NAVIGATION SOLUTIONS POWERED BY EUROPE

EUROPEAN GNSS (GALILEO) INITIAL SERVICES

OPEN SERVICE

QUARTERLY PERFORMANCE REPORT

APRIL - JUNE 2017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

This document is the *Galileo Initial Open Service (IS OS) Public Performance Report* for the period of April, May and June 2017. 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.

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 the 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, along with a short abstract of the Minimum Performance Levels (MPLs) definitions as per [OS-SDD].

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

Table 1 provides the status of the Galileo constellation for which 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-0204	22	264	B03	Available
GSAT-0205	24	265	A08	Available
GSAT-0206	30	266	A05	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-0207	7	267	C06	Available, since 29/05/2017 @ 18:23 [2]
GSAT-0214	5	26E	C01	Available, since 29/05/2017 @ 13:15 [3]

Table 1: Galileo Reported Constellation Information

At the time of publication of this report, two additional satellites, GSAT-0212 (E03) and GSAT-0213 (E04), have been declared available since August 2017 (information notified respectively by NAGU 2017029 and 2017033); however, this happened beyond the reporting period covered by this document, and thus they are not considered in the performance computations.

[2] Ref.: NAGU 2017018

[3] Ref.: NAGU 2017017

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: Galileo status information

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 second quarterly reporting period after declaration of Initial Services, the measured Galileo Initial Open Service performance figures generally exceed the Minimum Performance Level (MPL) targets specified in the [OS-SDD] with significant margins. However in June, ranging accuracy performance for one satellite, (GSAT-0203), was not within the specified limits. This was due to an anomaly in the on-board payload (clock frequency jump) followed by a prolonged unavailability of "healthy" signal in space declared by NAGUs 2017019, 2017020, 2017025. As a result of this situation, the accuracy averaged over all satellites did not meet the MPL, even though all other satellites performed well. The method of calculation is being analysed and possibly adapted to better reflect the overall performance levels experienced by the users.

The following dashboards summarize the compliance with MPLs, using the colour coding defined in the legend below:

OS MPLs			Target Value	Apr-17	May-17	Jun-17
OS SIS Ranging Service	Accuracy, Any Satellite	E5a-E1 user	≤ 7m [95%]			
		E5b-E1 user				
		E1 user				
		E5a user				
		E5b user				

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

GSAT-0101	GSAT-0102	GSAT-0103	GSAT-0210	GSAT-0214 [4]
GSAT-0203	GSAT-0204	GSAT-0205	GSAT-0211	
GSAT-0206	GSAT-0208	GSAT-0209	GSAT-0207 [4]	

Allocation of Satellites in previous dashboard

[4] Added to reporting period since June 2017.

Legend

- MPL measurement not available (e.g.: if satellite was not yet declared available)
- Target Value for MPL is fulfilled
- Target Value for MPL is NOT fulfilled (less than 10% away from the Target)
- Target Value for MPL is NOT fulfilled (more than 10% away from the Target)

OS MPLs				Target Value	Apr-17	May-17	Jun-17
SIS Ranging	Accuracy, Over All Satellites	E5a-E1 user		≤ 2m [95%]			
		E5b-E1 user					
		E1 user					
		E5a user					
		E5b user					
	Availability	Per-slot	E5a-E1	≥ 87%			
			E5b-E1				
			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)

As previously mentioned, compliance with the "Accuracy over All Satellites" MPL is not achieved over the month of June 2017, only because of the cited incident affecting the on-board clock of GSAT-0203.

Availability of the Galileo Ranging Service at the Worst User Location (WUL) has monthly values of **100%** in April and June, and **95.48**% in May. These are significantly above expectations, where the MPL is **87%**. The "per-satellite" **Availability of a Healthy Signal**, with average monthly values better than **94.71%**, is also significantly better than the MPL of **87%**.

The **Signal in Space Ranging Accuracy** shows a 95th percentile monthly accuracy better than **0.78** [m] for individual space vehicles ("Any Satellite") in April, lower than **1.98** [m] in May. Compliance with the [OS-SDD] MPL is achieved in April and May, with the threshold fixed to **7** [m]. Conversely, MPL compliance in June was not achieved by GSAT-0203 (E26) due to the anomaly in the GSAT-0203 on-board payload (clock frequency jump), which occurred during a maintenance period. GSAT-0203 broadcast signals experienced large ranging errors nearly 24 hours before the signals were declared UNHEALTHY. Additionally, prolonged unavailability declared by NAGUs 2017019, 2017020 and 2017025 resulted in a very low GSAT-0203 "healthy" interval of 32.15% of the month. Notwithstanding the reduced number of samples with a healthy SIS status, the computed metrics did not meet the published MPLs, resulting in the red status boxes appearing in Table 3 and Table 4. This event occurred during a maintenance action that should have been notified to the users through a NAGU and should have resulted in the appropriate setting of health and status flags. Changes have been implemented in the operational procedures to avoid any future occurrence of analogous situations.

The average over all space vehicles provides figures "per signal" that appear better than **0.66** [m] in April, **1.28** [m] in May; in June, the specified [OS-SDD] MPL threshold of **2** [m] is not met, due to the degraded ranging performance and low availability of GSAT-0203 (E26), as previously explained.

The **Availability of the Galileo UTC Time Determination Service** is comfortably achieved, with monthly values of **100%** (April), **95.48**% (May) and **100%** (June) well above the [OS-SDD] MPL target of **87%.**

The **Availability of GGTO Determination** was **97.79**% (April), **97.41**% (May) and **97.30%** (June). Annually normalised figures are obtained with a moving average applied since the Declaration of Initial Services; measured values are well above the [OS-SDD] MPL target of **80%.**

Excellent values are achieved for **UTC Time Dissemination Service Accuracy** ($\leq$ **11 [ns]**), **UTC Frequency Dissemination Service Accuracy** (normalized offset better than $\mathbf{6.71 \times 10^{-14}}$) and the **GGTO Determination Accuracy** ($\leq$ **7** [ns]), all computed by accumulating samples over the

previous 12 months [5]. The [OS-SDD] MPL targets are all met, these are respectively **30** [ns], $\mathbf{3\times10^{-13}}$ and **20** [ns].

The **Availability of HDOP** ≤ **5** is at least **68.99%,** while the Availability of a **Galileo Horizontal Positioning** better than 10 [m] with **PDOP** ≤ **5** is at least **80.42%.** These figures are in line with the deployment status of the Galileo constellation during the reporting period (11 operational satellites in April and May, 13 in June) and with the expected minimum threshold for Initial Services, defined in the [OS-SDD] as **50%** in both cases. These availabilities are constantly improving with the constellation completion towards the final operational capability; e.g.: in June, the **availability of the HDOP** ≤ **5** reached **100%** in some parts of the service area.

Availability figures are complemented with "Galileo-only" measured 3D positioning performance attainable when PDOP ≤ 6. The 95th percentile of **Horizontal and Vertical 3D Positioning Errors** (HPE and VPE, correspondingly) does not exceed **3.50** [m] and **5.69** [m] respectively during the reporting period, as measured by experimental reference receivers. 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 in April and May for both Planned and Unplanned events, so that the target of at least **24** hours before the start of a scheduled event, is always achieved, as well as not more than **72** hours after an unscheduled one. However, in June some NAGUs exceeded MPL thresholds; additional details about NAGU timeliness are presented in § 6 .

As already mentioned, further performance improvements are expected with the on-going Galileo System deployment, also in terms of system robustness and continuity of delivered services.

A successful simultaneous launch of four Galileo satellites (GSAT-0207, -0212, -0213, -0214) occurred on November 17th, 2016. They are all currently inserted within the active constellation providing Navigation Services; among them, GSAT-0212 (E03) and GSAT-0213 (E04) were not considered in this quarterly report, as they were declared available only since August 2017.

[5] Monthly figures related to time scales result from processing measurements accumulated since an initial time that is prior to the declaration of Galileo Initial Services.

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[6] 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.

