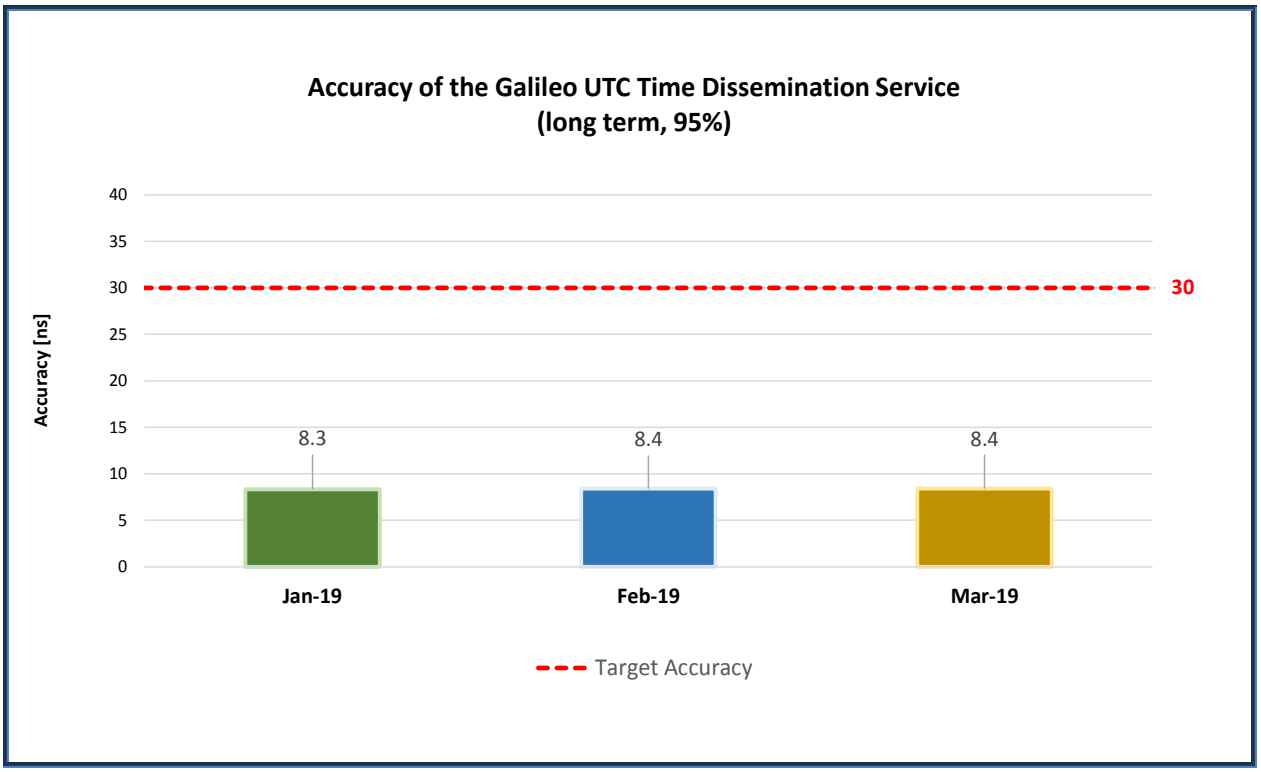


Figure 8: Long-term 95th percentile of UTC Time Dissemination Accuracy

Figure 9 shows the 95th percentile of the daily average of the GGTO Determination Accuracy, normalised annually.

[14] Note that the final UTC Determination Accuracy experienced by the user will also be affected by ranging errors, on top of the committed UTC Dissemination Accuracy

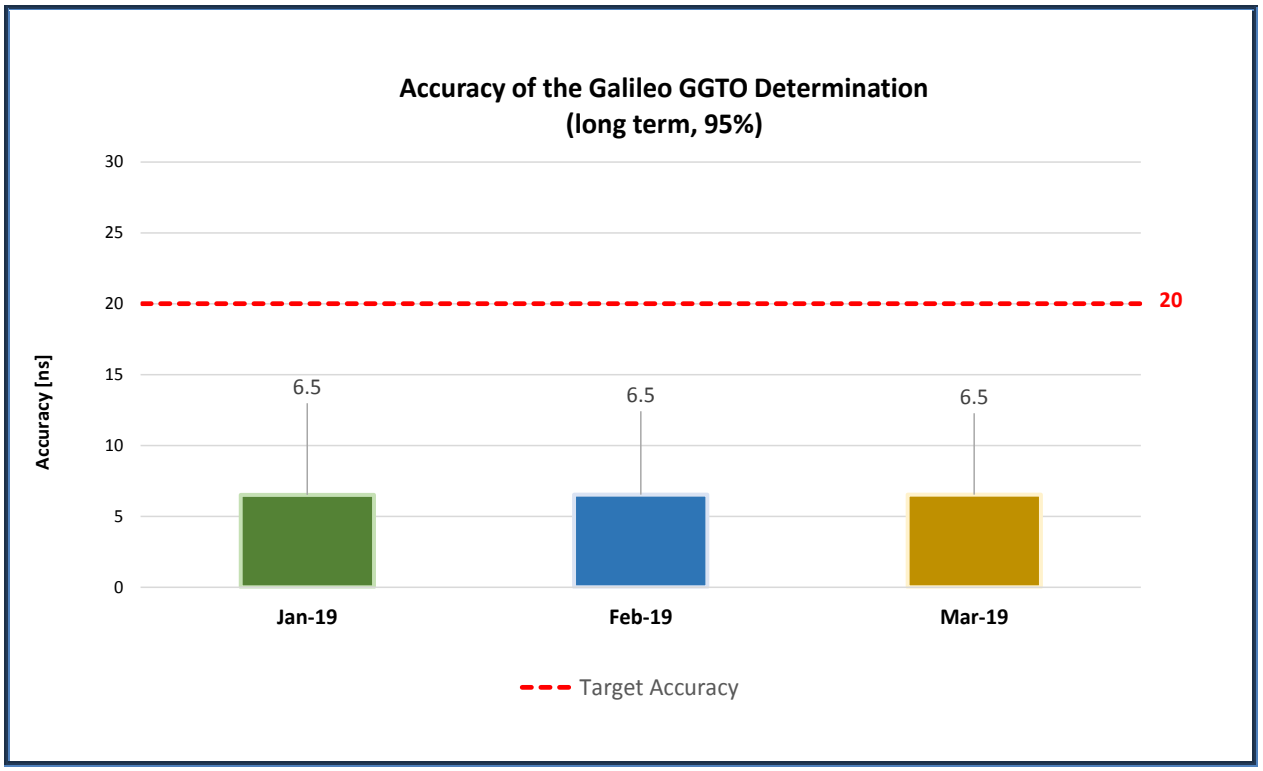


Figure 9: Long-term 95th percentile of GGTO Determination Accuracy

Figure 10 shows the 95th percentile of the UTC Frequency Dissemination Accuracy, computed accumulating measurement data over the past 12 months [15].

