



EUROPEAN GNSS (GALILEO) INITIAL SERVICES

OPEN SERVICE

QUARTERLY PERFORMANCE REPORT

OCTOBER - DECEMBER 2018



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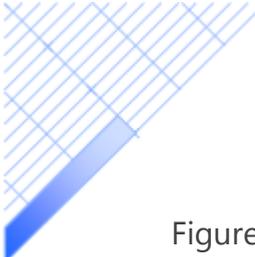


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1 INTRODUCTION

This document is the *Galileo Initial Open Service (IS OS) Public Performance Report* for the period of October, November and December 2018. 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 1a: 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 ² since October 12 th , 2018 |

Table 1a: Galileo Reported Constellation Information

| Satellite Code | SV ID (PRN) | CCSDS ID [hex] | Orbital Slot | Status |
|----------------|-------------|----------------|--------------|---------------------|
| GSAT-0219 | E36 | 713 | B04 | Under commissioning |
| GSAT-0220 | E13 | 704 | B01 | Under commissioning |
| GSAT-0221 | E15 | 705 | B02 | Under commissioning |
| GSAT-0222 | E33 | 706 | B07 | Under commissioning |

Table 1b: New Galileo Space vehicles under commissioning

² Ref.: NAGU [2018023](#), announcing initial usability of space vehicle GSAT-0215 (E21)

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 | October-18 | November-18 | December-18 |
|------------------------|-------------------------|--------------|-----------------------|-------------|-------------|
| OS SIS Ranging Service | Accuracy, Any Satellite | E1/E5a user | [Grid of green cells] | | |
| | | E1/E5b user | [Grid of green cells] | | |
| | | E1 user | [Grid of green cells] | | |
| | | E5a user | [Grid of green cells] | | |
| | | E5b user | [Grid of green cells] | | |
| | | ≤ 7m [95%] | | | |

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

| | | | | | |
|-----------|-----------|-----------|-----------|-----------|-----------|
| GSAT-0101 | GSAT-0203 | GSAT-0208 | GSAT-0211 | GSAT-0213 | GSAT-0217 |
| GSAT-0102 | GSAT-0205 | GSAT-0209 | GSAT-0207 | GSAT-0214 | GSAT-0218 |
| GSAT-0103 | GSAT-0206 | GSAT-0210 | GSAT-0212 | GSAT-0216 | GSAT-0215 |

Allocation of Satellites in dashboard above

Legend

| | |
|--------------|--|
| [White box] | MPL measurement not available |
| [Green box] | Target Value for MPL is fulfilled |
| [Orange box] | Target Value for MPL is NOT fulfilled (less than 10% away from the Target Value) |
| [Red box] | Target Value for MPL is NOT fulfilled (more than 10% away from the Target Value) |

| OS MPLs | | | Target Value | Oct-18 | Nov-18 | Dec-18 | |
|-----------------|-------------------------------|-----------------------------|--------------|---------------|--------|--------|--|
| 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 October and December, and **98.92%** in November, as a consequence of events leading to the publication of NAGU [2018027](#). The figures are in any case above expectations, where the MPL target is **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 **1.09** [m] for individual space vehicles (“Any Satellite”) on Single Frequency observables.³ For Dual Frequency signal combinations⁴, the figure is in the range from **0.19** [m] to **0.41** [m]. Compliance with the [OS-SDD] MPL is achieved with large margin, with the maximum threshold fixed to **7** [m].

The average **Ranging Accuracy at constellation level** (over “All Satellites”) provides figures “per signal” that are better than **0.59** [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 October and December, and **98.92%** in November, comfortably exceeding the [OS-SDD] MPL target of **87%**, despite the event concerned with NAGU [2018027](#).

The **Availability of GGTO Determination** was **98.59%** in October, **98.24%** in November and December. 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 [ns]), **UTC Frequency Dissemination Service Accuracy** (normalised offset $\leq 2.2 \times 10^{-14}$) 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], 3×10^{-13} and **20** [ns], are all met.

The monthly **Availability of HDOP ≤ 5** is over **89.95%**, achieving **100%** within some geographic areas in October and December. The monthly **Availability of Galileo Horizontal Positioning better than 10 [m]** is over **93.41%**, again achieving **100%** in some areas of the world in October and December. These figures are in line with the deployment status of the Galileo constellation during the reporting period (17 operational satellites at the beginning of the reporting period, then 18 since October 12th) 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 “Galileo-only” measured 3D positioning performance attainable when PDOP ≤ 6 . The 95th percentile of **Horizontal and Vertical 3D Positioning Errors** (HPE and VPE, correspondingly) did not exceed **2.39** [m] and **4.04** [m] respectively during the reporting period, as measured by 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 during the whole period for both Planned and Unplanned events. The target of at least **24** hours before the start of a scheduled

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

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

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 .

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 HEALTHY⁵ 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.

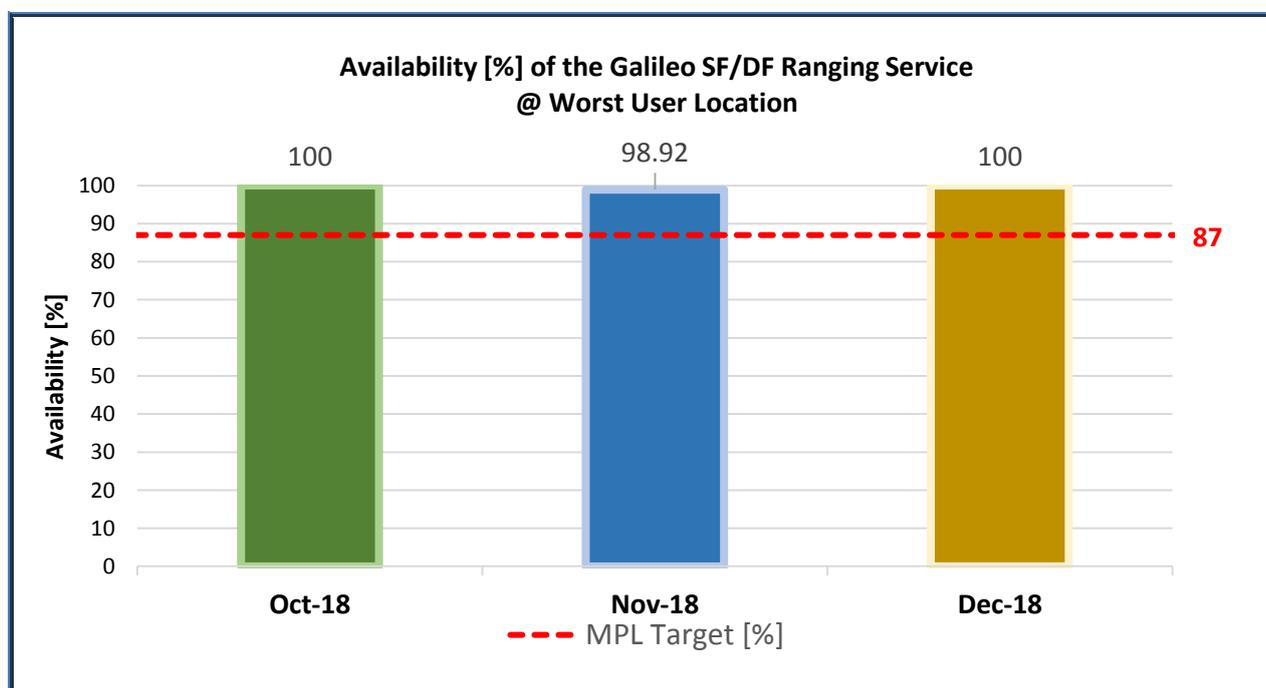


Figure 1: Monthly Availability of the Galileo SF/DF Ranging Service

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%** in October and December, **98.92%** in November. This significantly exceeds 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.