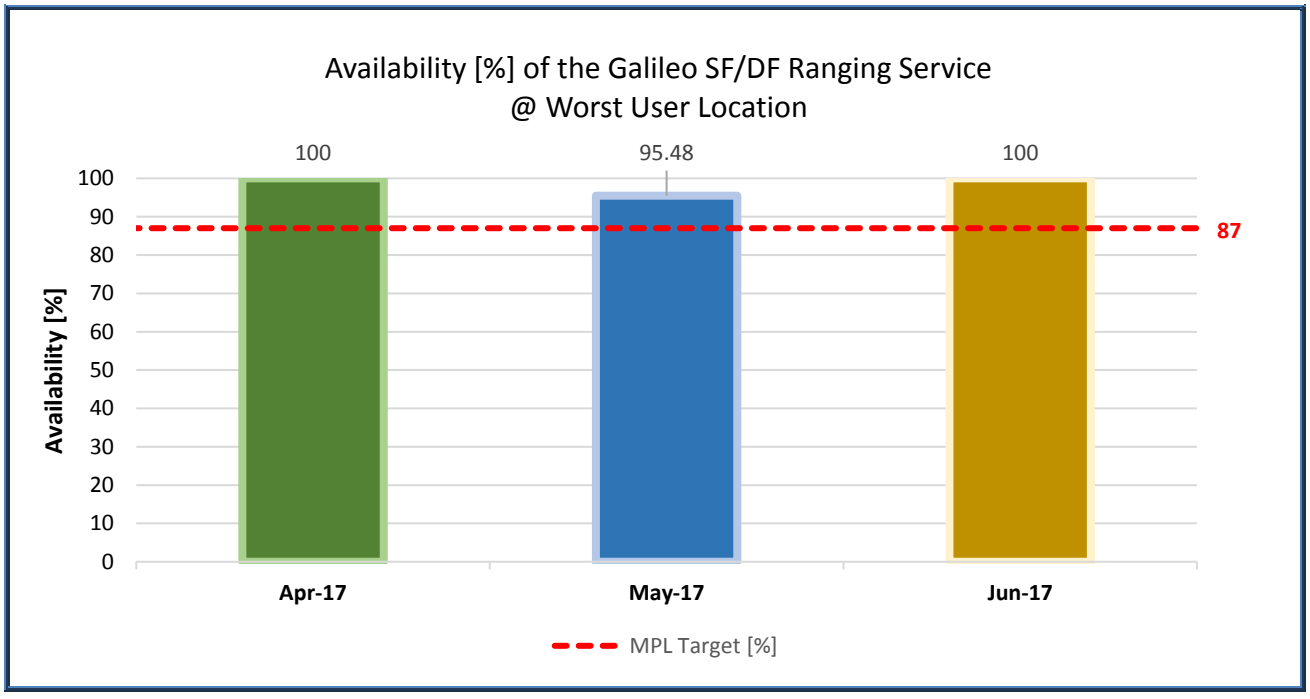


Figure 1: Monthly Availability of the Galileo SF/DF Ranging Service

[6] 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%** for April and June, while in May it equals **95.48**%. These figures are well above the Minimum Performance Level from [OS-SDD], specified as **87%**[7]. However, in May the Navigation message was not refreshed for any satellite in the constellation over an extended period, therefore exceeding the maximum tolerable "Age of toE" as per [OS-SDD]. With reference to NAGU 2017015, a service failure was indicated that extended to the **entire constellation**; recovery was subsequently announced by NAGU 2017016 .

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[6] Galileo Open Service Signals in Space.

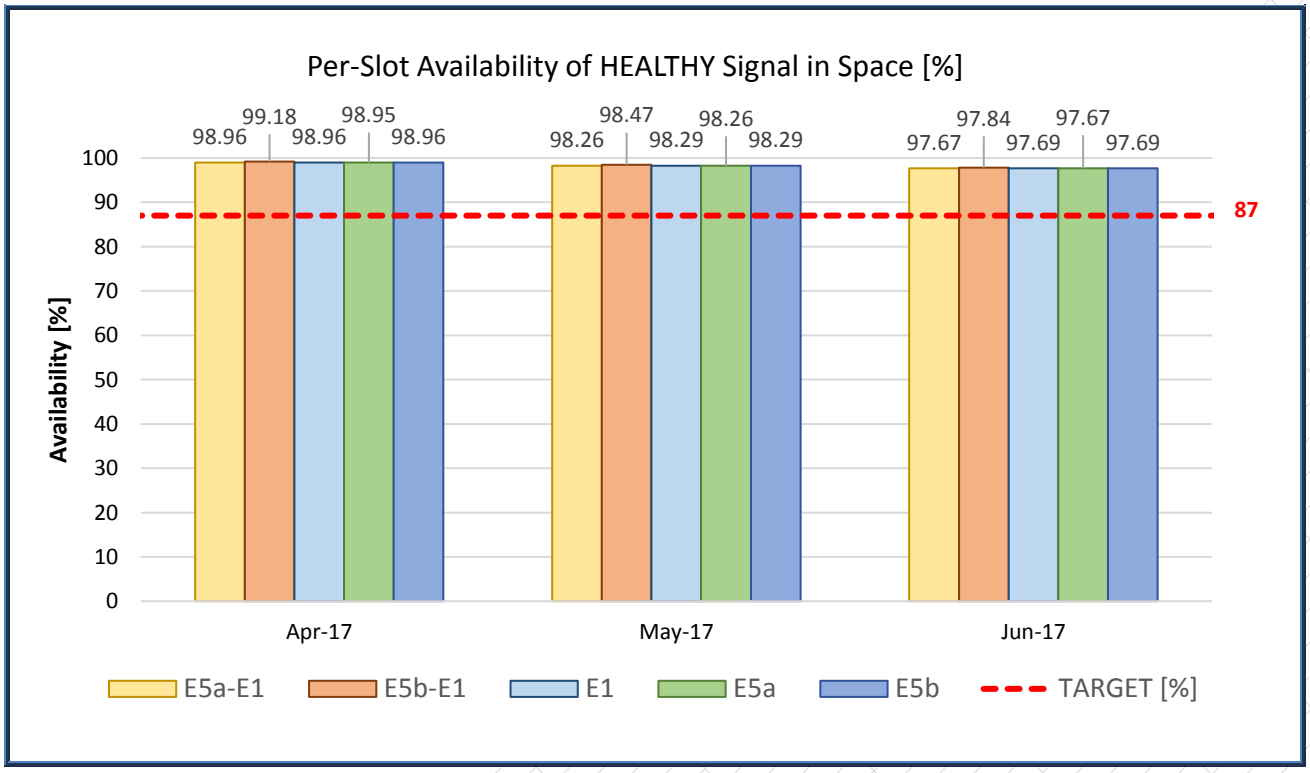


Figure 2: "Per-Slot" availability of HEALTHY Signal in Space for the reporting period

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.[8] The worst-case among Single

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

[8] The [OS-SDD] foresees an "annual normalisation", which is actually implemented with an incremental averaging process, accumulating data after the declaration of Initial Services in December 2016 until the referred month

Frequency/Dual Frequency RF signals and signal combinations is considered, per each space vehicle, and for each month.

The [OS-SDD] Minimum Performance Level (MPL) specifies **87%** [9] as target for the annually normalised constellation average. A moving average is implemented starting from January 2017; the monthly constellation behaviour is in line with the required annual figure.

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 Ageing 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 Galileo Signal in Space Ranging Accuracy "for any space vehicle", over all satellites and frequency combinations, is:

- better than **0.78** [m] (Dual Frequency) and **0.75** [m] (Single Frequency) for individual space vehicles in April;
- better than **1.96** [m] (Dual Frequency) and **1.98** [m] (Single Frequency) for individual space vehicles in May;
- better than **0.44** [m] (Dual Frequency) and **0.62** [m] (Single Frequency) for individual space vehicles in June, exception for GSAT-0203 (E26): for this satellite, due to the cited incident and the relatively short availability in "Healthy" SIS status during the month, Ranging Accuracy figures were as high as **461** [m].

[9] Ref.: [OS-SDD] , §3.5.1 (Table 14)

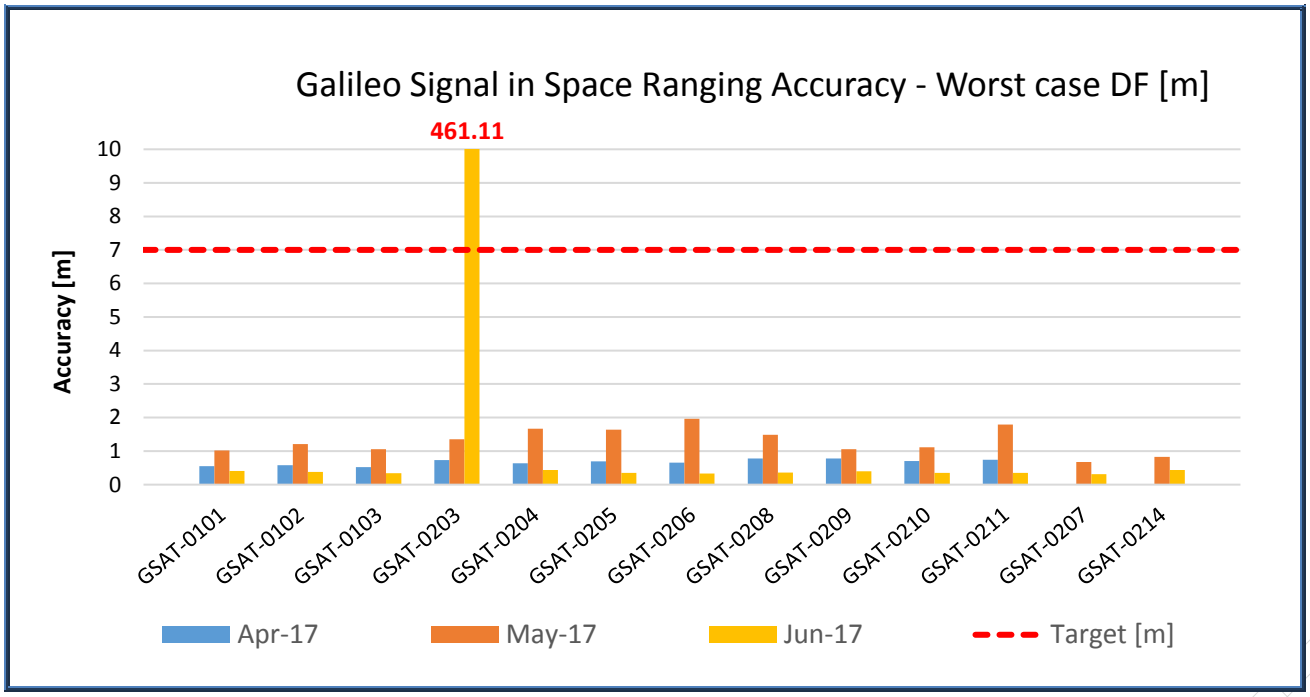


Figure 3: Monthly Galileo SIS Ranging Accuracy (95th percentile) "for any satellite", measured during reporting period for worst-case, Dual-Frequency (DF)