As seen in Figure 8 and Figure 9, the long term 95th percentile of UTC (Time) Dissemination Accuracy is around **8.4** [ns] and the GGTO Determination Accuracy is consistently equal to **6.5** [ns]. These figures are both well within the [OS-SDD] Minimum Performance Level specifications of **30** [ns] and **20** [ns], respectively [16].

Regarding UTC Frequency Dissemination accuracy, Figure 10 shows that the measured 95th percentile value is at most around **3E–14**, which is an order of magnitude better than the [OS-SDD] MPL normalised annual ceiling of **3.0E–13** [17].

[15] Long-term figures result from processing measurements accumulated since 2017

[16] Ref.: [OS-SDD] , §3.4.3 (Table 12) and §3.6.1.2 (Table 18)

[17] Ref.: [OS-SDD] , §3.4.4 (Table 13)

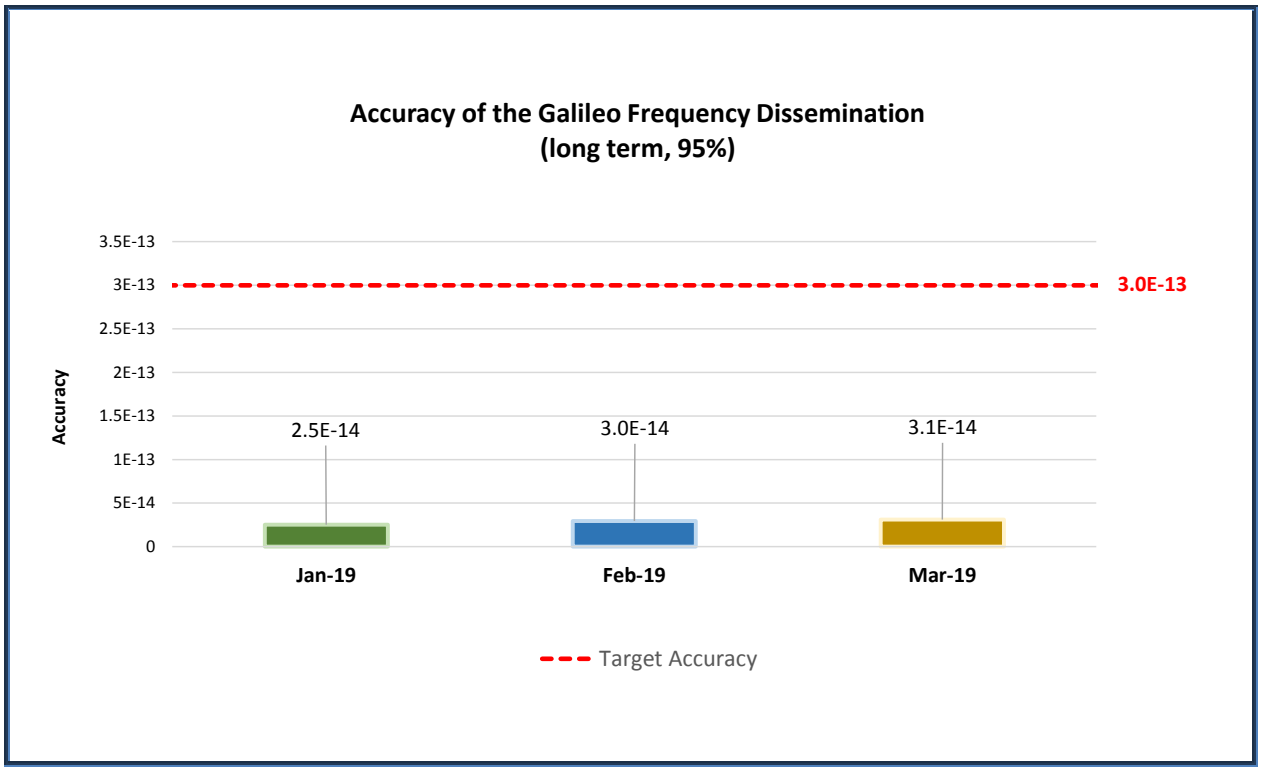


Figure 10: Long-term 95th percentile of UTC Frequency Dissemination Accuracy

5 GALILEO POSITIONING PERFORMANCE

In this section of the report the following performance figures are provided for information:

- ◊ Availability of Global Horizontal Dilution of precision (HDOP);
- ◊ Availability of Galileo Horizontal Positioning;
- ◊ Galileo measured Positioning Performance.

Note that the current version of the [OS-SDD] does not define specific MPLs for Galileo stand-alone positioning performance. Nevertheless, the target expectation is an availability of at least 50% [18].

5.1 AVAILABILITY OF GLOBAL HORIZONTAL DILUTION OF PRECISION (HDOP)

For 2D positioning [19], the *Availability of Global Horizontal Dilution of precision* (HDOP) is defined as the percentage of time that at least 3 Galileo satellites transmitting HEALTHY Galileo Open Service Signal in Space, above a minimum elevation angle of 5 degrees and satisfying a condition of HDOP less than or equal to 5, are in view from the user locations.