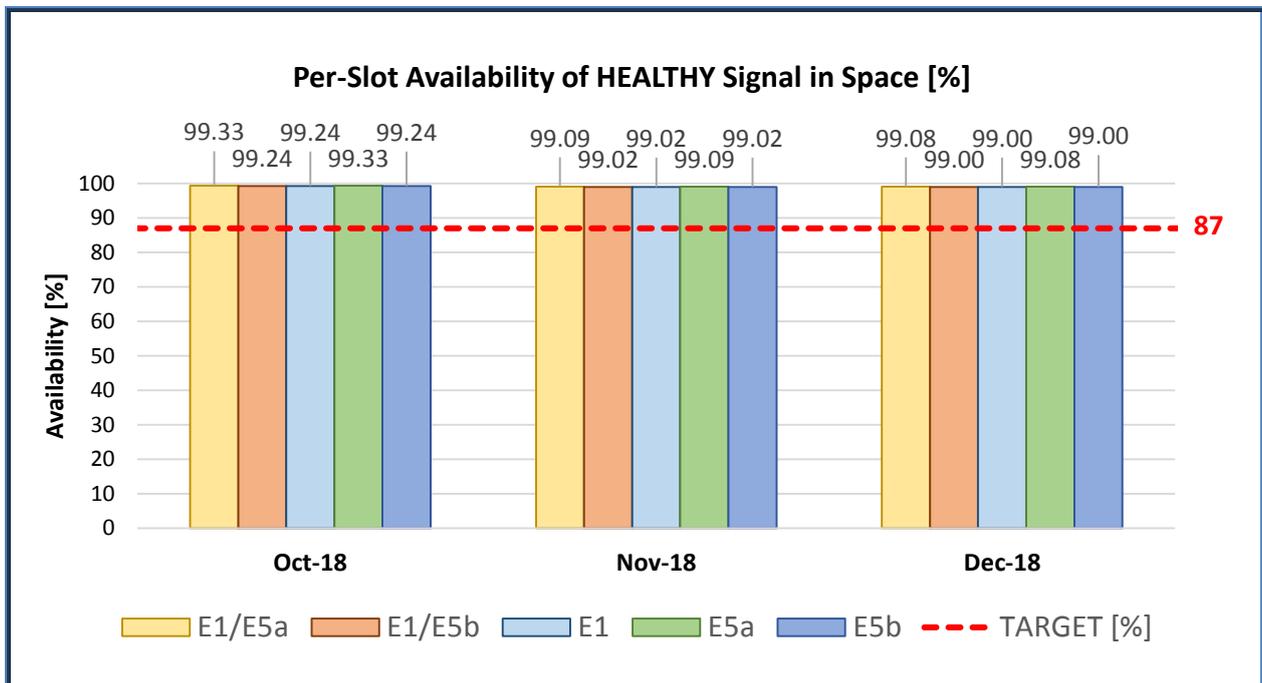


Figure 2: “Per-Slot” availability of HEALTHY Signal in Space for the reporting period

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.

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 **99.00%** (I/NAV SIS, December) and **99.33%** (F/NAV SIS, October).

The availability of Galileo HEALTHY SIS, evaluated individually per frequency combination, satellite and month (without annual normalisation), was comprised between **83.10%** (all signals) and **100%**, the former due to on-board maintenance of GSAT-0103 (E19) in November.

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 and frequency combinations, is:

- for individual space vehicles in **October**, between **0.27 [m]** and **0.41 [m]** for Dual Frequency, and between **0.32 [m]** and **0.60 [m]** for Single Frequency;
- for individual space vehicles in **November**, between **0.23 [m]** and **0.53 [m]** for Dual Frequency, and between **0.29 [m]** and **1.09 [m]** for Single Frequency;
- for individual space vehicles in **December**, between **0.19 [m]** and **0.33 [m]** for Dual Frequency, and between **0.24 [m]** and **0.67 [m]** for Single Frequency.

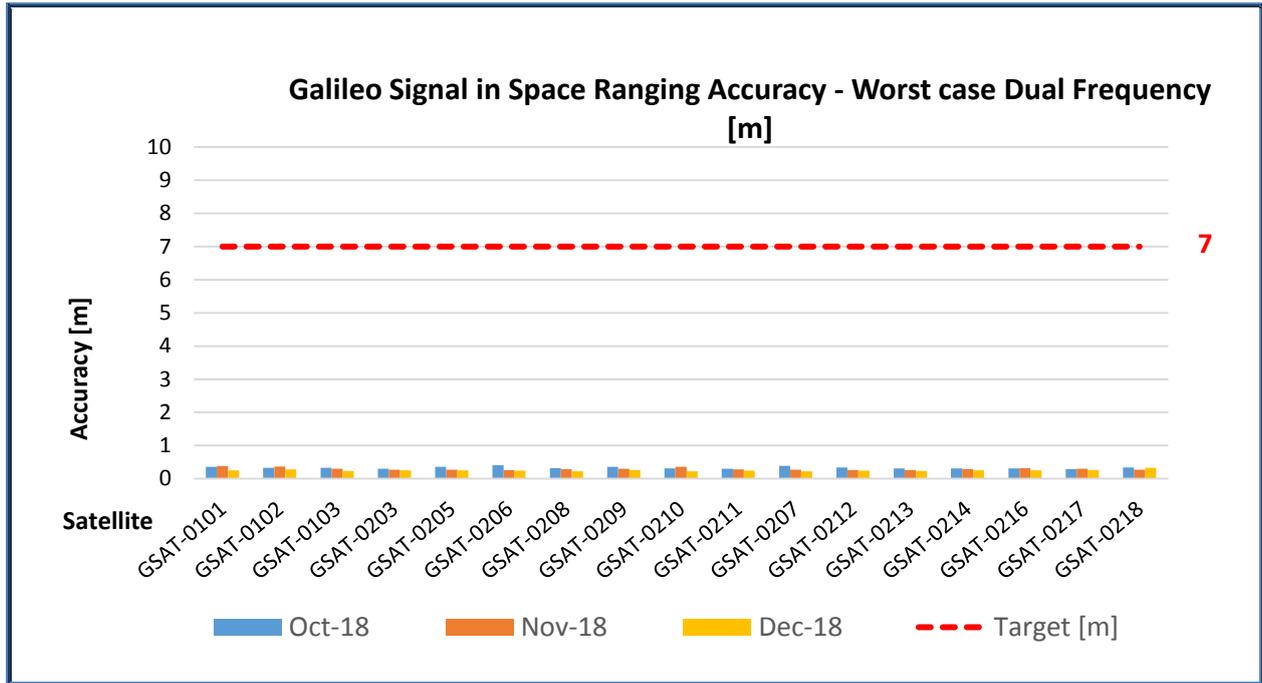


Figure 3: Monthly Galileo SIS Ranging Accuracy (95th percentile) “for any satellite”, measured during reporting period for worst-case, Dual-Frequency (DF)

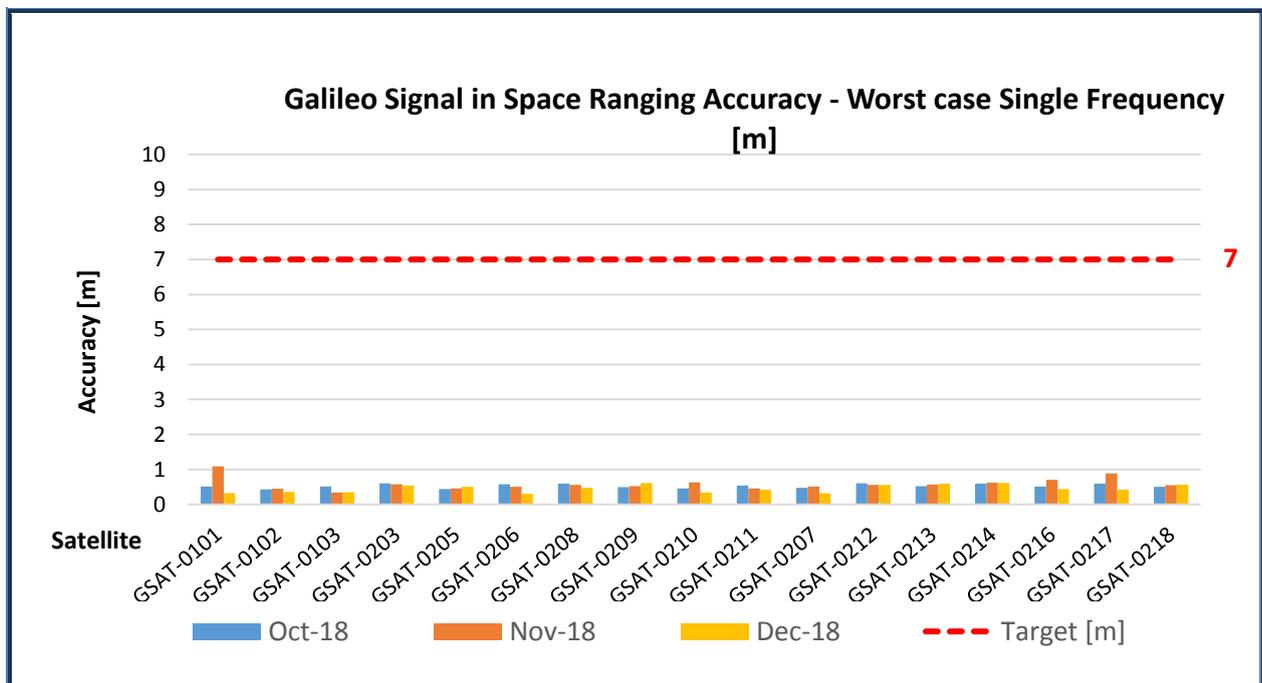


Figure 4: Monthly Galileo SIS Ranging Accuracy (95th percentile) “for any satellite”, measured during the reporting period for worst-case, Single-Frequency (SF)

Compliance with the MPL in [OS-SDD] is always achieved, with a specified maximum threshold of 7 [m]⁹ 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.