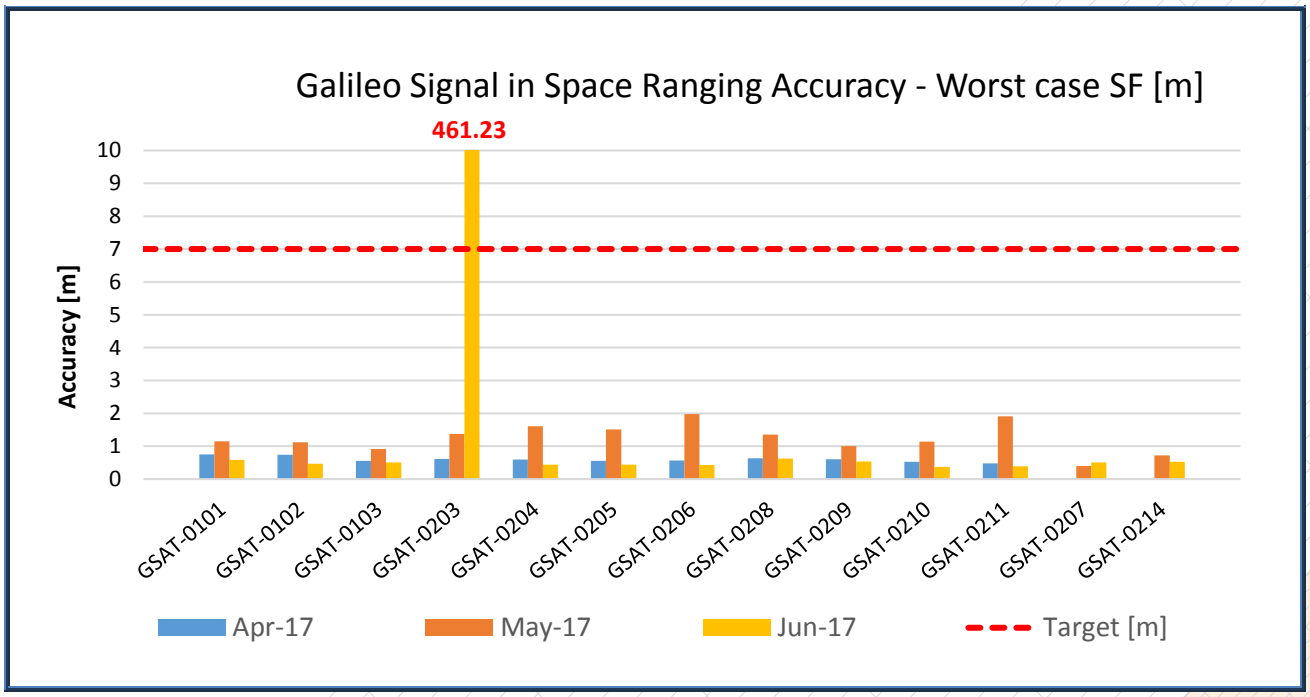


Figure 4: Monthly Galileo SIS Ranging Accuracy (95th percentile) "for any satellite", measured during reporting period for worst-case, Single-Frequency (SF)

Compliance with [OS-SDD] MPL was not achieved in June for one single space vehicle - GSAT-0203 (E26), a maximum threshold of **7** [m] [10] is specified 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 not met in June, due to the performance of a single satellite GSAT-0203 impacting the Constellation average value.

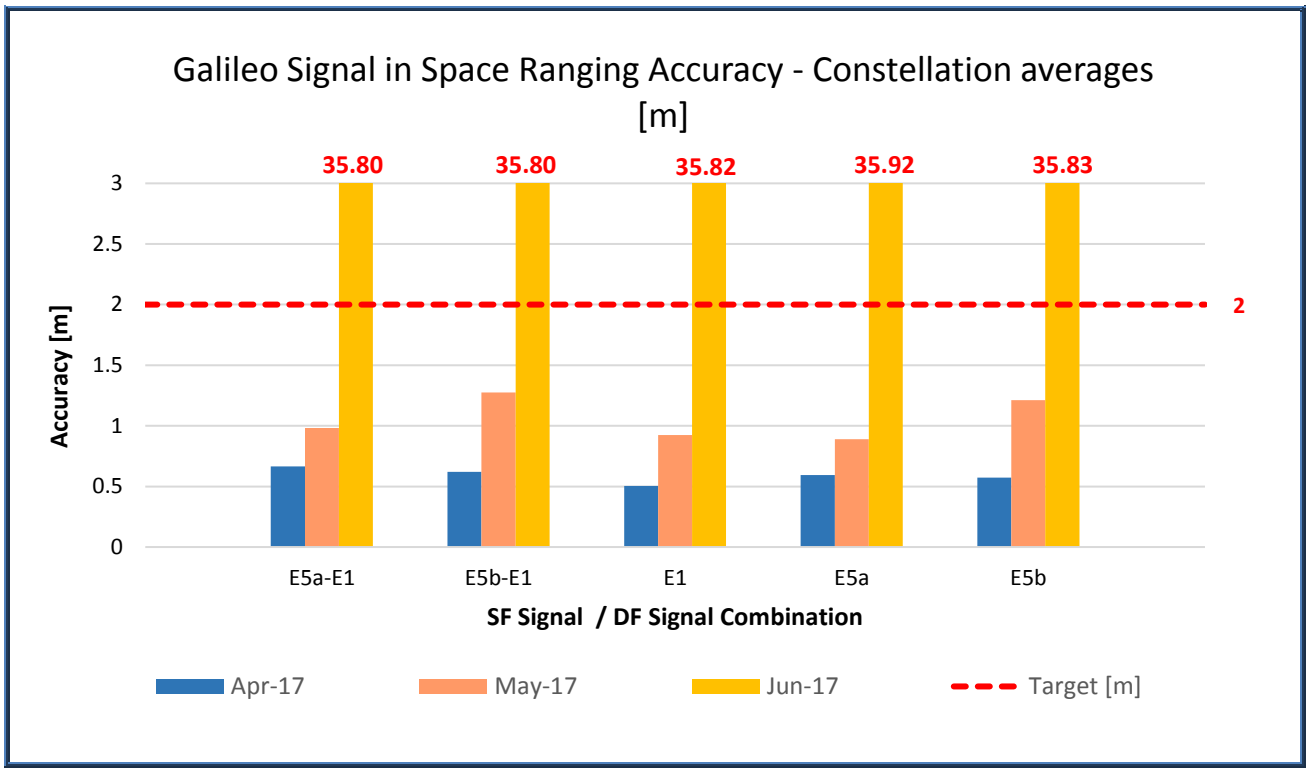


Figure 5: Monthly Galileo SIS Ranging Accuracy (95th percentile) "over all satellites" (constellation average), measured during the reporting period

[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 the 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[6] 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.

