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EUROPEAN GNSS (GALILEO) INITIAL SERVICES

SAR SERVICE

QUARTERLY PERFORMANCE REPORT

OCTOBER - DECEMBER 2018



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1 INTRODUCTION

This document is the Galileo Initial Search and Rescue Service (SAR/GALILEO IS) 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 actual performance statistics of the SAR/Galileo Service.

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

- ◇ Detection Performance;
- ◇ Location Performance;
- ◇ Infrastructure Availability Performance;

The document comprises the following sections:

Section 1: Introduces the Galileo constellation status for the Search and Rescue Service over the quarterly reporting period. Information about the planned evolution of the constellation is given in Section 2.

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

Section 3: Provides the detailed performance for the SAR/Galileo Initial Service Detection and Location Performance and is organised in three subsections: "Detection Probability", "Location Probability" and "Location Accuracy".

Section 4: Provides the detailed performance for the SAR/Galileo Initial Service Infrastructure availability and is presented in three subsections: "Availability of the SAR/Galileo Ground Segment", "Availability of SAR/Galileo Space Segment" and "Availability of the SAR/Galileo Server".

Section 5: The cited reference documents are listed.

Table 1a and Table 1b provide the status of the Galileo constellation relevant for the SAR/Galileo Initial Service, for which the performance data has been derived for the reporting period.

Satellite Code	SV ID (PRN)	Cospas-Sarsat ID	Orbital Slot	Status
GSAT-0103	19	419	C04	Available
GSAT-0104	20	420	C05	Available ¹
GSAT-0201	18	418	Ecc ²	Available
GSAT-0202	14	414	Ecc ²	Available
GSAT-0203	26	426	B08	Available
GSAT-0205	24	424	A08	Available
GSAT-0206	30	430	A05	Available
GSAT-0207	07	407	C01	Available
GSAT-0208	08	408	C07	Available
GSAT-0209	09	409	C02	Available
GSAT-0210	01	401	A02	Available
GSAT-0211	02	402	A06	Available
GSAT-0212	03	403	C03	Available
GSAT-0213	04	404	C06	Available
GSAT-0214	05	405	C08	Available
GSAT-0215	21	2C5	A03	Available ³ since October 12 th
GSAT-0216	25	2C6	A07	Available
GSAT-0217	27	2C7	A01	Available
GSAT-0218	31	2C8	A04	Available

Table 1a: Galileo Reported Constellation Information for the SAR/Galileo Service

Satellite Code	SV ID (PRN)	CCSDS ID [hex]	Orbital Slot	Status
GSAT-0219	36	2C9	B04	Under commissioning
GSAT-0220	31	2C0	B01	Under commissioning
GSAT-0221	15	2C1	B02	Under commissioning
GSAT-0222	33	2C2	B07	Under commissioning

Table 1b: New Galileo Space vehicles under commissioning

¹ Galileo satellite GSAT-0104 SART is active and used in operations.

² Although Galileo satellites GSAT-0201 and GSA-0202 are located in an eccentric orbit, they have been declared operational for the SAR/Galileo Initial Service

³ Ref.: NAGU [2018023](#), announcing initial usability of space vehicle GSAT-0215

Note that performance for these satellites will be reported once their availability for SAR/Galileo Service has been declared.

For the most up-to-date information, please refer to the European GNSS Service Centre (GSC) Web pages:

GNSS Service Centre Web Resources	
Constellation 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	https://www.gsc-europa.eu/helpdesk/galileo-incident-report-form (Galileo Incidents Report Form)
Interactive support to users	https://www.gsc-europa.eu/contact-us/helpdesk (Galileo Help Desk)

Table 2: GSC Main Information web pages about Galileo Status

Note that the Galileo Help Desk 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.

Finally, an important service provided by the GSC consists of the provision of detailed orbit data for the Galileo satellites on a server accessible by the SAR community and for which access can be requested via the Galileo Help Desk.

2 EXECUTIVE SUMMARY

During the quarterly reporting period, the measured SAR/Galileo Initial Service performance figures generally exceed the Minimum Performance Level (MPL) targets specified in the [SAR-SDD] with significant margins. The following dashboard summarise the compliance with the MPLs, using the colour coding defined in the legend below Table 3.