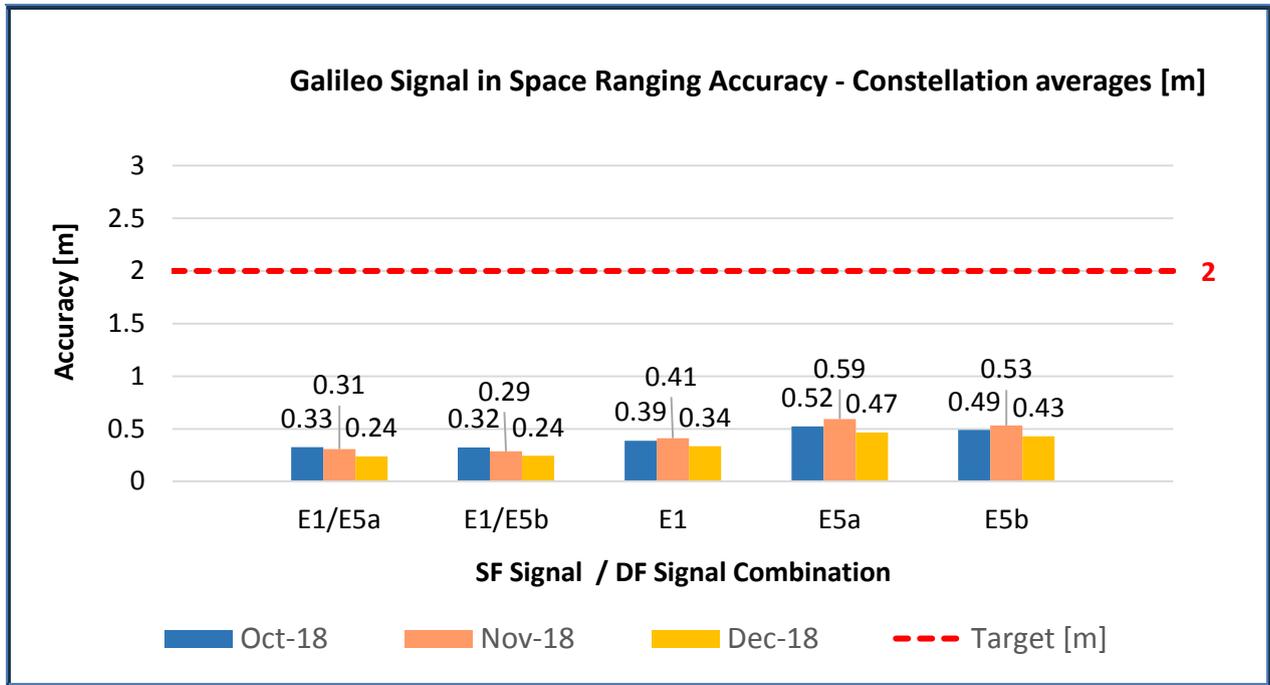


Figure 5: Monthly Galileo SIS Ranging Accuracy (95th percentile) “over all satellites” (constellation average), measured during the reporting period

⁹ 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 HEALTHY⁵ 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.

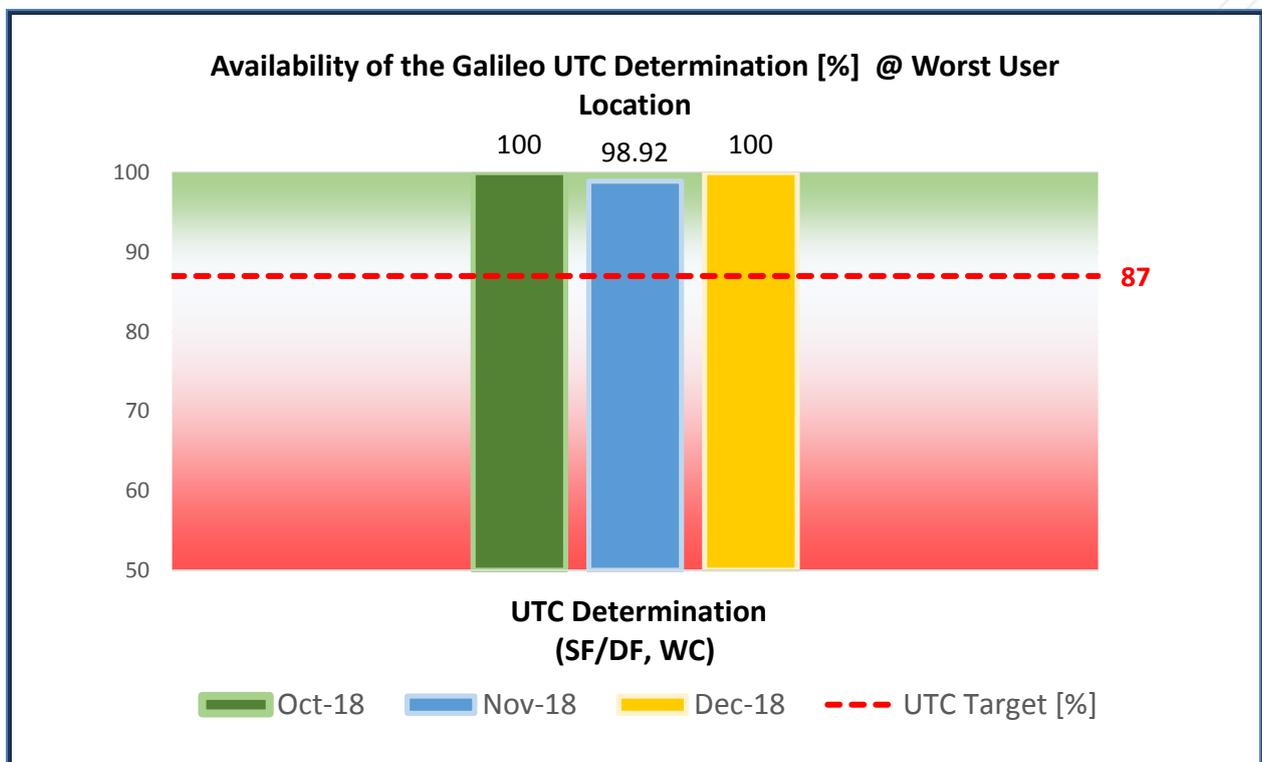


Figure 6: Monthly availability of the UTC Determination Service during the reporting period

As shown in Fig. 6, the monthly (short term) availability of the Galileo UTC Determination Service reached **100%** in October and December, **98.92%** in November due to events communicated through NAGU [2018027](#).

The MPL of **87%**¹⁰ 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 GGTO¹¹ 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.

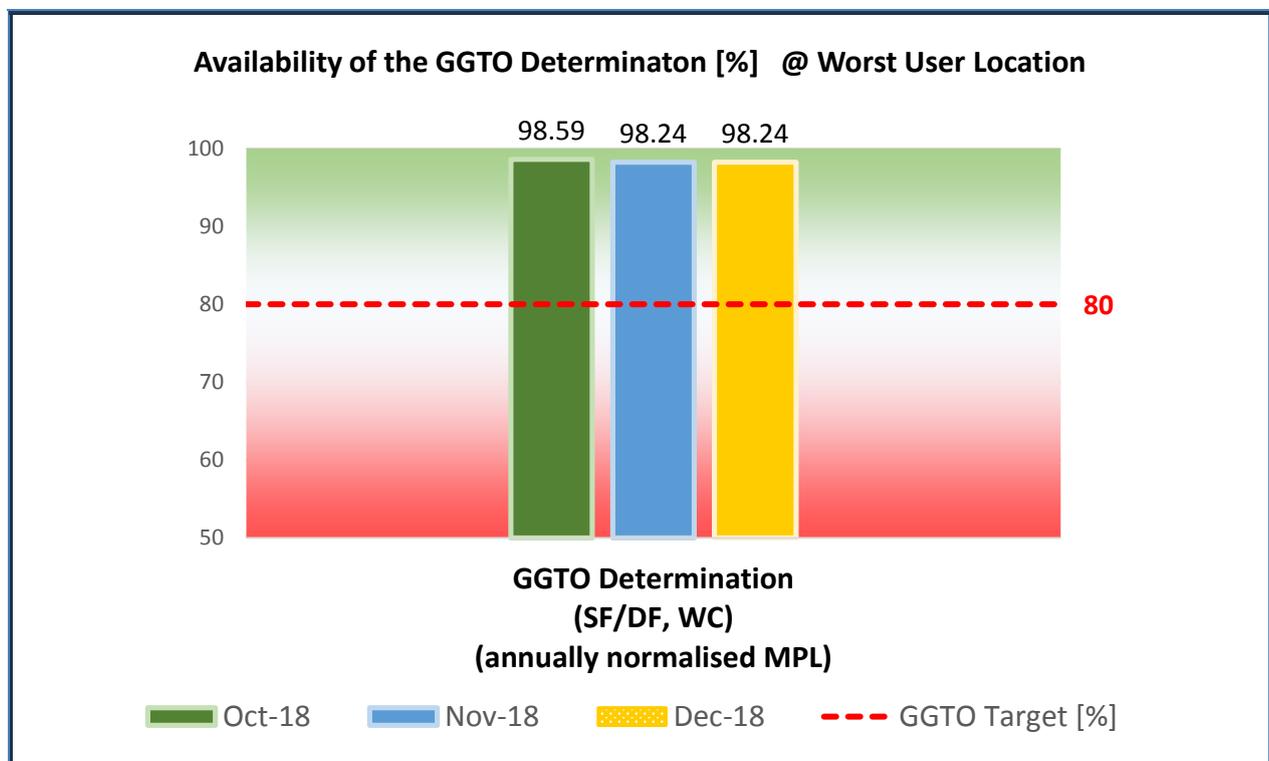


Figure 7: Annually normalised availability of the GGTO Determination, during the reporting period