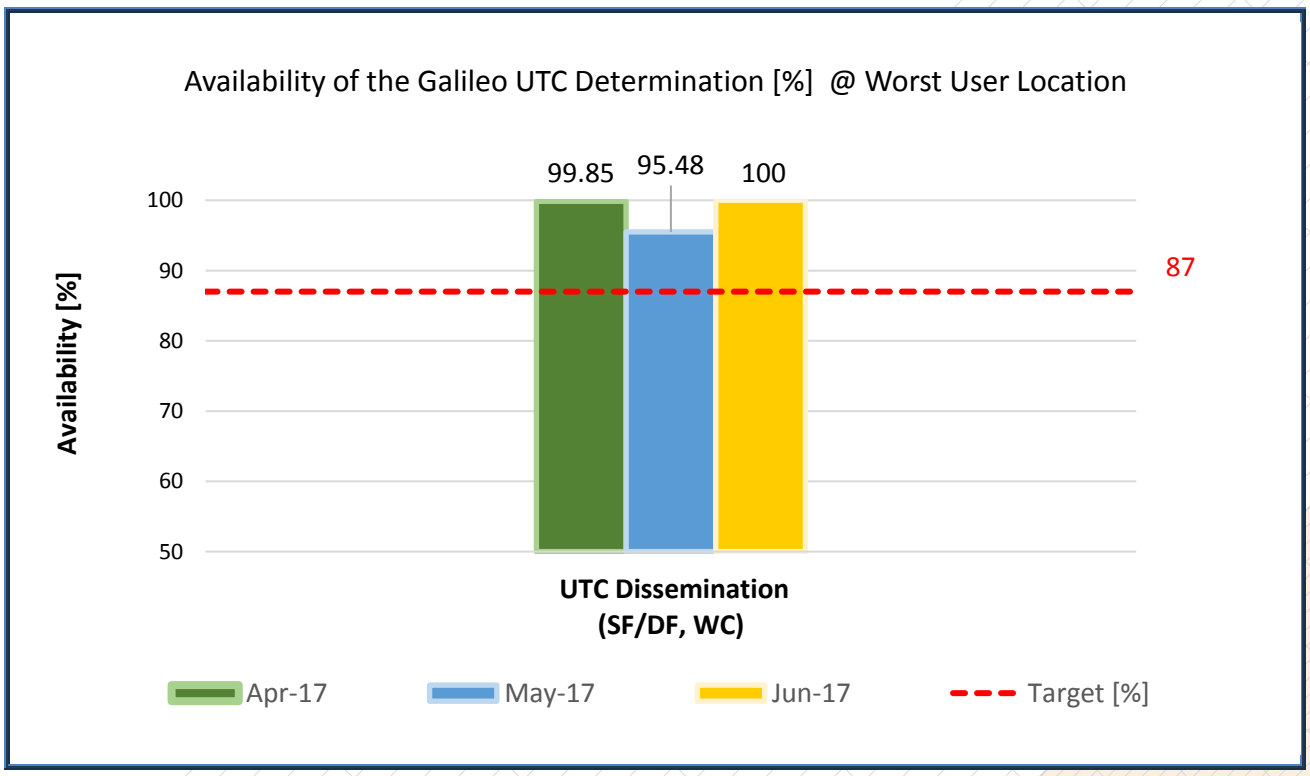


Figure 6: Monthly availability of the UTC Determination Service during the reporting period

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[11] 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.

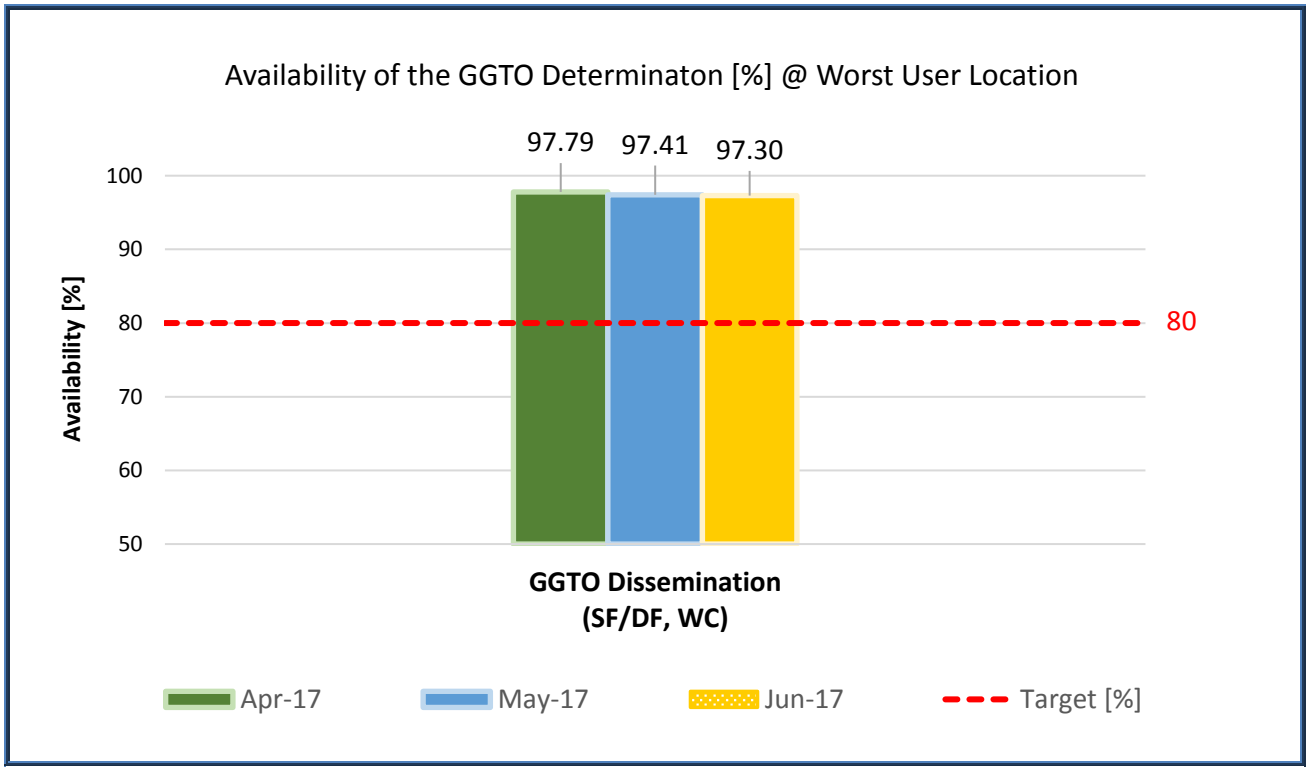


Figure 7: Evolution of the annually normalised availability of the GGTO Determination, during the reporting period

The monthly availability of the Galileo UTC Determination Service reached **100**% in April and June, and **95.48**% in May. The reason for a slight drop of availability figure in May is related to the lack of "healthy" SIS status and the expiration of Navigation message validity ("Age of toE" exceeding 4 hours), which is considered applicable to all Navigation message elements.

The Galileo user GGTO Determination capability is **97.79%** in April, **97.41**% in May and **97.30**% in June, having implemented a moving average approach for the annual normalisation.

The MPL of **87%** [12] specified by [OS-SDD] is fully achieved in both cases.

[11] "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.

[12] Ref.: [OS-SDD] , §3.5.4 (Table 17) and §3.6.1.2 (Table 19)

4.2 ACCURACY OF THE 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 normalized time and frequency offset relative to UTC for a user equipped with a Standard Timing / Calibration Laboratory Receiver. [13]

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 12 month period.