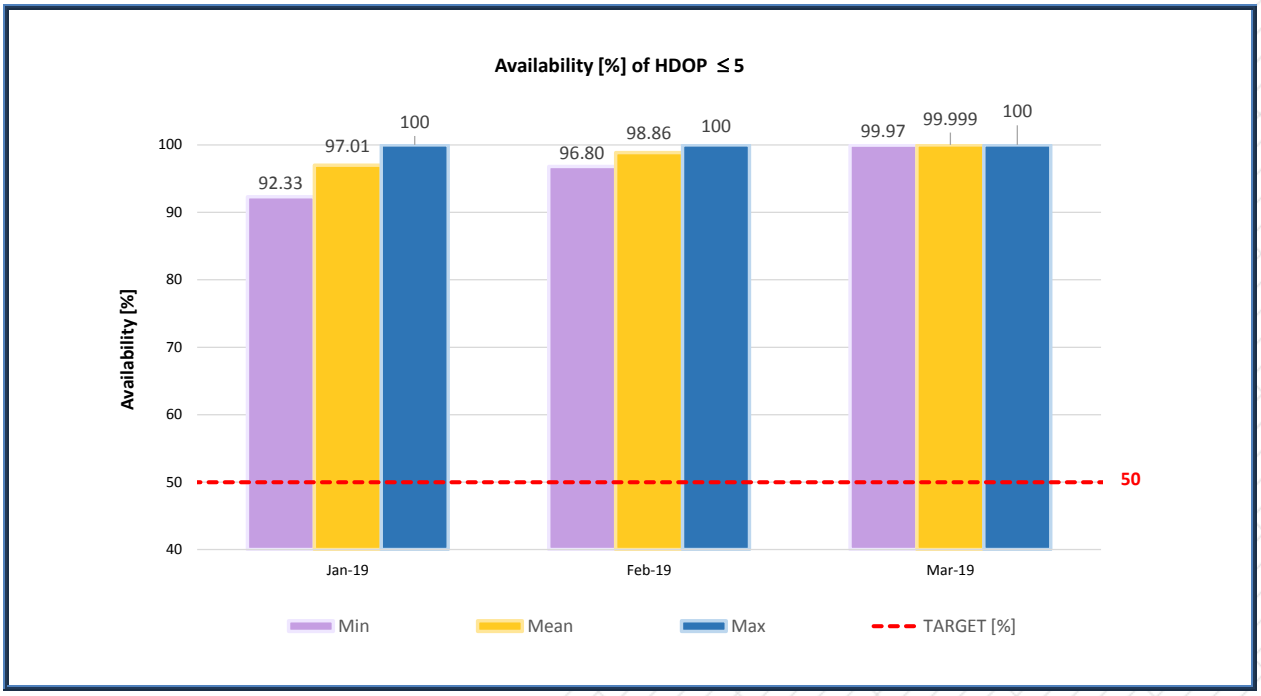


Figure 11: Availability of HDOP ≤ 5

[18] Ref.: [OS-SDD] , §C.7.1 (Table 25) and §C.7.2 (Table 26)

Figure 11 above shows the monthly HDOP average availability computed for a grid of user locations within the service coverage area. The probability of achieving a standalone Galileo 2D positioning solution with favourable DOP, thus with good accuracy, was quite high over the whole world during the full quarter. As noted in Table 1, four (4) new Galileo satellites have been declared usable since February 11th 2019, which explains the significant improvements in both the HDOP figures and the Horizontal Positioning Availability ones presented next in chapter 5.2.

5.2 AVAILABILITY OF GALILEO HORIZONTAL POSITIONING

The *Availability of Galileo Horizontal Positioning* is defined as the percentage of time with a horizontal positioning error less than or equal to 10 [m], considering only HEALTHY [5] Galileo Open Signal in Space from satellites above a minimum elevation angle of 5 degrees and assuming a receiver operating in "altitude hold" mode. Horizontal Positioning assumes that Navigation Equations are to be solved in two dimensions only[19].

Figure 12 shows the monthly average availability computed for a grid of user locations within the service coverage area, considering only system level contributions to the positioning error.

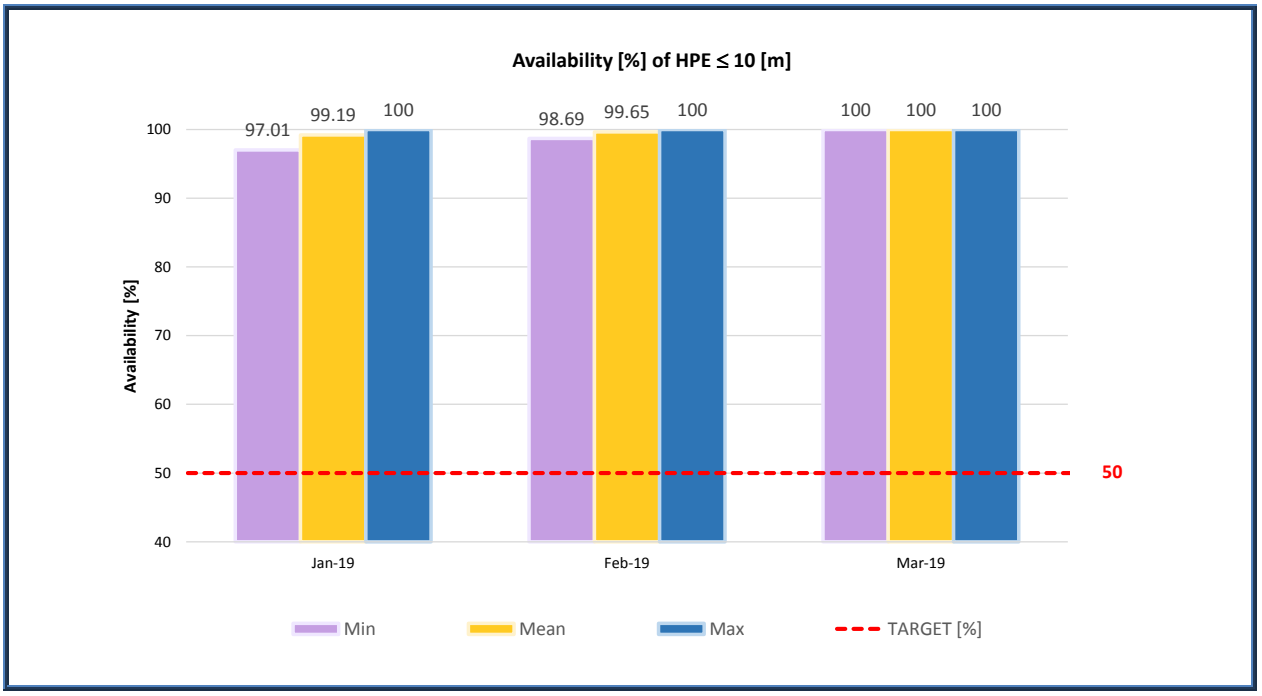


Figure 12: Availability of the Galileo Horizontal Positioning Service with Accuracy ≤ 10 [m]