The MPL of **80%**¹² specified by [OS-SDD] for the long-term is totally met.

The monthly (short-term) Galileo user GGTO Determination capability, which is not shown in the figures, was **93.81%** in October, **95.76%** in November and **100%** in December.

¹⁰ Ref.: [OS-SDD] , §3.5.4 (Table 17)

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] , §3.6.1.2 (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 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 period of 12 months.

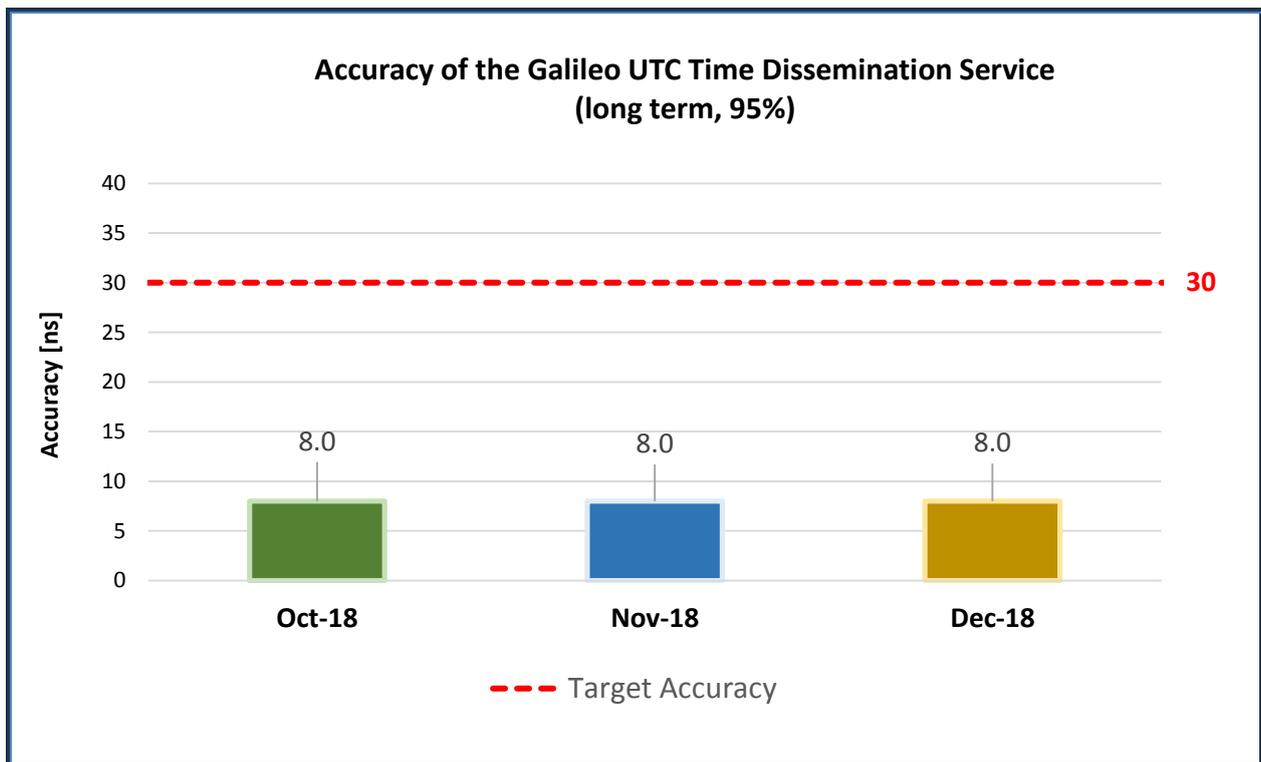


Figure 8: 95th Long-term 95% percentile of UTC Time Dissemination Accuracy

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 also be affected by ranging errors, on top of the committed UTC Dissemination Accuracy

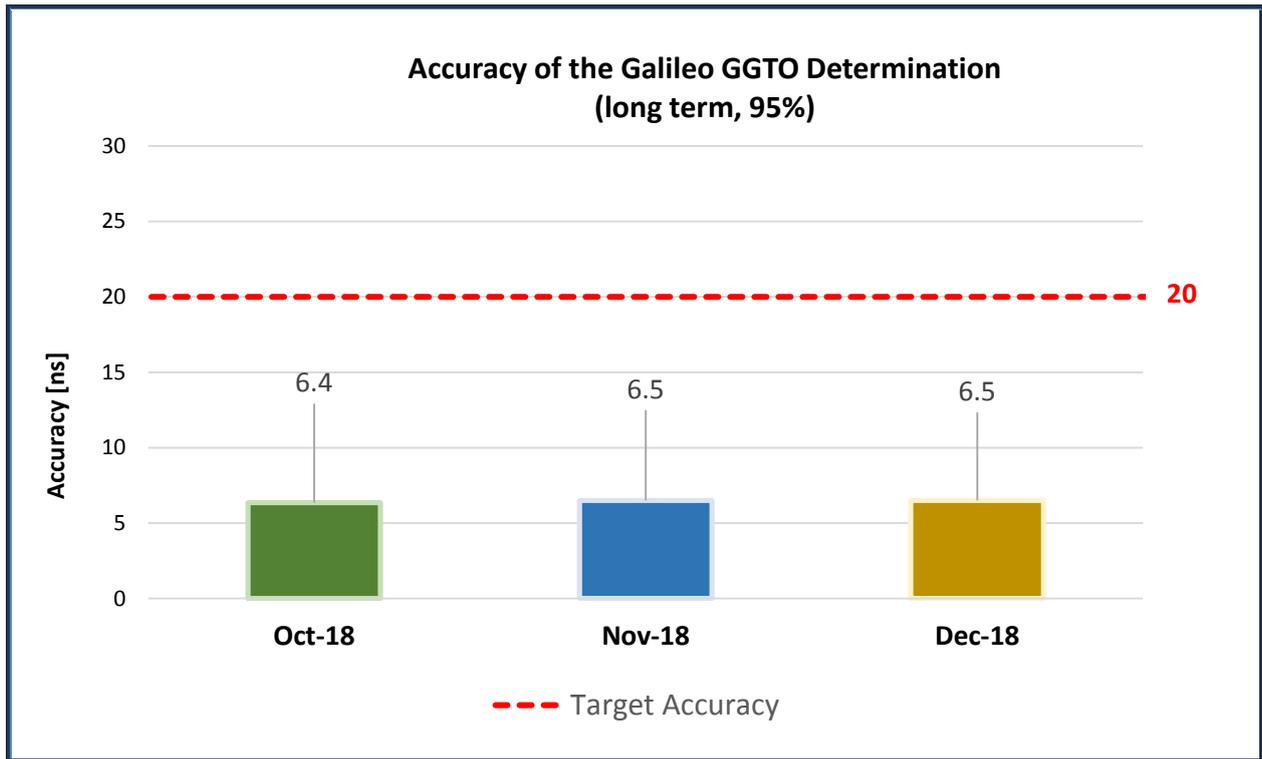


Figure 9: Long-term 95th percentile of GGTO Determination Accuracy

Figure 10 shows the 95th percentile of the UTC Frequency Dissemination Accuracy, computed accumulating measurement data over the past 12 months¹⁴.

As seen in Figure 8 and Figure 9, the long term 95th percentile of UTC (Time) Dissemination Accuracy is constantly around **8** [ns]. The GGTO Determination Accuracy is less than or equal to **6.5** [ns]. These figures are both well within the [OS-SDD] Minimum Performance Level specifications of **30** [ns] and **20** [ns], respectively¹⁵.