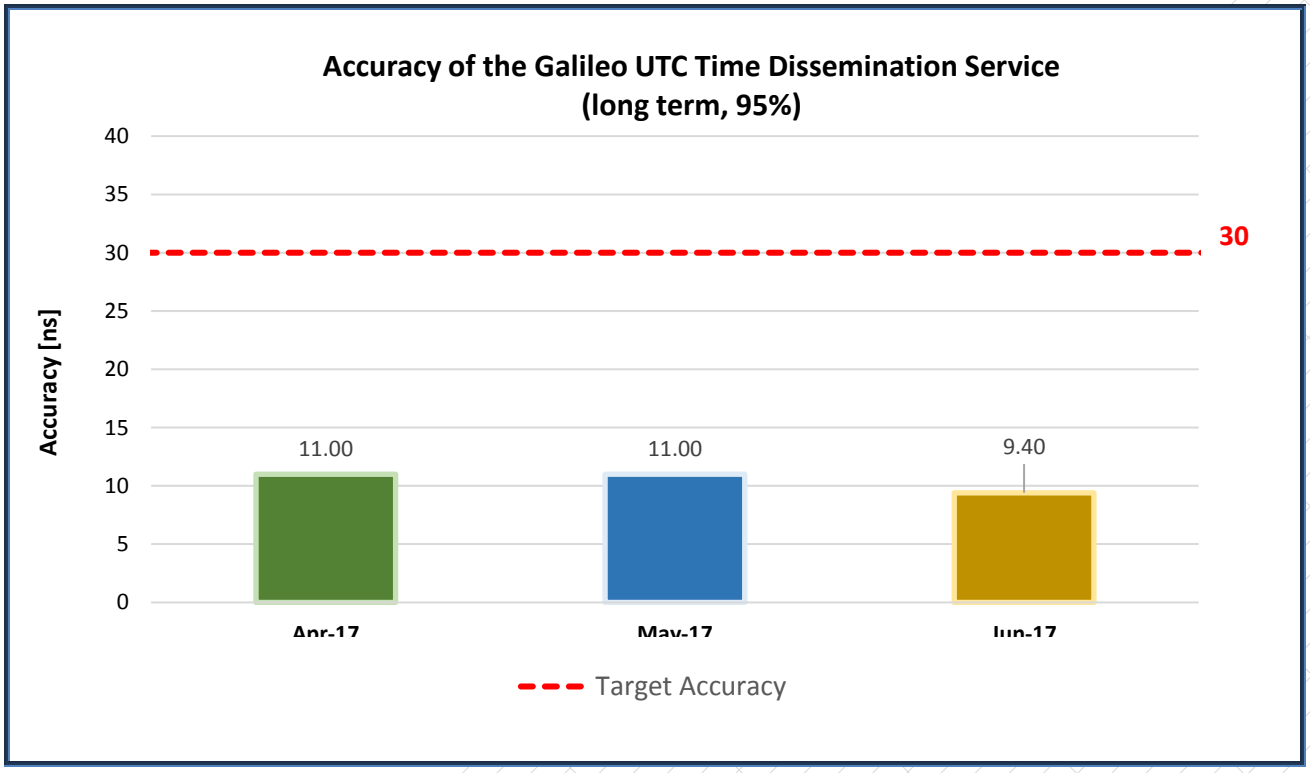


Figure 8: 95th Long-term 95% percentile of UTC Time Dissemination Accuracy

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

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

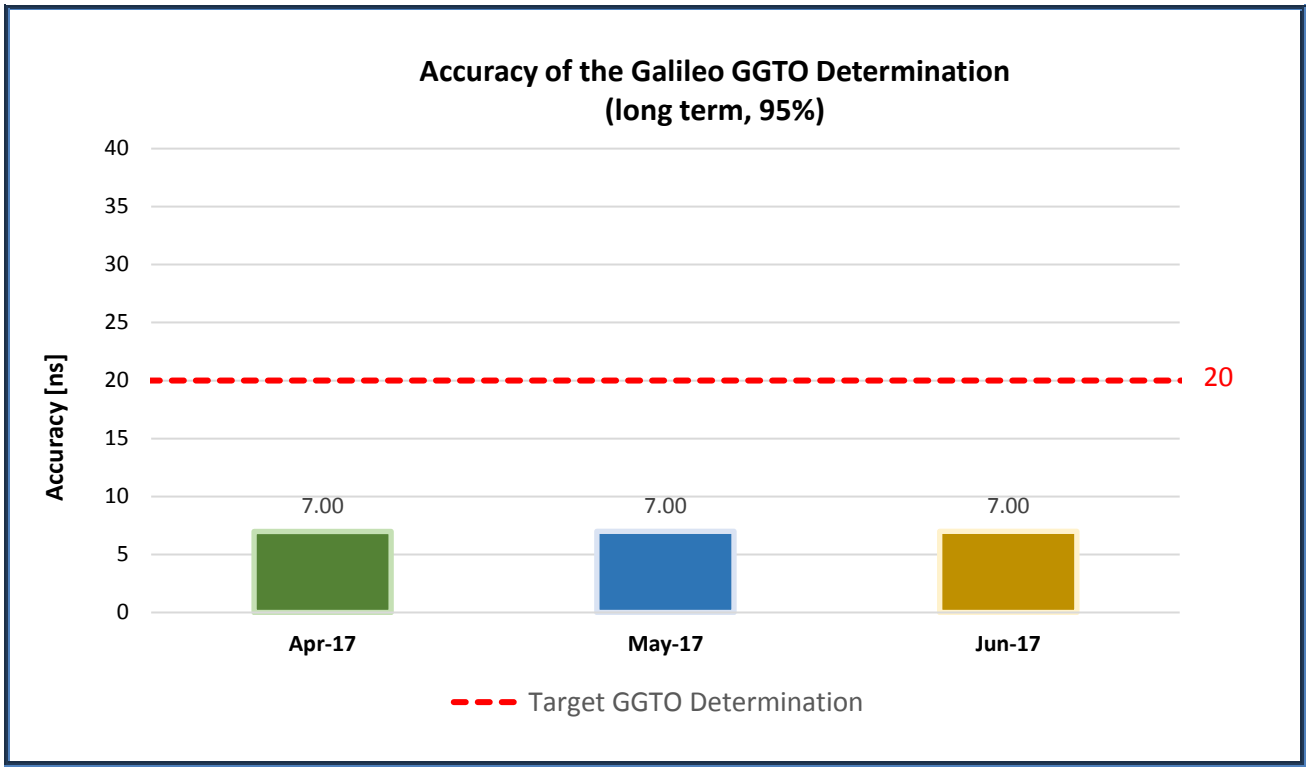


Figure 9: Long-term 95th percentile of GGTO Determination Accuracy

Figure 10 shows the 95th percentile of the UTC Frequency Dissemination Accuracy, computed accumulating measurement data over the past 12 months[14].

As seen in Figure 8 and Figure 9, the long term 95th percentile of UTC (Time) Dissemination Accuracy is always better than **11** [ns] and the GGTO Determination Accuracy of **7** [ns], which are both well within the [OS-SDD] Minimum Performance Level specifications of **30** [ns] and **20** [ns], respectively [15].

Regarding UTC Frequency Dissemination accuracy, Figure 10 shows that the maximum measured 95th percentile value of **6.71E–14** is well within the [OS-SDD] MPL normalised annual ceiling of **3.0E–13** [16].

[14] Monthly figures result from a processing that includes measurements accumulated since an initial time which is antecedent to the declaration of Galileo Initial Services

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

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

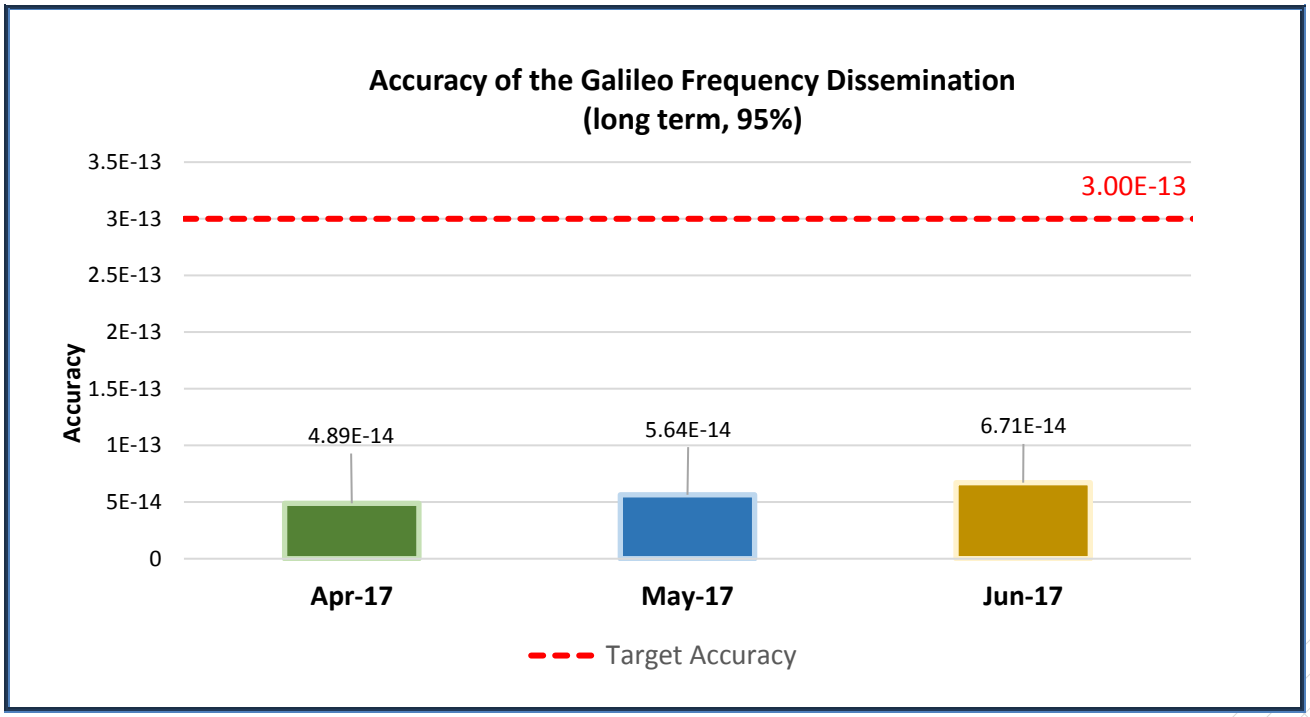


Figure 10: Long-term 95th percentile of UTC Frequency Dissemination Accuracy

5 GALILEO POSITIONING PERFORMANCE

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

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

No specific MPLs are defined in this case, but the target expectation is an availability of at least 50% [17].

5.1 AVAILABILITY OF GLOBAL HORIZONTAL DILUTION OF PRECISION (HDOP)

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 below 5, are in view from the user locations.