[19] E.g.: determining only user latitude and longitude, while the altitude over Earth ellipsoid is provided as input known *a priori*

5.3 GALILEO MEASURED POSITIONING PERFORMANCE

Although the Galileo FOC constellation is not yet complete and hence positioning is not yet declared as a Galileo Service, this section provides Navigation Sensor Error estimates as an indication of Galileo Navigation Positioning performance capabilities for a full (3D) solution of Navigation equations.

The following figures show the *Horizontal and Vertical Positioning Accuracy Performance* based on measurements collected over a number of test receivers, solving for user coordinates with a constraint of PDOP ≤ 6 and following [OS-SDD] recommendations about SIS health status, "Age of toE" [20].

To this aim it is recalled that, according to the [OS-SDD] directions, Navigation message coefficients with an "Age of toE" beyond 4 hours are no longer valid, so that ranging observables from the corresponding satellite and signal should not be used for positioning and/or time measurement purposes.

The horizontal axis is limited on each plot to a maximum error of 20 metres. Each figure reports also the number of samples exceeding a horizontal or vertical error larger than 20 [m].

[20] Parameter "toE" (Time of Ephemeris) is disseminated in the Navigation message, as part of the Ephemeris Set. See [SIS-ICD], section 5.1.1

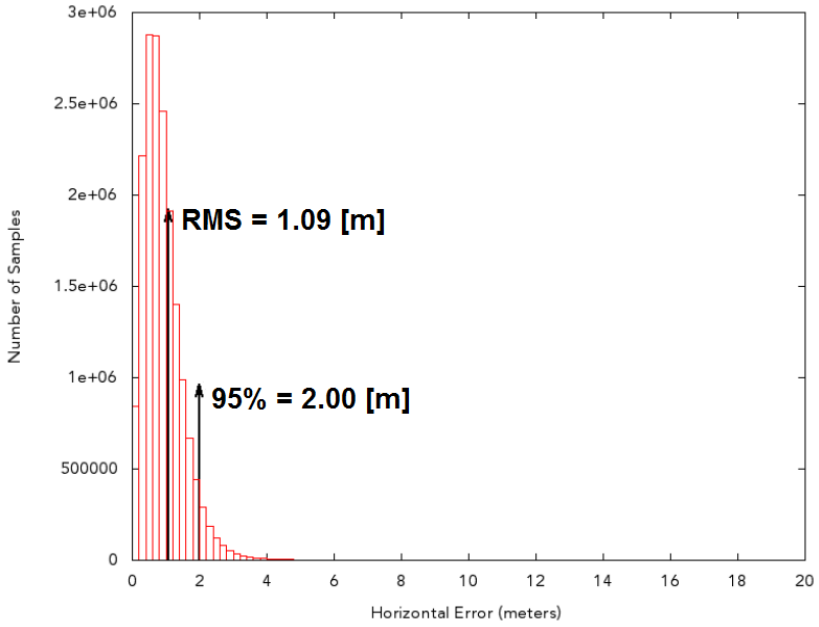
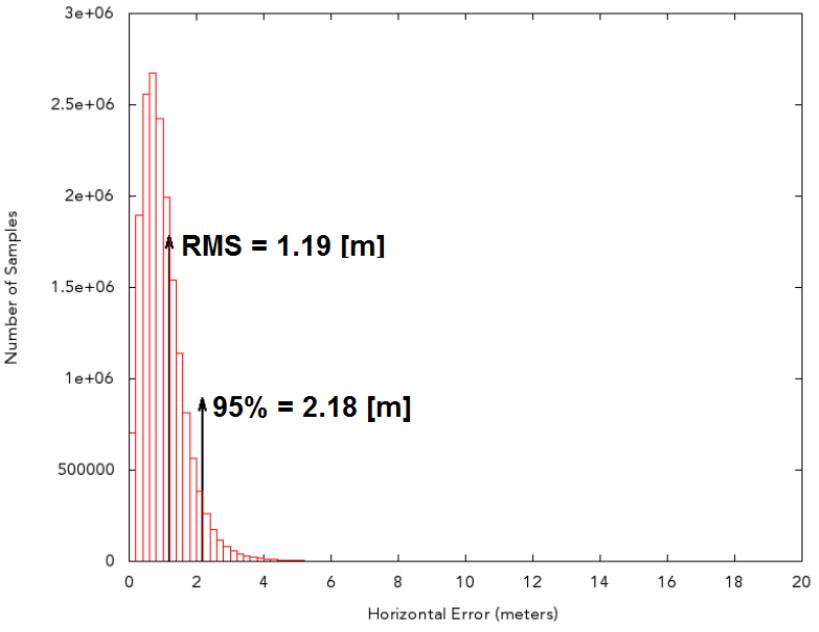
January 2019 **HPE** **3D Positioning** **E1-E5a (DF)** **F/NAV**	
Note: 1 sample > 20 [m], less than 0.01%	
January 2019 **HPE** **3D Positioning** **E1-E5b (DF)** **I/NAV**	
Note: 31 samples > 20 [m], less than 0.01%	

Figure 13: Horizontal Positioning Error (HPE) for "Galileo-only" users in January 2019