SAR/ MPLs			Target Value	October-18	November-18	December-18	
Detection and Location Service	Probability	Valid Message Detection Probability after transmitted 1 burst	≥ 99%				
		Location Probability after 1 transmitted burst	≥ 75%				
		Location Probability after 12 transmitted bursts	≥ 98%				
	Accuracy	Location accuracy after 1 transmitted burst within 5 km	≥ 70%				
		Location accuracy after 12 transmitted bursts within 5km	≥ 95%				
		Location accuracy after 12 transmitted bursts within 2km	≥ 80%				
Infrastructure Availability	MEOLUT	Maspalomas/ EU MEOLUT Availability	Nominal	≥ 95%			
			Nominal + Degraded	≥ 97.5%			
		Spitsbergen/EU MEOLUT Availability	Nominal	≥ 95%			
			Nominal + Degraded	≥ 97.5%			
		Larnaca/EU MEOLUT Availability	Nominal	≥ 95%			
			Nominal + Degraded	≥ 97.5%			
	Satellites	Average SAR Transponder Availability		≥ 90%			

Table 3: MPL Fulfilment Status Dashboard

GSAT-0103	GSAT-0203	GSAT-0208	GSAT-0212	GSAT-0216
GSAT-0104	GSAT-0205	GSAT-0209	GSAT-0213	GSAT-0217
GSAT-0201	GSAT-0206	GSAT-0210	GSAT-0214	GSAT-0218
GSAT-0202	GSAT-0207	GSAT-0211	GSAT-0215	

Allocation of Satellites in the dashboard above

Legend

	MPL measurement not available or not applicable
	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)

The Detection and Location Performance KPIs are computed based on 5 reference beacons (REFBE) located in the SAR/Galileo Coverage area (SGC) defined in the [SAR-SDD] and are provided for the worst and best Reference Beacon Location for each of the applicable individual performance parameters.

The **Performance of the Detection Service** is above expectations, with monthly values of a valid message detection probability after a single transmitted burst of **100%**, where the MPL target is 99%.

Excellent values are achieved for **Performance of Location Probability**, with monthly values higher than **99.7%** for single burst location probability, where the MPL target is 75%, and **100%** after 12 transmitted bursts (multi-burst), where the MPL target is 98%.

The **Performance of Location Accuracy** continues to be above expectations with monthly values higher than **95.7%** for single burst and **99.2%** for multi-burst transmissions with an accuracy of **5** [km], while the MPLs are 70% and 95% respectively. The **Probability of Location Accuracy** within **2** [km] for multi-burst transmissions attained values over **93.3%** well above the MPL target of 80%.

The **Availability Performance of the SAR/Galileo MEOLUT Facilities** in “Nominal” and “Nominal + Degraded” modes during the reporting period always achieved better values than **96.3%** and **97.6%** respectively. Annually normalised figures are obtained with an incremental average process over a period of 12 continuous months as defined in the [SAR-SDD]. The measured values are well above the MPL target of 95% in “Nominal” and 97.5% in “Nominal + Degraded”.

The **Availability of the SAR Transponders** remains at excellent levels of performance with a monthly availability of **100%** for the active constellation with the exception of GSAT-0208 that archives an average of **88.8%** in October 2018 as a result of an on-board anomaly and thus not meeting the MPL target value of 90%.

3 DETECTION AND LOCATION PERFORMANCE

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

- ◇ Detection Probability in section 3.1
- ◇ Location Probability in section 3.2
- ◇ Location Accuracy in section 3.3

3.1 DETECTION PROBABILITY

The detection probability performance is computed for each SAR/Galileo Reference Beacon as the valid message detection probability after 1 transmitted burst. The detailed computation process for this performance parameter is described in the [SAR-SDD].

Figure 1 below shows the monthly single burst detection probability for each Reference Beacon, achieving 100% during the reporting period, always above the MPL target specified at 99%⁴.