Regarding UTC Frequency Dissemination accuracy, Figure 10 shows that the measured 95th percentile value is at most around **2E-14**, which is an order of magnitude better than the [OS-SDD] MPL normalised annual ceiling of **3.0E-13**¹⁶.

¹⁴ Long-term figures result from processing measurements accumulated since 2017

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)

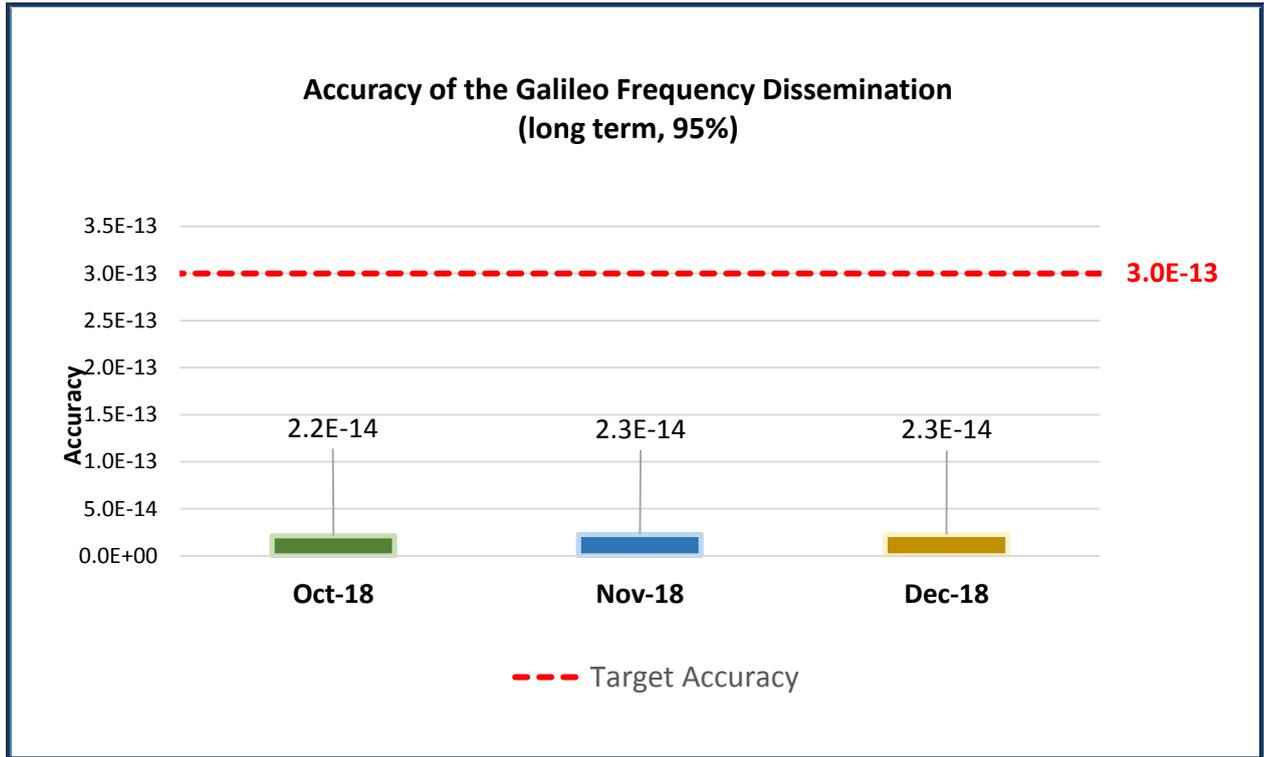


Figure 10: Long-term 95th percentile of UTC Frequency Dissemination Accuracy

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.

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% ¹⁷.

5.1 AVAILABILITY OF GLOBAL HORIZONTAL DILUTION OF PRECISION (HDOP)

For 2D positioning ¹⁸, 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.

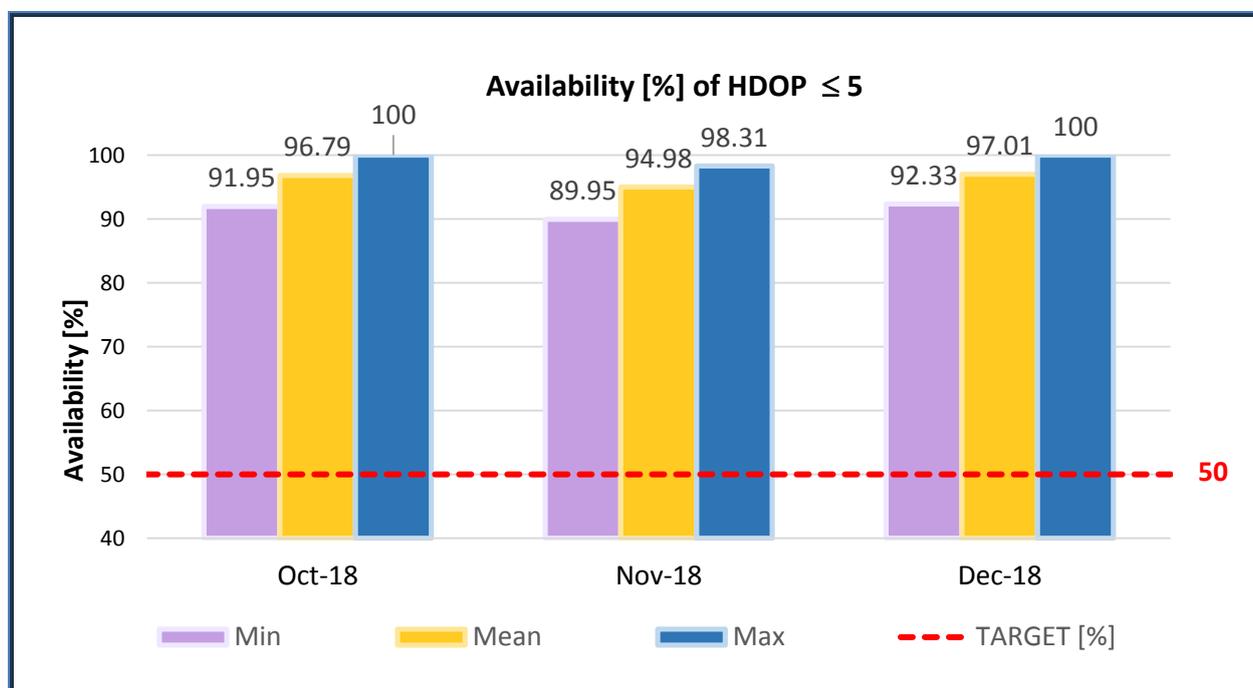


Figure 11: Availability of HDOP ≤ 5

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. 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.

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 HEALTHY⁵ 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 dimensions¹⁸.

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.

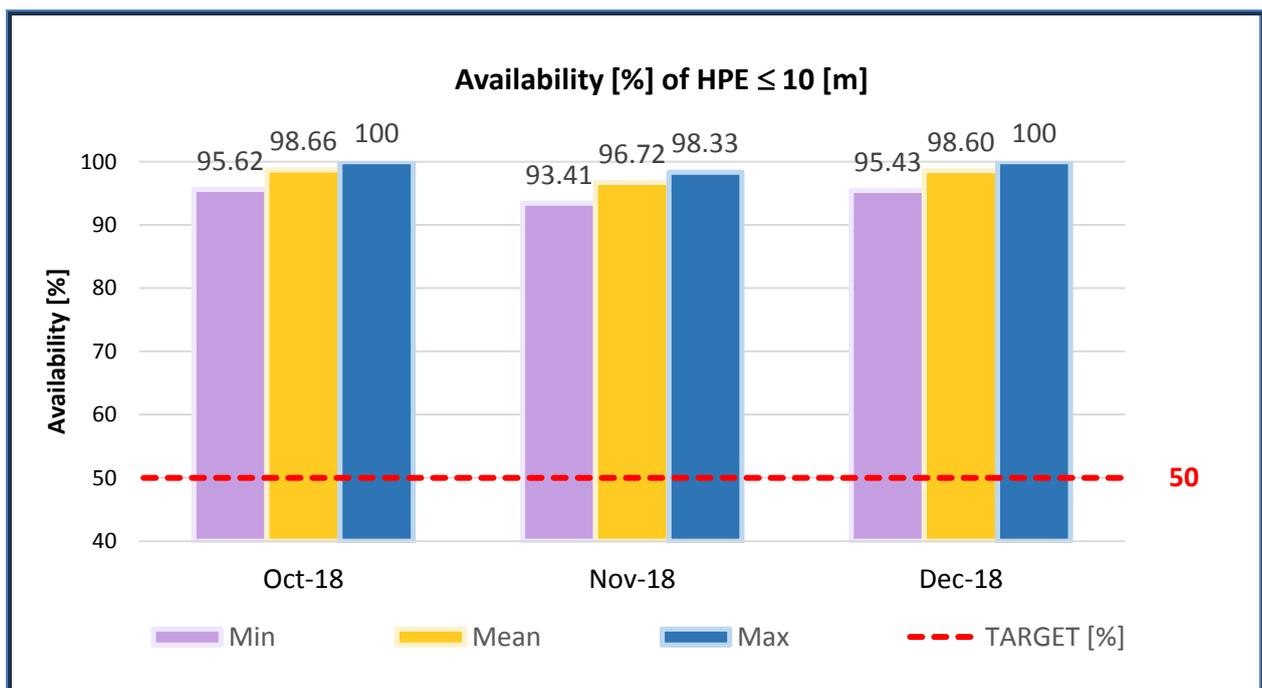


Figure 12: Availability of the Galileo Horizontal Positioning Service with Accuracy ≤ 10 [m]

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 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 $PDOP \leq 6$ and following [OS-SDD] recommendations about SIS health status, “Age of toE”¹⁹.