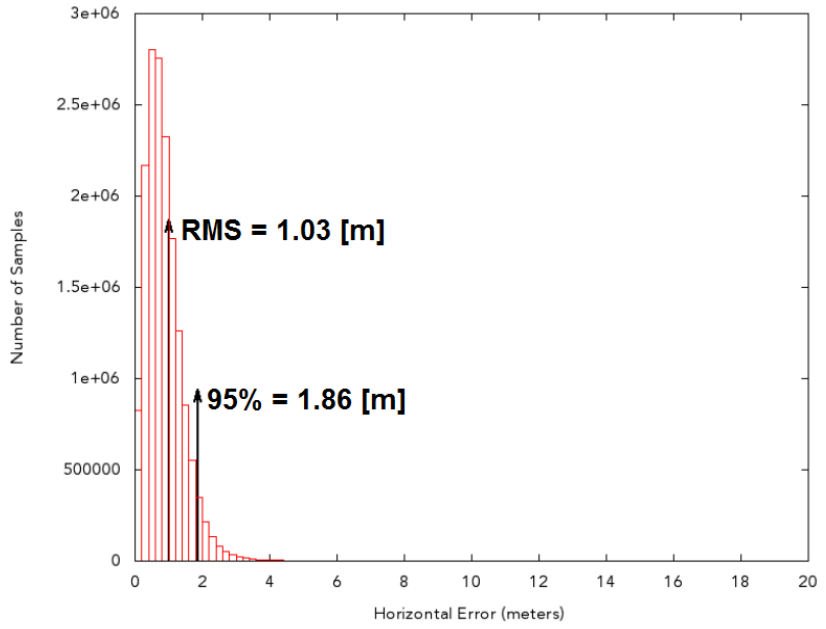
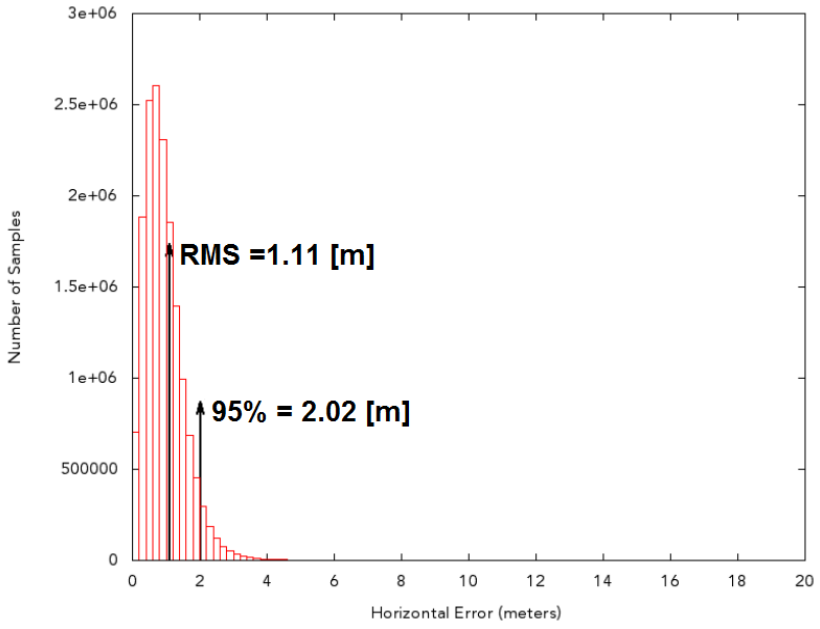
February 2019	
HPE 3D Positioning E1-E5a (DF) F/NAV	
Note: 44 samples > 20 [m], less than 0.01%	
February 2019	
HPE 3D Positioning E1-E5b (DF) I/NAV	
Note: 42 samples > 20 [m], less than 0.01%	

Figure 14: Horizontal Positioning Error (HPE) for "Galileo-only" users in February 2019

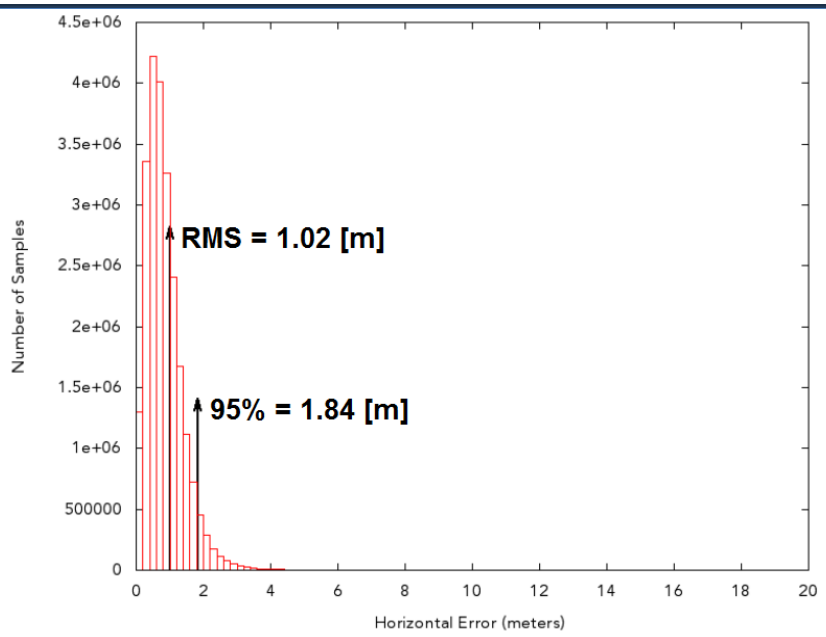
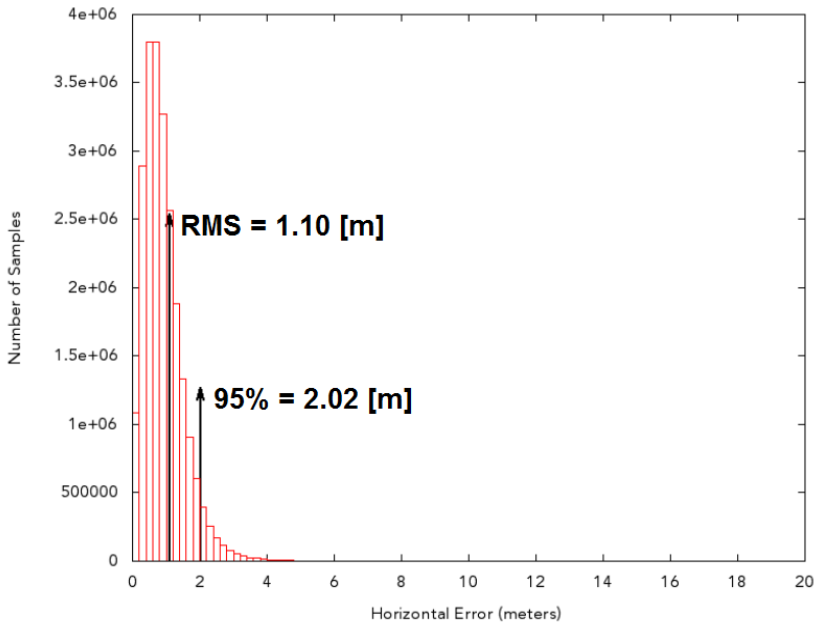
March 2019	
HPE 3D Positioning E1-E5a (DF) F/NAV	
Note: No samples > 20 [m]	
March 2019	
HPE 3D Positioning E1-E5b (DF) I/NAV	
Note: 6 samples > 20 [m], less than 0.01%	