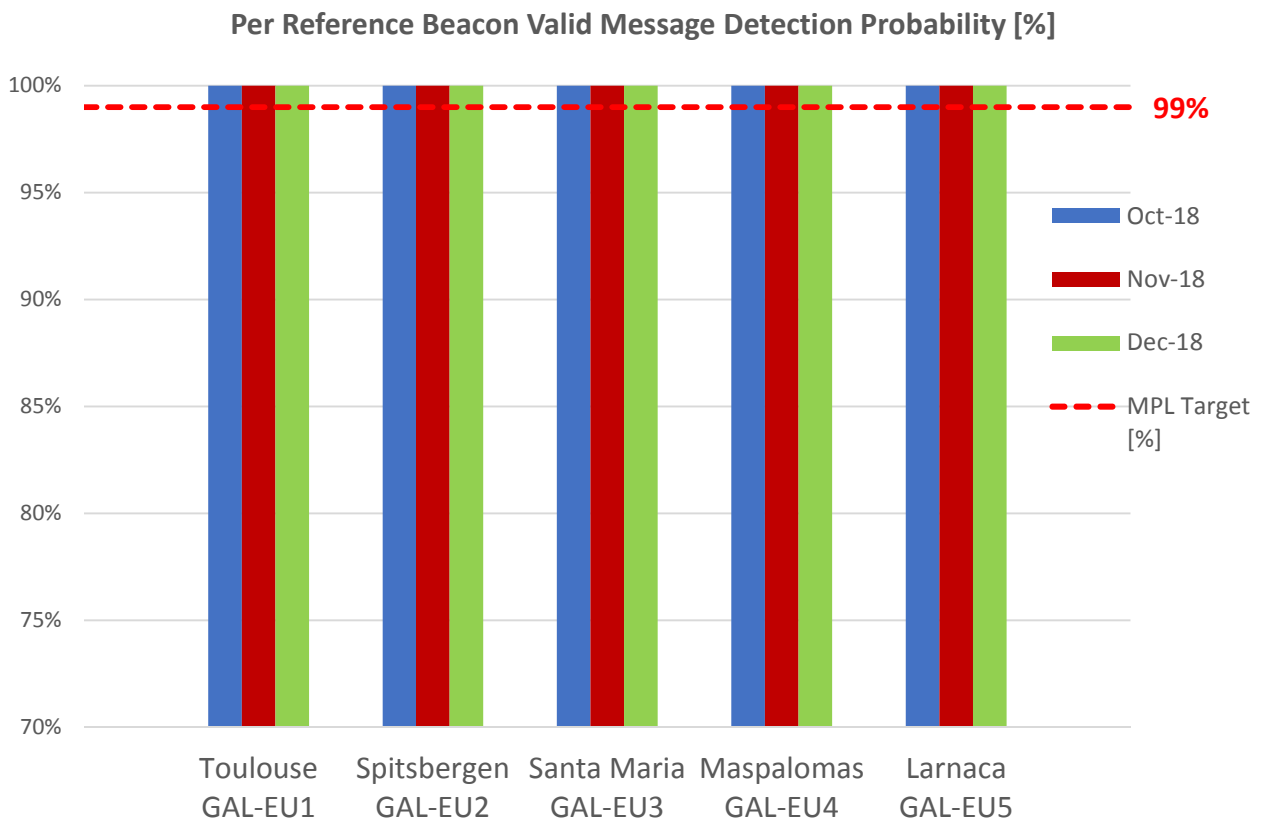


Figure 1: Per Reference Beacon Single Burst Detection Probability

⁴ Ref.: [SAR-SDD] , §5.1.1 (Table 9)

3.2 LOCATION PROBABILITY

The location probability performance is computed for each Reference Beacon after 1 transmitted burst (single-burst) and after 12 transmitted burst (multi-burst). The detailed computation process for this performance parameter is described in the [SAR-SDD]⁵ and the MPL levels specified as 75%⁶ are valid when the SAR/Galileo MEOLUTs Facilities are in Nominal Mode.

Figure 2 below shows the monthly single-burst location probability, which comfortably exceeds the MPL for each of the SAR/Galileo Reference Beacons, with a minimum value of 99.7% and an average of 99.9%.