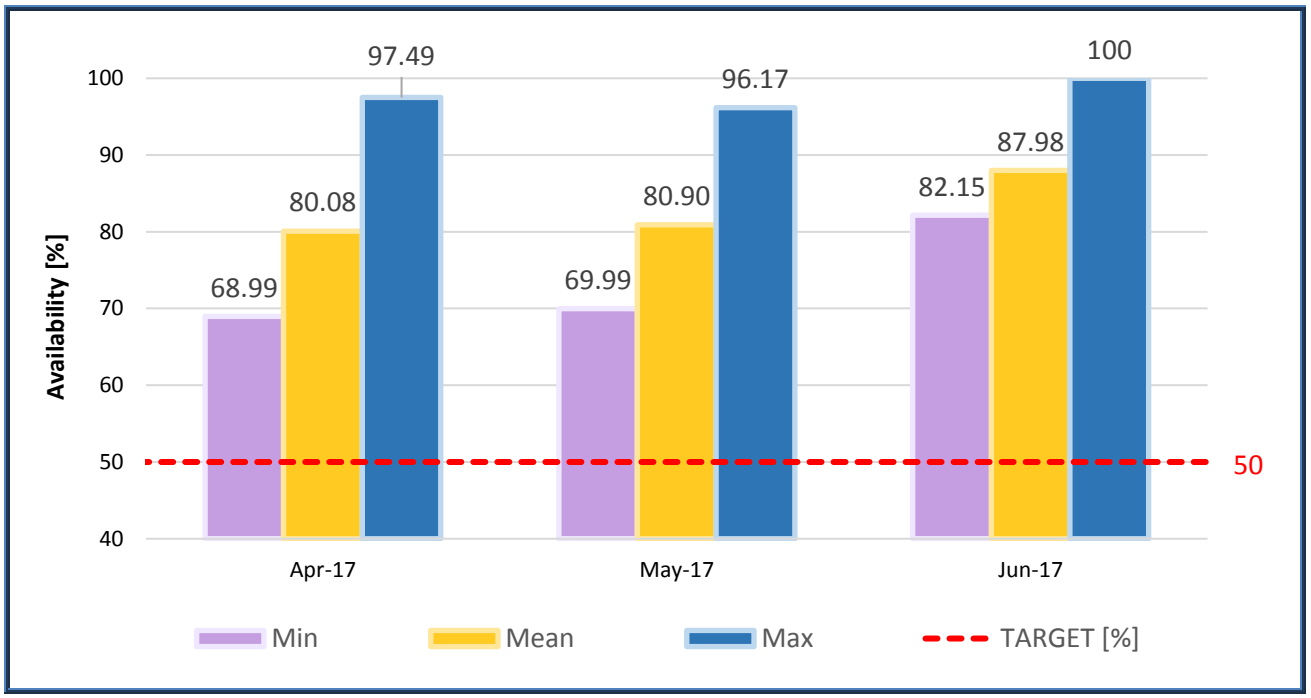


Figure 11: Availability of HDOP ≤ 5

[17] 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. One clearly sees the progressive improvement of the availability figures over the observation period.

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[6] Galileo Open Signal in Space from satellites above a minimum elevation angle of 5 degrees and assuming a receiver operating in "altitude hold" mode, with HDOP filtering . Horizontal Positioning assumes that Navigation Equations are to be solved in two dimensions[18].

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.

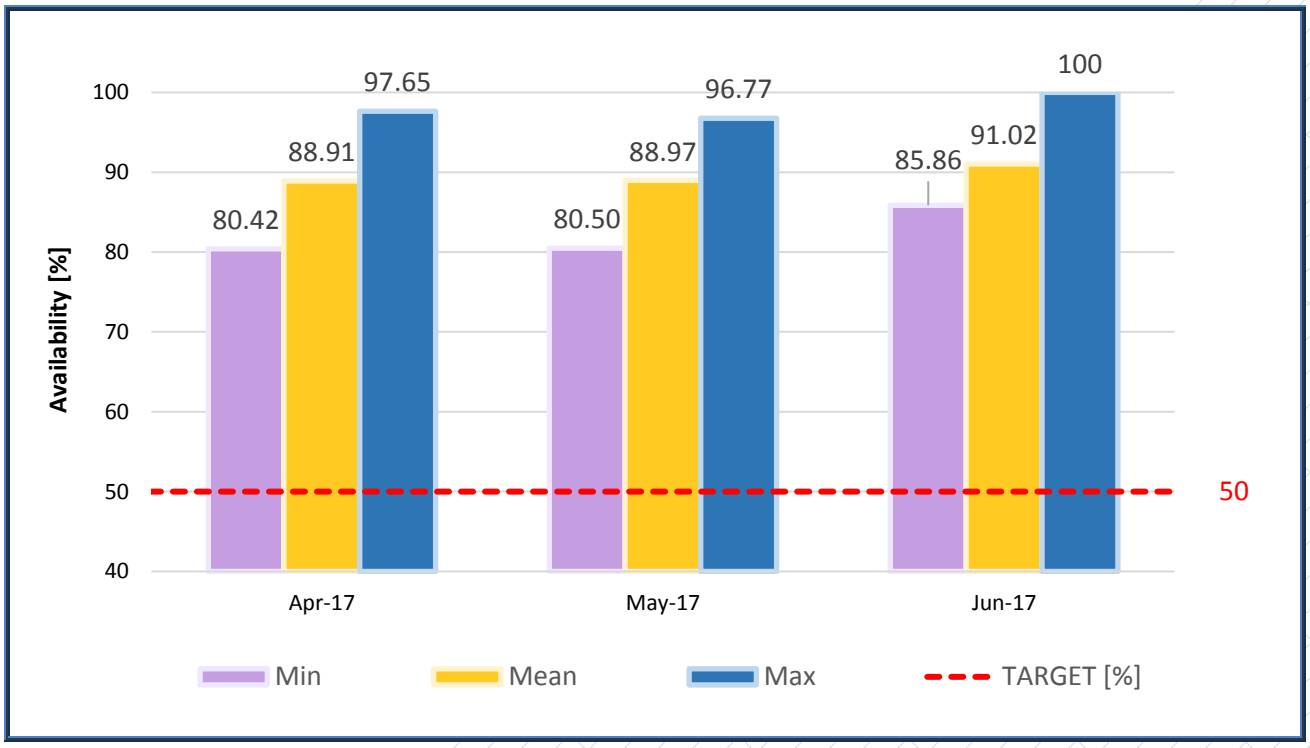


Figure 12: Availability of the Galileo Horizontal Positioning Service with Accuracy ≤ 10 [m]

Again, the figures show a clear increase of the performance from April to June.

[18] 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 positioning is not declared as a Galileo Service, this section provides Navigation Sensor Error estimates as an indication of Galileo Navigation Positioning performance capabilities.

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 by following OS-SDD recommendations about SIS health status, "Ageing of toE" [19] and PDOP ≤ 6. To this aim it is recalled that, according to the [OS-SDD] directions, Navigation message coefficients with an "Ageing of toE" beyond 4 hours have expired validity, so that ranging observables from a 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].

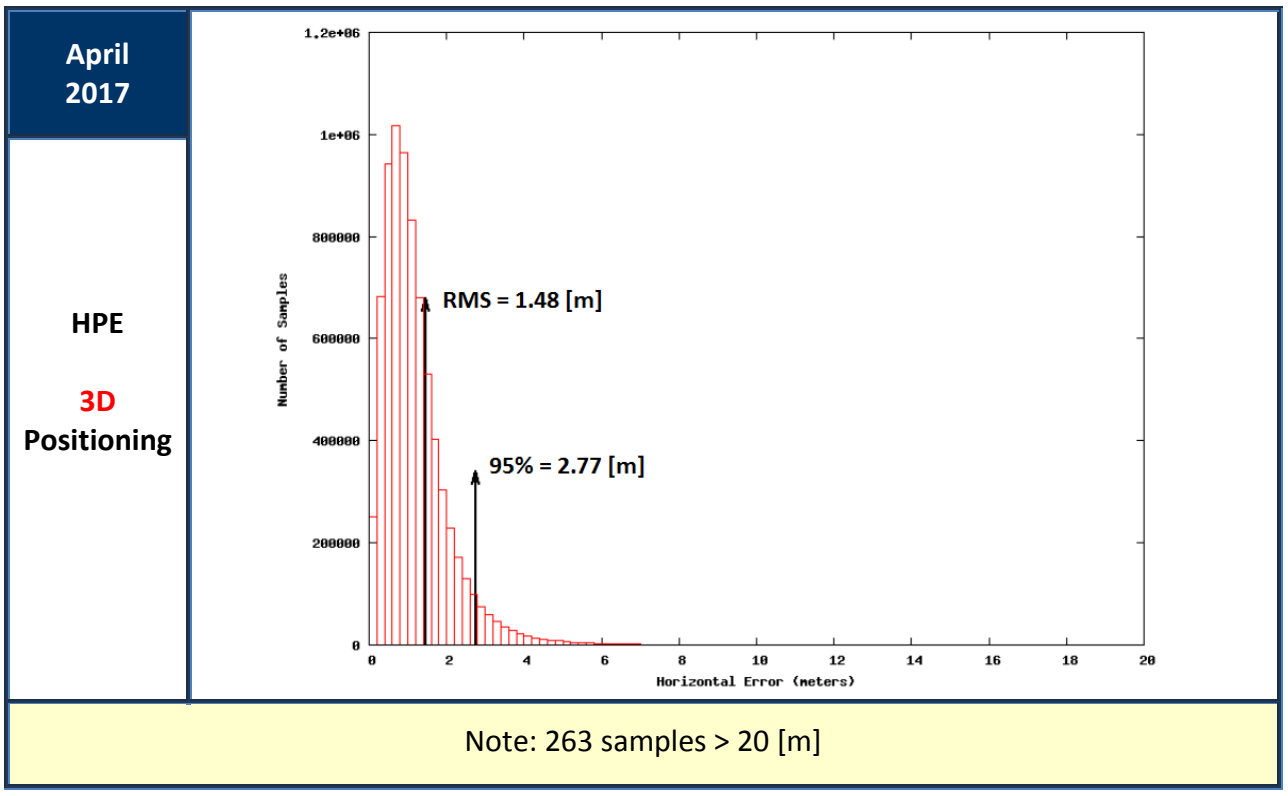


Figure 13: Horizontal Positioning Error (HPE) for "Galileo-only" users (April 2017)

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

[20] Increased number of samples exceeding plot threshold of 20m during May and June is influenced by the sporadic excursions of ranging accuracy errors that took place for several satellites as introduced in § 2.