Figure 15: Horizontal Positioning Error (HPE) for "Galileo-only" users in March 2019

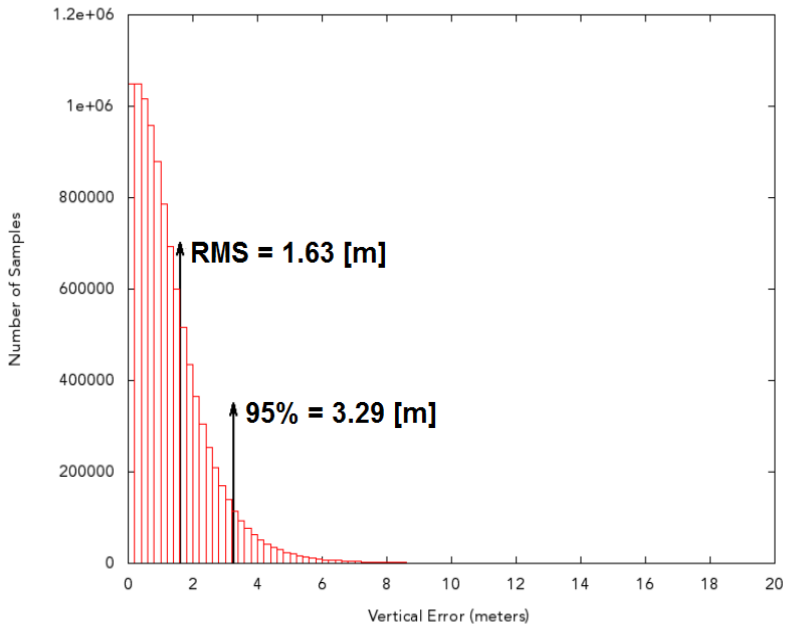
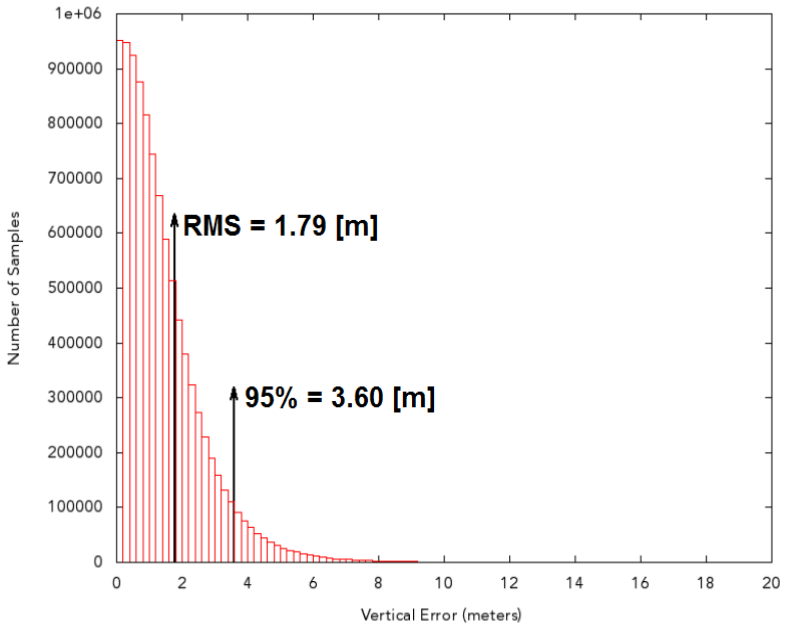
January 2019	
VPE 3D Positioning E1-E5a (DF) F/NAV	
Note: 21 samples > 20 [m], less than 0.01%	
January 2019	
VPE 3D Positioning E1-E5b (DF) I/NAV	
Note: 40 samples > 20 [m], less than 0.01%	

Figure 16: Vertical Positioning Error (VPE) for "Galileo-only" users in January 2019