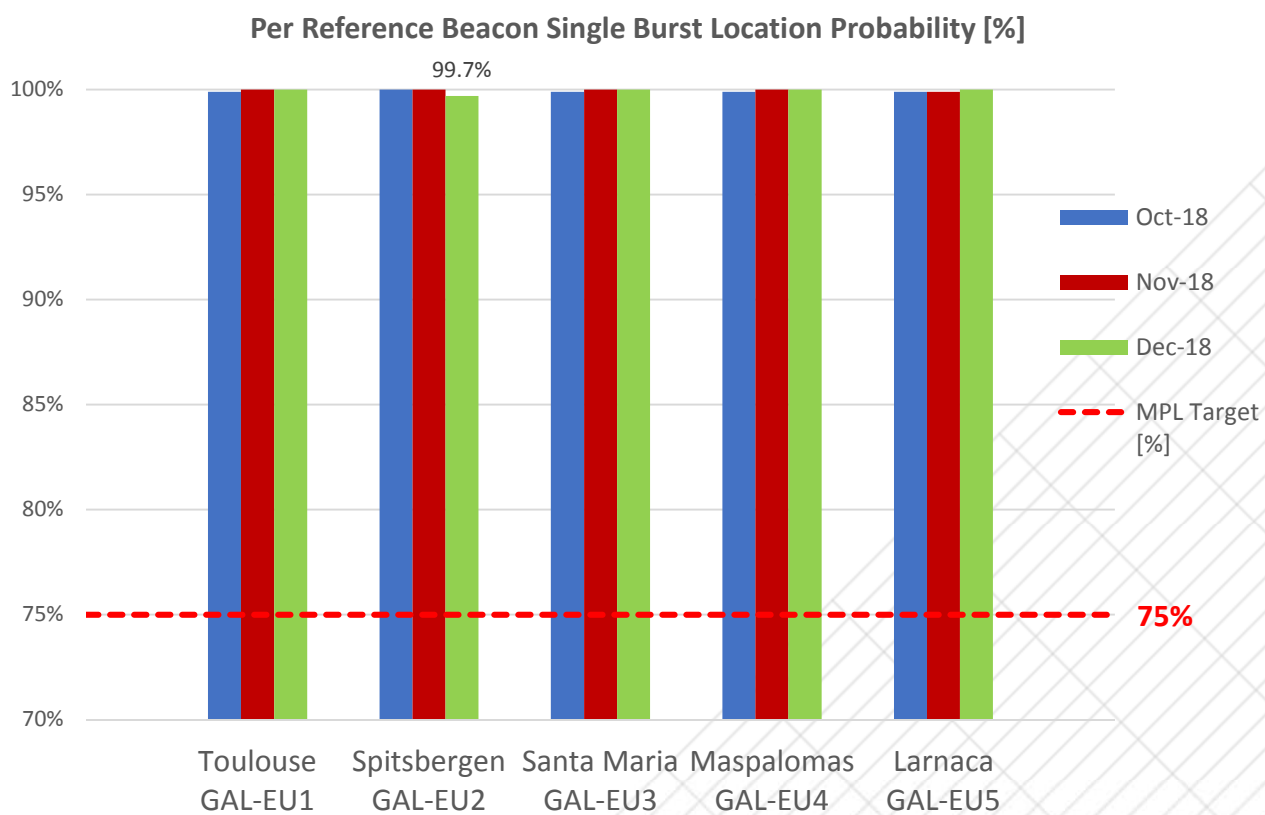


Figure 2: Per Reference Beacon Single Burst Location Probability

The multi-burst location probability, displayed in Figure 3 below, is always 100% for each of the REFBE thus meeting the defined [SAR-SDD]⁷ minimum performance level target of 98%.