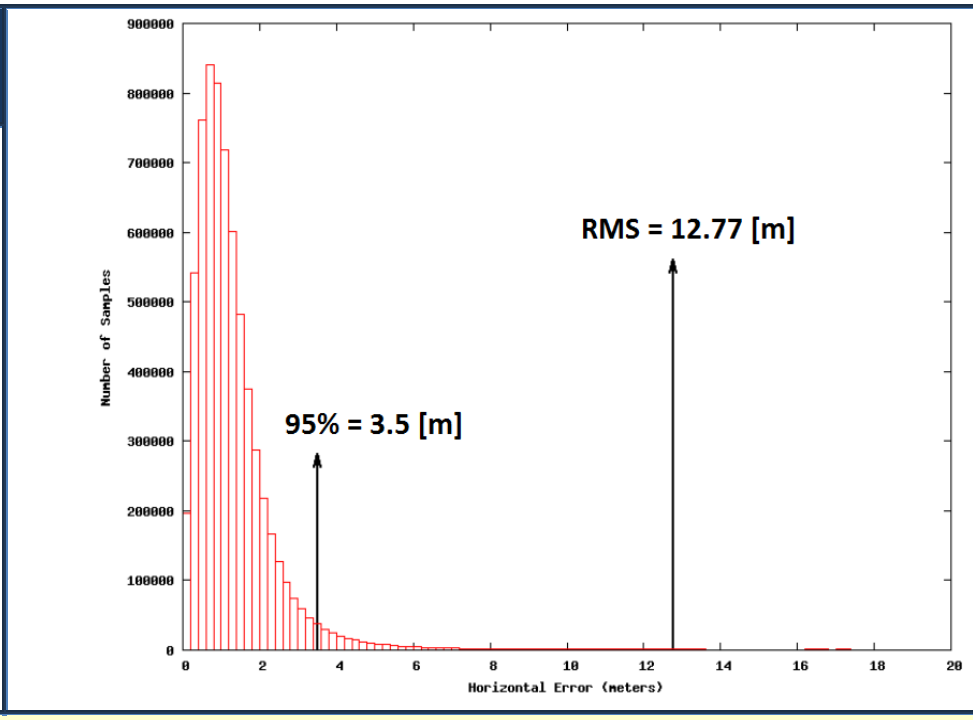
May 2017	
HPE 3D Positioning	
Note: 67,925 samples > 20 [m]	

Figure 14: Horizontal Positioning Error (HPE) for "Galileo-only" users (May 2017)

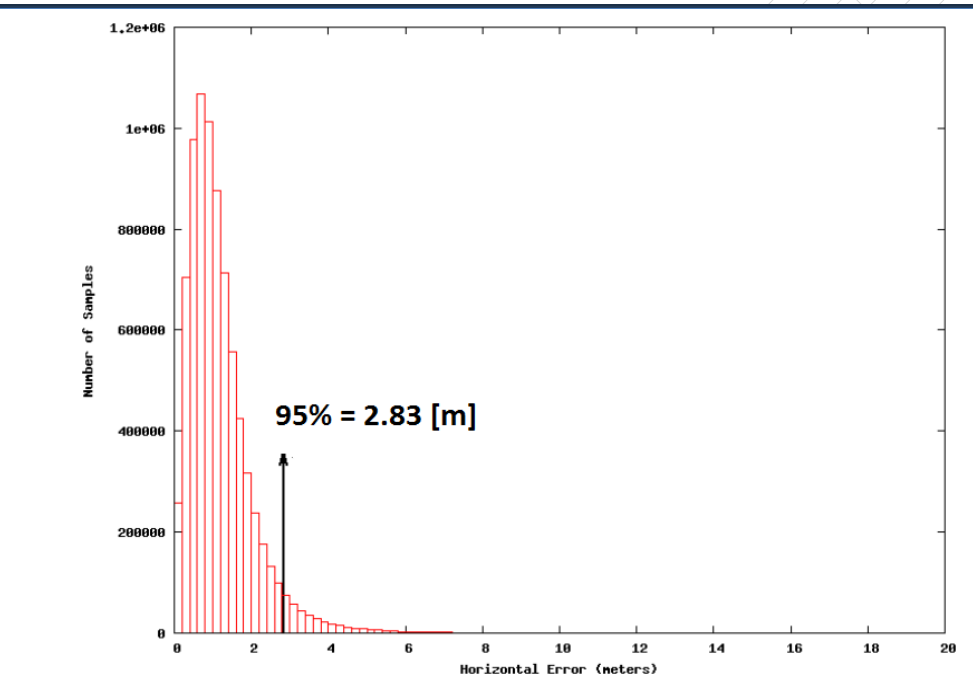
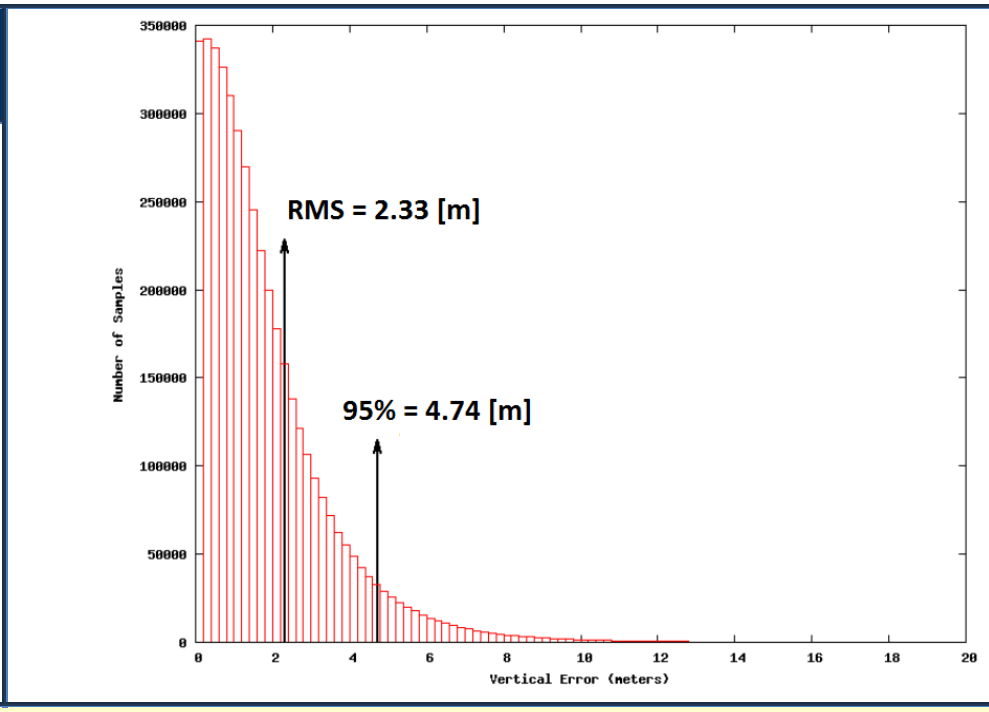
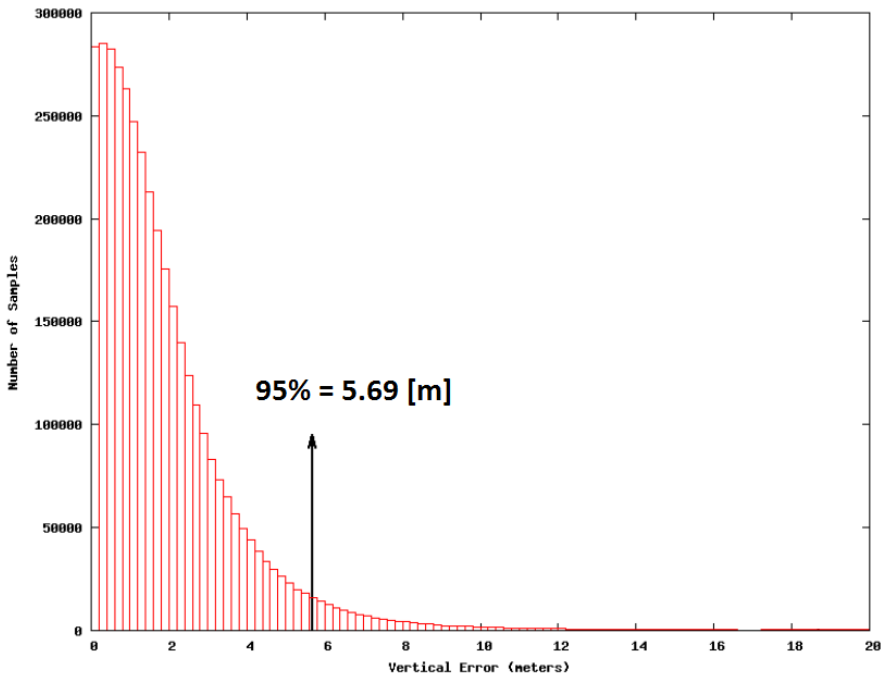
June 2017	
HPE 3D Positioning	
Note: 46,213 samples > 20 [m]	