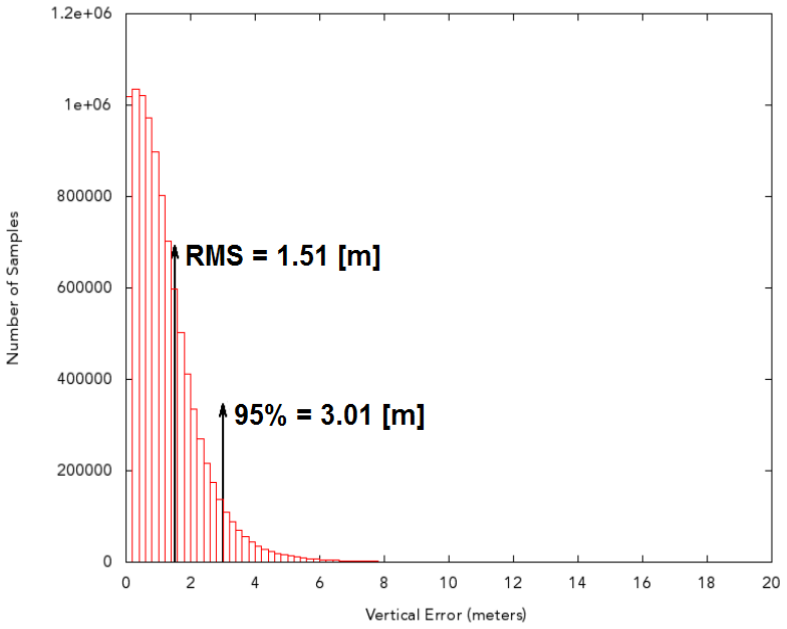
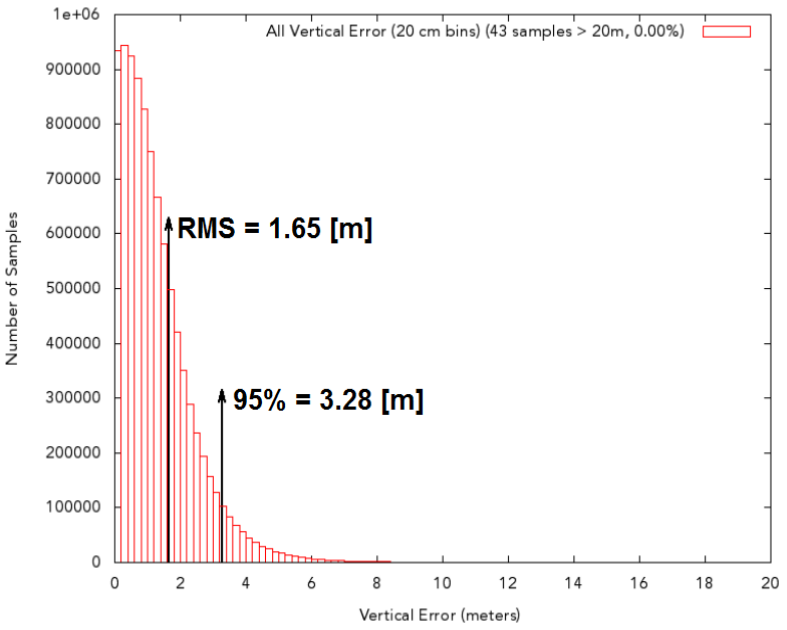
February 2019	
VPE 3D Positioning E1-E5a (DF) F/NAV	
Note: 33 samples > 20 [m], less than 0.01%	
February 2019	
VPE 3D Positioning E1-E5b (DF) I/NAV	
Note: 43 samples > 20 [m], less than 0.01%	

Figure 17: Vertical Positioning Error (VPE) for "Galileo-only" users in February 2019

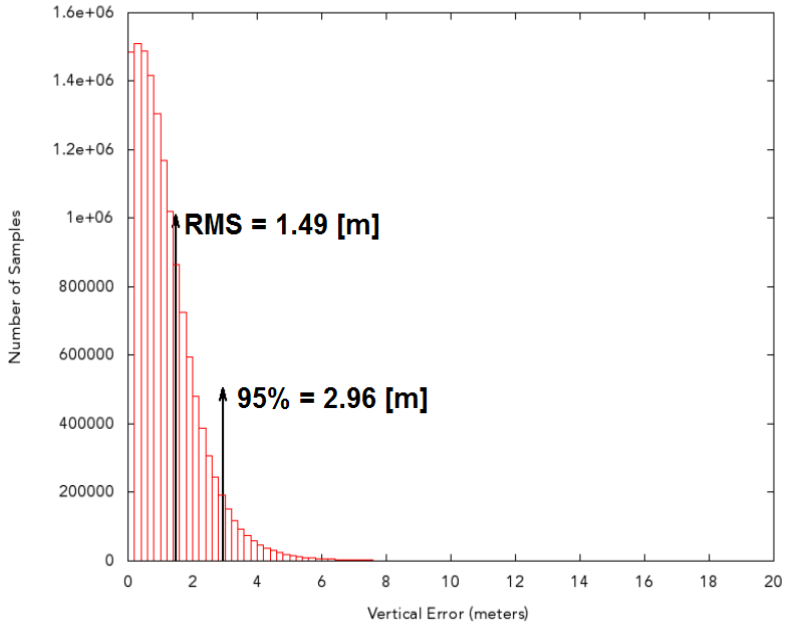
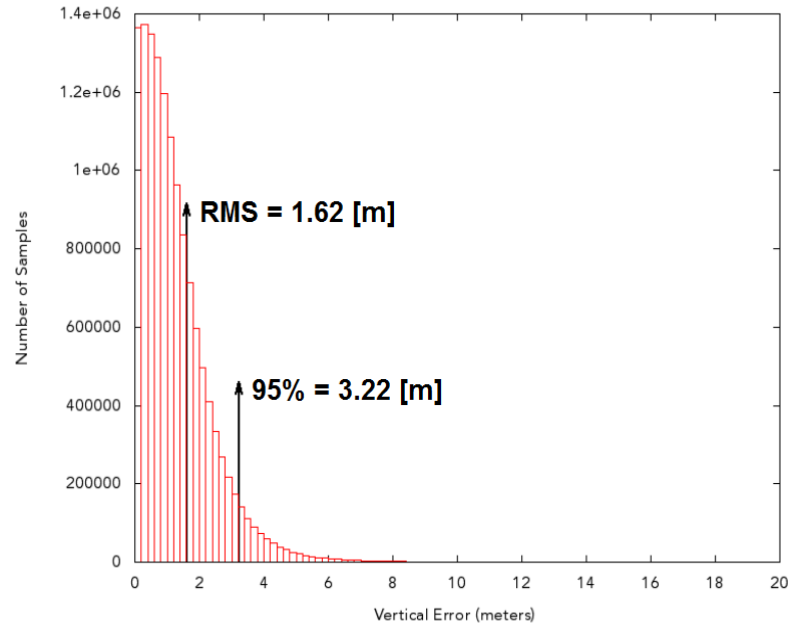
March 2019 **VPE** **3D Positioning** **E1-E5a (DF)** **F/NAV**	
Note: 5 samples > 20 [m], less than 0.01%	
March 2019 **VPE** **3D Positioning** **E1-E5b (DF)** **I/NAV**	
Note: 44 samples > 20 [m], less than 0.01%	