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].

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

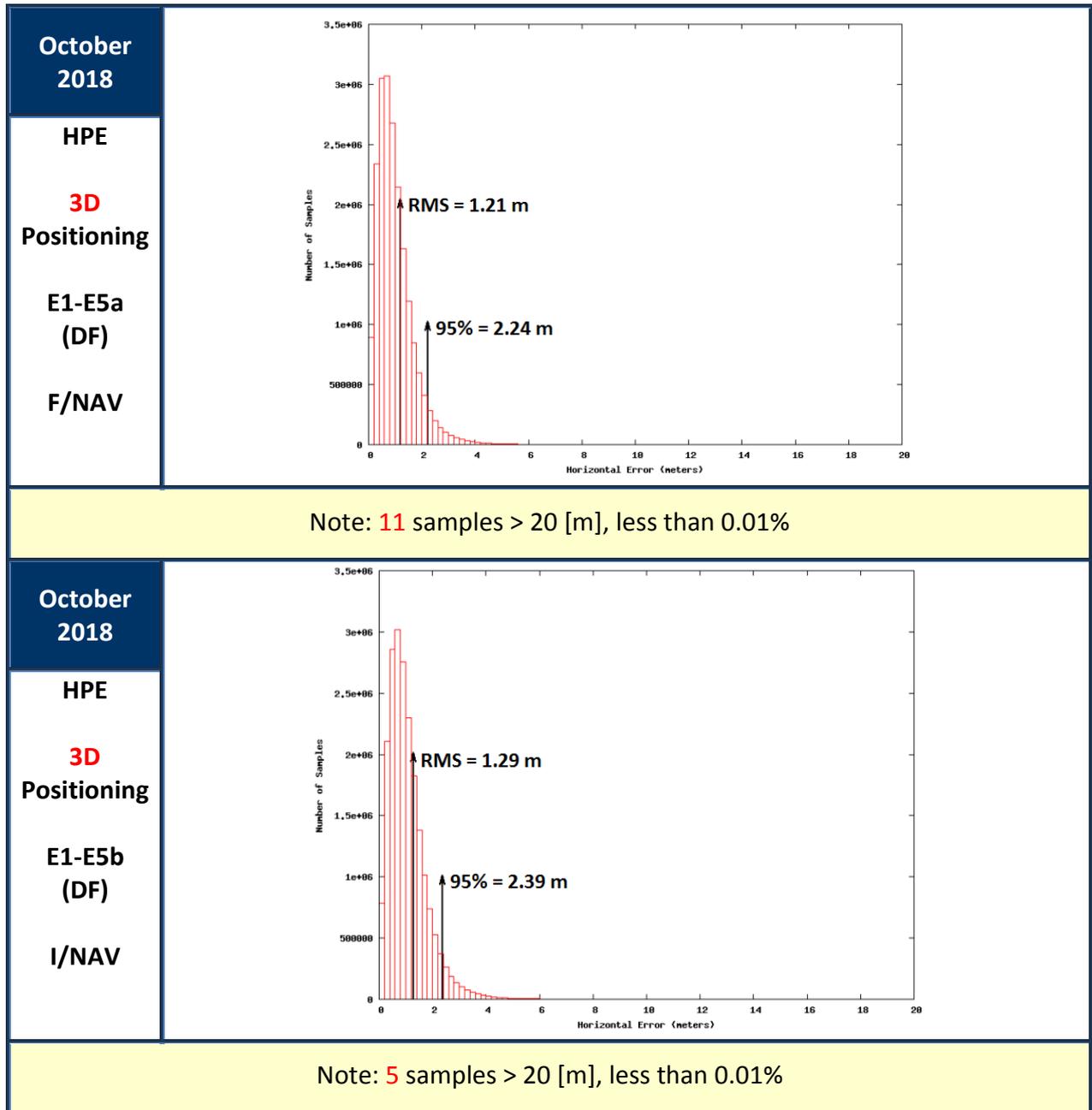


Figure 13: Horizontal Positioning Error (HPE) for “Galileo-only” users in October 2018

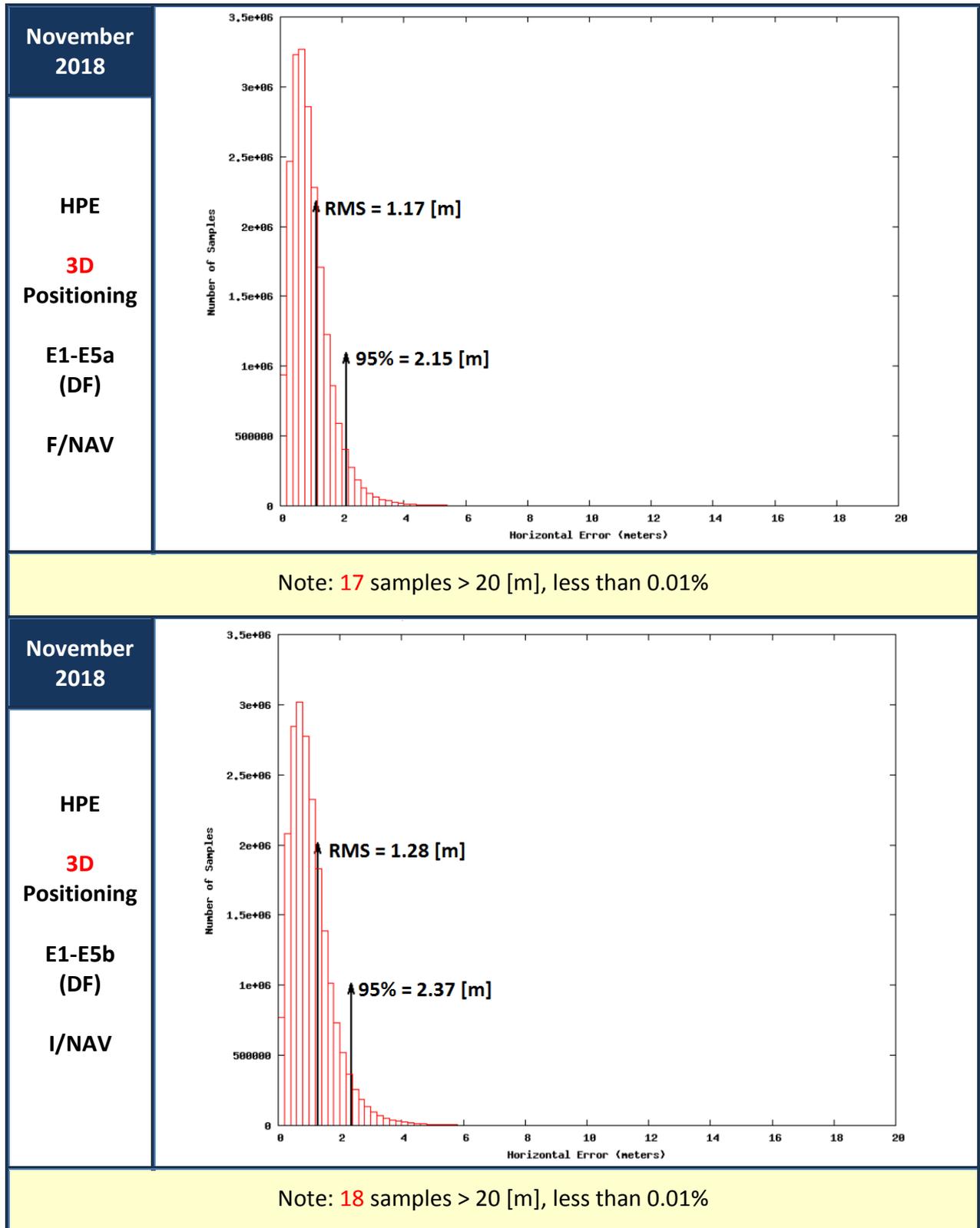


Figure 14: Horizontal Positioning Error (HPE) for “Galileo-only” users in November 2018