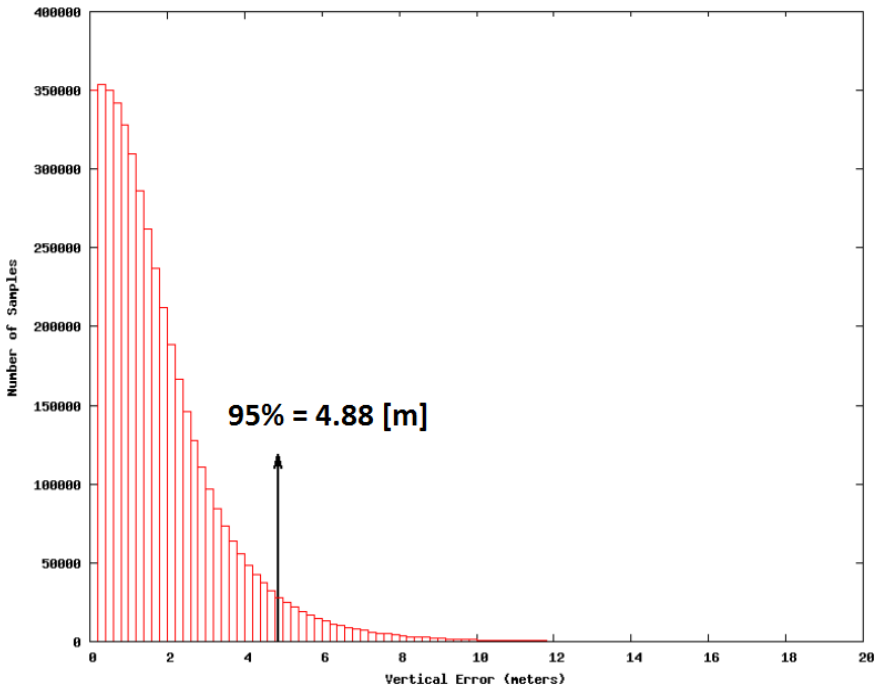
Figure 15: Horizontal Positioning Error (HPE) for "Galileo-only" users (June 2017)

April 2017	
VPE 3D Positioning	
Note: 84 samples > 20 [m]	

Figures 16: Vertical Positioning Error (VPE) for Galileo only users (April 2017)

May 2017	
VPE 3D Positioning	
Note: 46,778 samples > 20 [m]	

Figures 17: Vertical Positioning Error (VPE) for Galileo only users (May 2017)

June 2017	
VPE **3D** **Positioning**	
Note: 29,225 samples > 20 [m]	

Figures 18: Vertical Positioning Error (VPE) for Galileo only users (June 2017)

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 Main Information web pages about Galileo Status (2/2)

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.

During the reporting period, the target MPL for the (single) Planned NAGU published over April and May has been achieved, with more than **45** hours of advanced notification before occurrence of the intended operational event. In June, the MPL thresholds were not met:

- **14.58** hours elapsed from publication of NAGU 2017022 up to the relevant event; however, planned maintenance (regarding GSAT-0206) was already announced in timely fashion by NAGU 2017021 ; the new NAGU 2017022 just slightly rescheduled the event start time.

During the same month, the best performance observed was with NAGU 2017020 and NAGU 2017025 , which were published more than **139** hours and **340** hours before the respective events.

For Unplanned events, the [OS-SDD] allows a delay of up to **72** hours [21] from the detection of the unplanned event until a corresponding NAGU is issued.

The target MPL for Unplanned NAGUs was achieved in all cases in April and May, with an average less than **23** hours and a worst case of around **29** hours after detection of the unplanned event. In June, MPL thresholds were not met:

- **91.02** hours and **93.98** hours were required to publish NAGU 2017023 and 2017024. The first NAGU is to announce usability of GSAT-0206 (E30) after a period of maintenance and it is not related to any unexpected failure event. The second NAGU informs about unavailability of

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

GGTO, already evident to users from the transmission of "dummy" coefficients, and related to a feature that is not yet declared as a Galileo Service.

The best performance over the same month was achieved with NAGU 2017019 and NAGU 2017026, which were published less than **21** hours and **22** hours after the respective unplanned events.

Table 6 shows a summary of the NAGUs that have been published during the reporting period:

Month	Category	Reason for publishing	Notice Advisory ID	Type
April	PLN_OUTAGE	GSAT-0206 (E30): clock thermal test, SIS marginal (DVS="WWG")	2017013	P
	USABLE	Conditions for NAGU 2017013 ended.	2017014	U
May	GENERAL	Navigation Message not refreshed for most of the constellation	2017015	U
	GENERAL	Conditions for NAGU 2017015 ended	2017016	U
	USABINIT	New space vehicle GSAT-0214 (E05) usable for the first time on 2017-05-29 @ 13:15	2017017	U
	USABINIT	New space vehicle GSAT-0207(E07) usable for the first time on 2017-05-29 @ 18:23	2017018	U
June	UNP_UNUFN	GSAT-0203 (E26) declared unavailable from 2017-06-08 @ 12:53 till further notice	2017019	U
	PLN_EXTNS	GSAT-0203 (E26) unavailability prolonged to 2017-06-27 @ 23:59	2017020	P
	PLN_OUTAGE	GSAT-0206 (E30) declared unavailable on 2017-06-16 from 09:00 to 15:00	2017021	P
	PLN_RESCH	GSAT-0206 (E30) unavailability extended from 2017-06-16 @ 07:20 to 2017-06-17 15:00	2017022	P
	USABLE	GSAT-0206 (E30) declared usable since/as of 2017-06-16 @ 15:29	2017023	U
	GENERAL (TIMING UNP_SHTRCVR)	GGTO unavailability occurring in the period from 2017-06-16 @ 12:31 until 2017-06-17 @ 13:25	2017024	U
	PLN_EXTNS	GSAT-0203 (E26) unavailability prolonged to 2017-07-09 @ 23:59	2017025	P
	GENERAL	Potential GGTO unavailability from 2017-06-29 @ 12:00 up to 2017-06-30 @ 23:59	2017026	U
	USABLE	GSAT-0203 (E26) declared usable again from 2017-06-27 @ 19:25	2017027	U
NAGU Type Categorization: "P" = Planned, "U" = Unplanned				

Table 6: NAGUs published during Quarter

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/).

For an exhaustive description about Minimum Performance Levels (MPLs), the reader is referred to the [OS-SDD]: individual sections of the Service Definition Document have been addressed throughout this report when referring to MPL target values.

8 LIST OF ACRONYMS

Acronym	Definition
AOD	Age Of Data – Elapsed time, since a data set was generated by GMS
DF	(Galileo OS) Dual Frequency combination (E5a-E1, E5b-E1)
DOP	Dilution of Precision
DVS	Data Validity Status (L-band flag)
FOC	Full Operational Capability
GCS	Galileo Control Segment
GGTO	GST-GPS Time Offset
GESS	Galileo Experimental Sensor Stations
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
IOV	In-Orbit Validation
IS	(Galileo) Initial Services
MPL	Minimum Performance Level
NAGU	Notice Advisory to Galileo Users
NAPA	No Accuracy Prediction Available
NDV	Navigation Data Valid
OOS	Out Of Service
OS	(Galileo Navigation) Open Service
PDOP	Position Dilution of Precision

Acronym	Definition
PTF	Primary Timing Facility
RMS	Root Mean Square
SAR	Search and Rescue
SDD	Service Definition Document
SF	(Galileo OS) Single Frequency (E1, E5a, E5b)
SHS	Signal Health Status L-band flag
SIS	Signal in Space
SISE	Signal In Space Error vector (4-dimensional)
SISA	Signal in Space Accuracy (L-band flag)
UTC	Universal Time Coordinated
VPE	Vertical Positioning Error
WUL	Worst User Location
WWG	Work Without Guarantee

End of Document

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