Figure 18: Vertical Positioning Error (VPE) for "Galileo-only" users in March 2019

6 TIMELY PUBLICATION OF NOTICE ADVISORY TO GALILEO USERS (NAGUS)

The European GNSS Service Centre (GSC) is responsible for timely publication of Notice Advisory to Galileo Users (NAGU) messages on its web pages:

GNSS Service Centre NAGU Publication Service Web Pages		
NAGUs Information	https://www.gsc-europa.eu/system-status/user-notifications	(Active user Notifications)
	https://www.gsc-europa.eu/system-status/user-notifications-archive	(Archived user Notifications)

Table 5: GSC web pages for Galileo User Notifications (NAGUs)

During the reporting period, the **target MPLs for publishing NAGUs have been met in all cases.**

According to MPLs in the [OS-SDD], NAGUs related to Planned events need to be published at least **24** hours [21] before the event starts. For Unplanned events, the [OS-SDD] specifies a delay of up to **72** hours [21] from the detection of the unplanned event until a corresponding NAGU is issued.

No NAGUs issued in the period refer to unplanned events affecting the Space Segment.

The summary of NAGUs that have been published during the reporting period is as follows:

[21] Ref.: [OS-SDD] , §3.7.1 (Table 20)

Month	NAGU Type	Reason for publishing	Notice Advisory ID	Categorisation
January	UNP_SHTRCVR	Announcing recovery from maintenance activity on GSAT-0102 (E12). Due to its short duration, outage was communicated "a posteriori" by a single NAGU, as per applicable definition criteria (SIS was marginal over less than 6 hours, starting 28/01/2019 @ 10:15 UTC)	2019001	U
February	USABINIT	Announcing insertion of satellite GSAT-0219 (E36) in the active service provision, starting 11/02/2019 @ 10:26 UTC	2019002	U
	USABINIT	Announcing insertion of satellite GSAT-0222 (E33) in the active service provision, starting 11/02/2019 @ 10:56 UTC	2019003	U
	USABINIT	Announcing insertion of satellite GSAT-0220 (E13) in the active service provision, starting 11/02/2019 @ 11:26 UTC	2019004	U
	USABINIT	Announcing insertion of satellite GSAT-0221 (E15) in the active service provision, starting 11/02/2019 @ 11:26 UTC	2019005	U
	GENERAL	Warning about dissemination of "dummy" GGTO coefficients, starting 22/02/2019 @ 13:01 UTC	2019006	U
	GENERAL	Announcing restart of nominal GGTO coefficients dissemination, from 24/02/2019 @ 13:39 UTC	2019007	U
March	PLN_OUTAGE	Announcing maintenance on-board of GSAT-0102 (E12), starting 28/03/2019 @ 07:15 UTC	2019008	P
	PLN_OUTAGE	Announcing maintenance on-board of GSAT-0222 (E33), starting 02/04/2019 @ 01:00 UTC	2019009	P
	USABLE	Announcing restart of nominal operation of space vehicle GSAT-0102 (E12)	2019010	U
	GENERAL	Warning about dissemination of "dummy" GGTO coefficients, starting 30/03/2019 @ 13:01 UTC	2019011	U
NAGU Categorisation for timeliness evaluation: "P" = Planned, "U" = Unplanned				

Table 6: NAGUs published during 1st Quarter 2019

7 REFERENCES

This section identifies the documents explicitly referenced in this Galileo Initial Open Service Public Performance Report.

[SIS-ICD] European GNSS (Galileo) Open Service Signal-In-Space Interface Control Document (OS-SIS-ICD), Issue 1.3, European Union, December 2016

[IONO] Ionospheric Correction Algorithm for Galileo Single Frequency Users, Issue 1.2, European Union, September 2016

[OS-SDD] European GNSS (Galileo) Open Service Definition Document (OS-SDD), Issue 1.0, European Union, December 2016.

Previous documents are made available to users through the web portal of the European GNSS Service Centre (http://www.gsc-europa.eu/), exception made for the Issue 1.0 of OS-SDD.

IMPORTANT NOTE
A new version of the OS-SDD (Issue 1.1) has been published and is in force since May 2019. This new version is now accessible for download from the European GNSS Service Centre (GSC) website.
However, the current OS Quarterly Performance Report refers to a quarterly period during which Issue 1.0 of the OS-SDD was still the applicable one. This previous version can be obtained from the GSC upon request.

For an exhaustive description of the Minimum Performance Levels (MPLs), the reader is referred to the [OS-SDD]. Individual sections of the [OS-SDD] have been referenced throughout this report when referring to MPL target values.

8 LIST OF ACRONYMS

Acronym	Definition
DF	(Galileo OS) Dual Frequency combination (E1/E5a, E1/E5b)
DOP	Dilution of Precision
ECEF	Earth Centred, Earth Fixed frame coordinates
F/NAV	Navigation message provided by the E5a signal [SIS-ICD]
FOC	Full Operational Capability
GSA	European Global Navigation Satellite Systems Agency
GGTO	GST-GPS Time Offset
GMS	Galileo Mission Segment
GPS	Global Positioning System
G/S	Ground Segment
GSC	European GNSS Service Centre
GST	Galileo System Time
HDOP	Horizontal Dilution of Precision
HPE	Horizontal Positioning Error
ICD	Interface Control Document
I/NAV	Navigation message provided by the E1-B and E5b signals [SIS-ICD]
IS	(Galileo) Initial Services
MPL	Minimum Performance Level
NAGU	Notice Advisory to Galileo Users
OS	(Galileo Navigation) Open Service
PDOP	Position Dilution of Precision
SDD	Service Definition Document
SF	(Galileo OS) Single Frequency (E1, E5a, E5b)
SIS	Signal in Space
SISE	Signal In Space Error vector (4-dimensional)
toE	Time of Ephemeris
UTC	Universal Time Coordinated
VPE	Vertical Positioning Error
WUL	Worst User Location

End of Document

European GNSS Service Centre:
https://www.gsc-europa.eu/