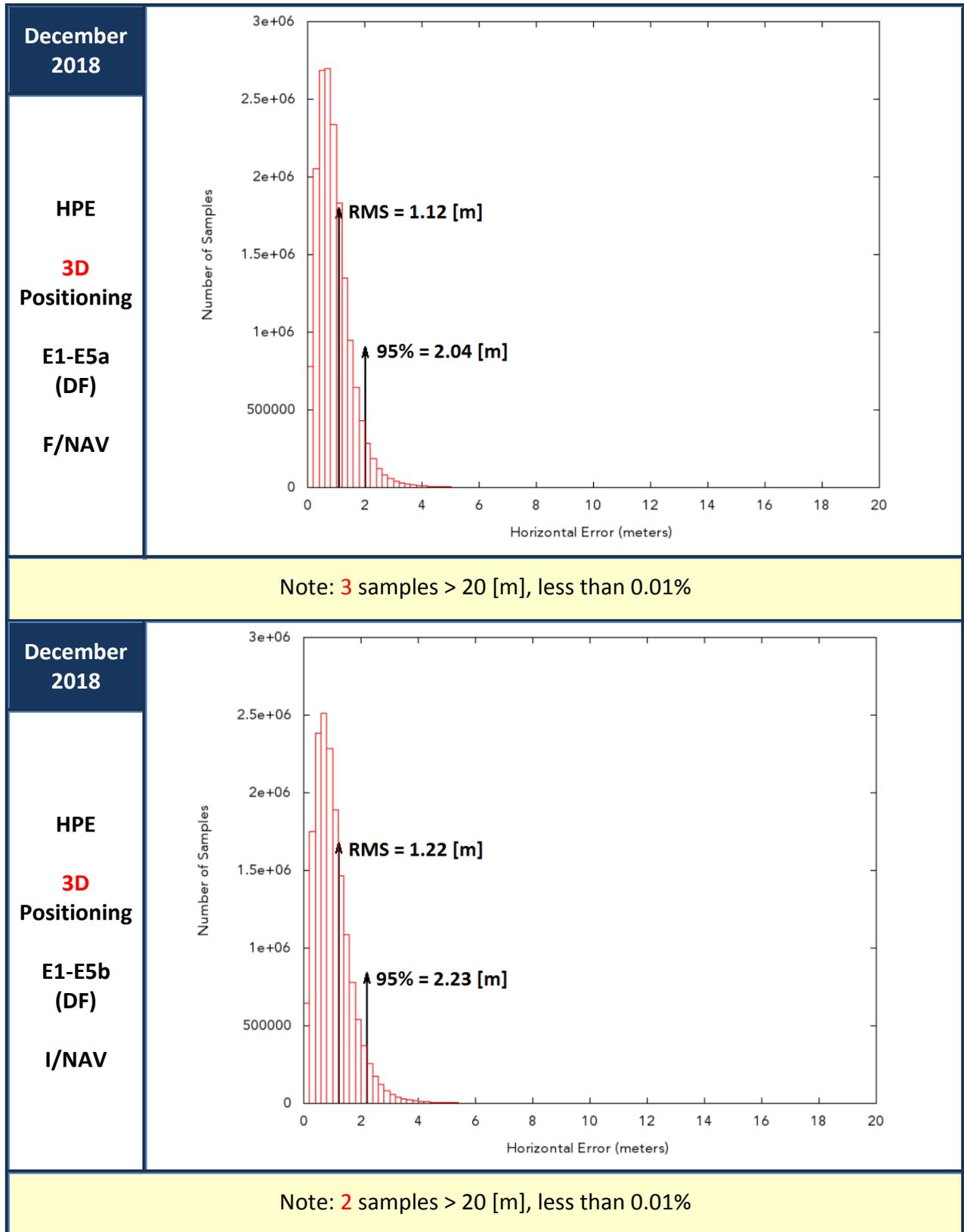


Figure 15: Horizontal Positioning Error (HPE) for “Galileo-only” users in December 2018

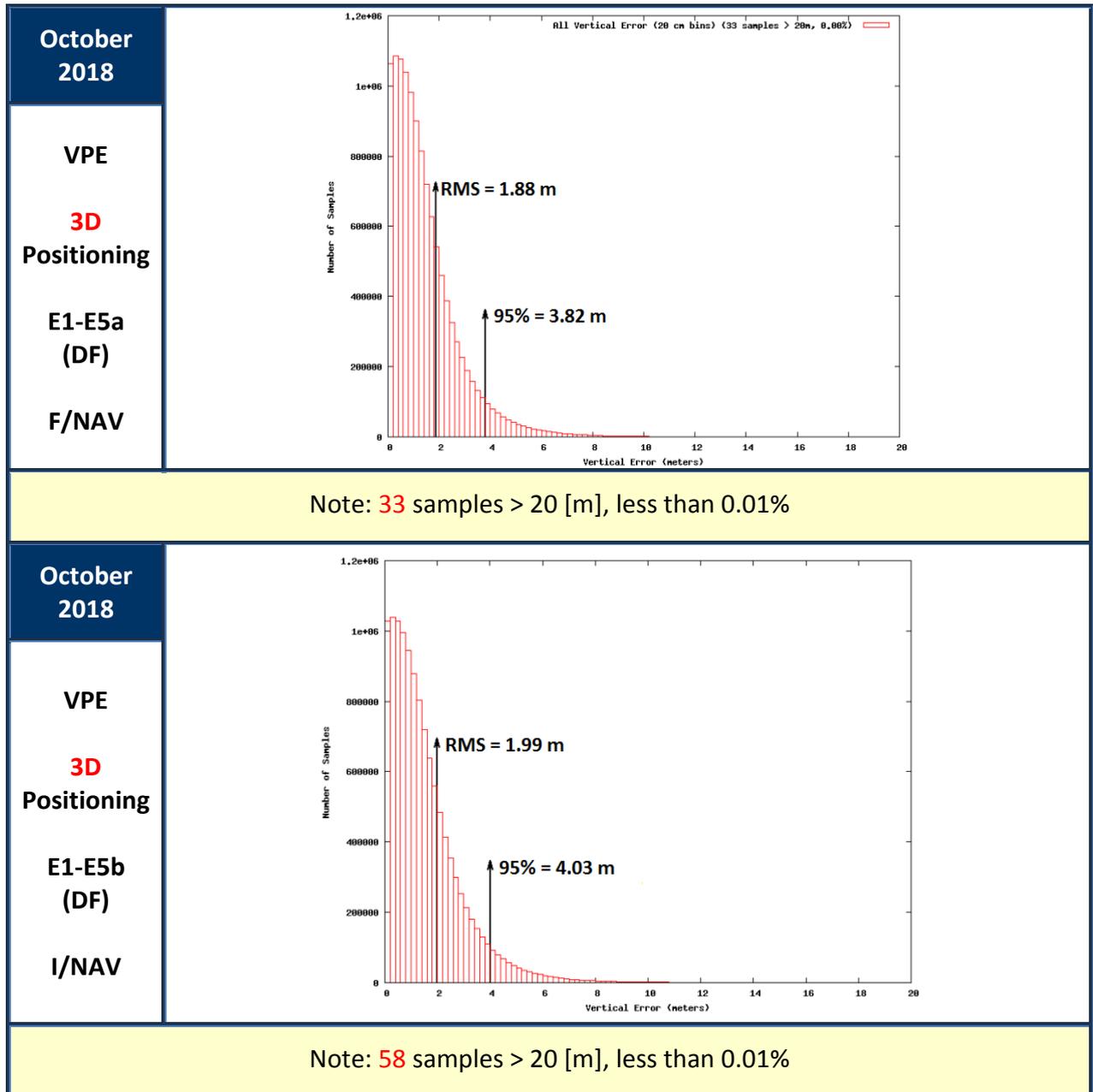


Figure 16: Vertical Positioning Error (VPE) for Galileo only users in October 2018

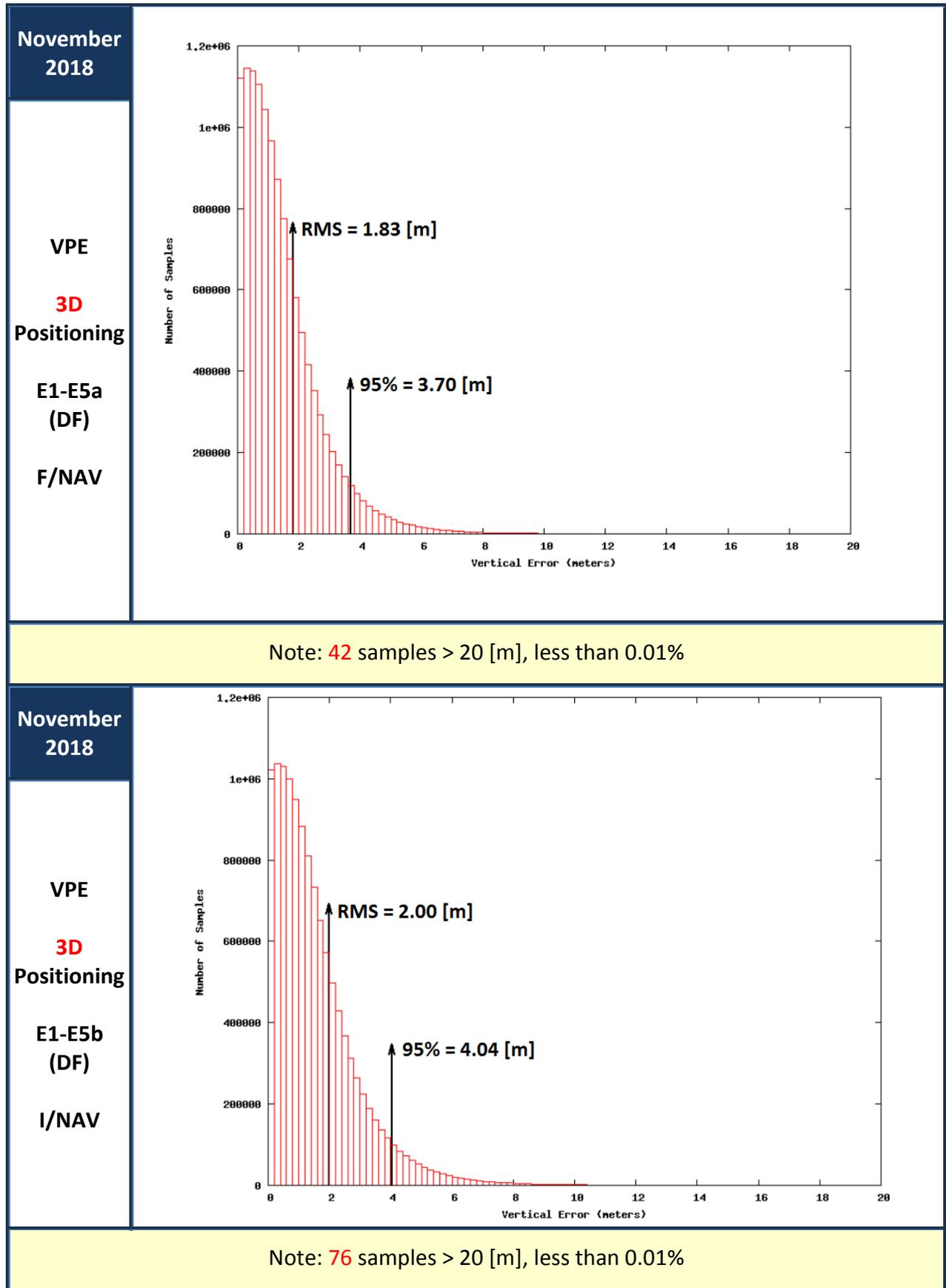


Figure 17: Vertical Positioning Error (VPE) for Galileo only users in November 2018

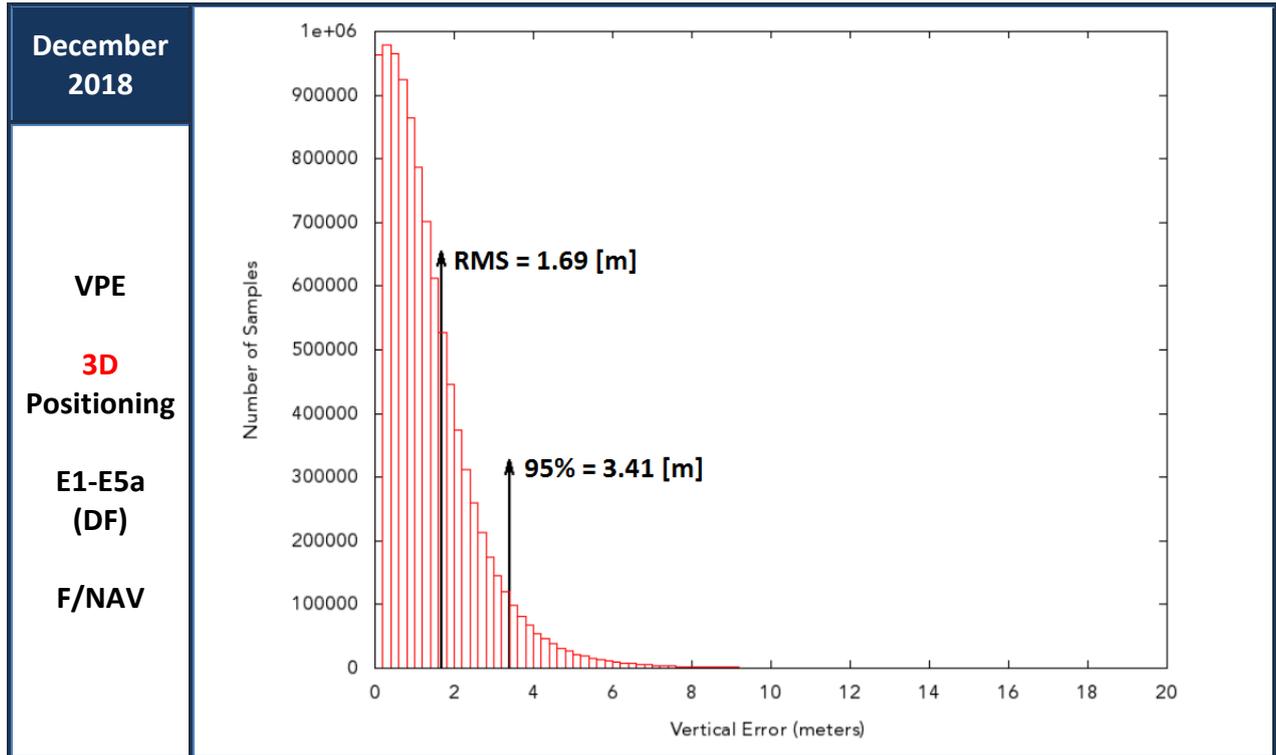


Figure 18: Vertical Positioning Error (VPE) for Galileo only users in December 2018

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 | https://www.gsc-europa.eu/system-status/user-notifications (Active user Notifications) |
| Information | 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**²⁰ before the event starts. For Unplanned events, the [OS-SDD] specifies a delay of up to **72 hours**²⁰ 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:

²⁰ Ref.: [OS-SDD] , §3.7.1 (Table 20)

| Month | NAGU Type | Reason for publishing | Notice Advisory ID | Categorisation |
|---|--|--|-------------------------|----------------|
| October | USABLE | Announcing recovery of Navigation service by GSAT-0101 (E11) since 02/10/2018 @ 21:20 | 2018022 | U |
| | USABINIT | Declaring first introduction of GSAT-0215 (E21) to the provision of Navigation and SAR/Galileo services, since 12/10/2018 @ 08:07. | 2018023 | U |
| | GENERAL | Warning on unavailability of valid GGTO coefficients since 16/10/2018 @ 12:51. | 2018024 | U |
| | GENERAL | Linked to NAGU 2018024: advising on recovered dissemination of proper GGTO coefficients since 18/10/2018 @ 13:12 | 2018025 | U |
| November | PLN_OUTAGE | Warning about marginal SIS due to on-board maintenance for GSAT-0102 (E12), starting on 07/11/2018 @ 12:05 | 2018026 | P |
| | GENERAL | Warning on potential marginal SIS event(s) affecting any satellite of the constellation from 07/11/2018 @ 14:10 | 2018027 | U |
| | GENERAL | Linked to NAGU 2018027: announcing restored service capabilities but potential instability of performance on 08/11/2018 @ 04:50 | 2018028 | U |
| | GENERAL | Warning on unavailability of valid GGTO coefficients since 15/11/2018 @ 13:11. | 2018029 | U |
| | GENERAL | Linked to NAGU 2018029: advising on recovered dissemination of proper GGTO coefficients since 16/11/2018 @ 12:51 | 2018030 | U |
| | GENERAL | Linked to NAGU 2018028: announcing restored nominal service capability (end of performance instability) On 16/11/2018 @ 12:51 | 2018031 | U |
| | USABLE | Linked to NAGU 2018026: announcing restored availability of GSAT-0102 (E12) for Navigation services since 08/11/2018 @ 04:50 | 2018032 | U |
| December | No NAGU was published in December 2018 | | | |
| NAGU Categorisation for timeliness evaluation: "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 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/>