⁵ An integration window of 140 [s] is considered (since 1st August 2018) instead of 90 [s] described in the [SAR-SDD] §5.1.2 for the computation of the location probability after 1 transmitted burst

⁶ Ref.: [SAR-SDD] , §5.1.2 (Table 10)

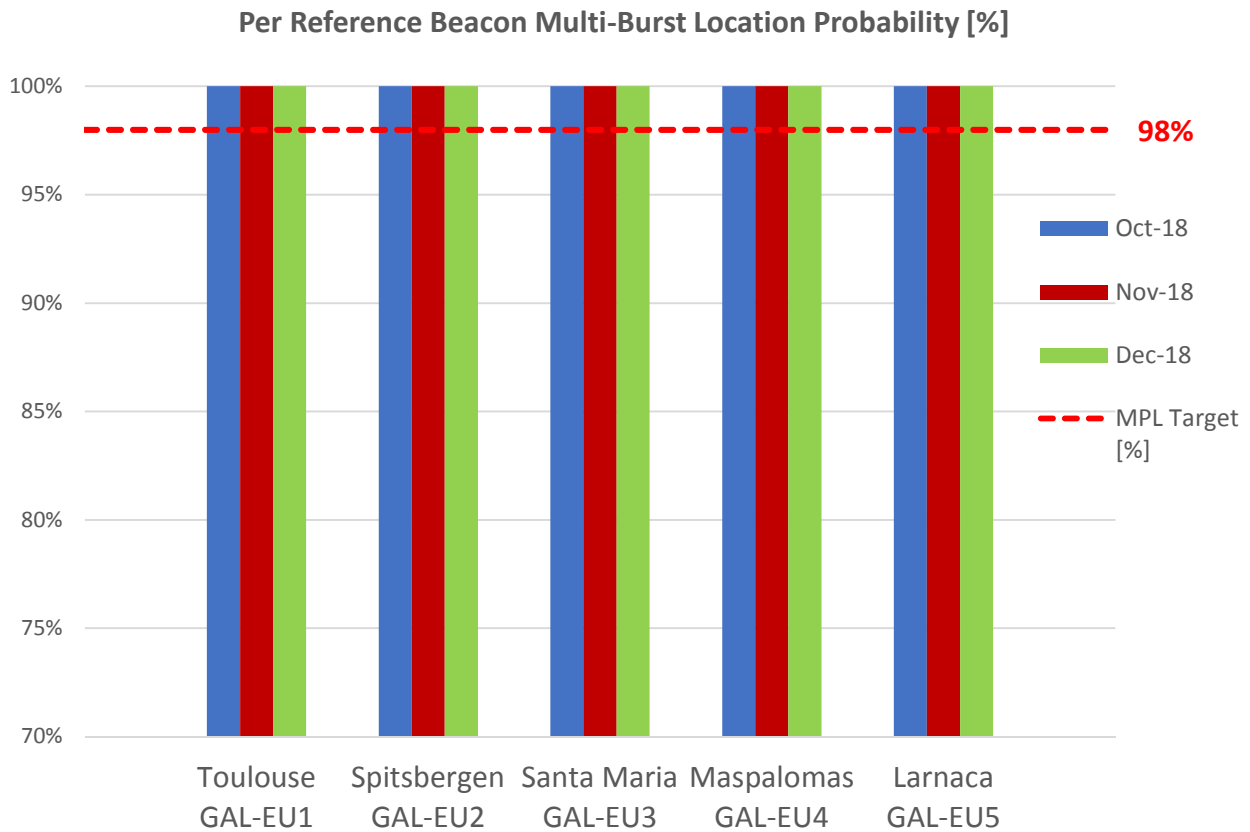


Figure 3: Per Reference Beacon Multi-Burst Location Probability

3.3 LOCATION ACCURACY

The Location Accuracy performance is defined in the [SAR-SDD] as the probability that the SAR/Galileo Service produces a location with an error bounded by a given threshold, namely 2 and 5km. The Location Accuracy Minimum Performance Levels specified in the [SAR-SDD]⁷ are valid when the MEOLUT is in Nominal mode and the results are presented per REFBE after 1 transmitted burst (single-burst) and after 12 transmitted bursts (multi-burst) for the 5km threshold and in multi-burst only for the 2km threshold.

The single-burst 5 km location accuracy is depicted in Figure 4 depicts with 5km. All REFBE comfortably achieve the [SAR-SDD] MPL target of 70%, with average values above 98.3%, worst performing REFBE achieving 95.7% and best performing above 99.7%.

⁷ Ref.: [SAR-SDD] , §5.1.2 (Table 10)

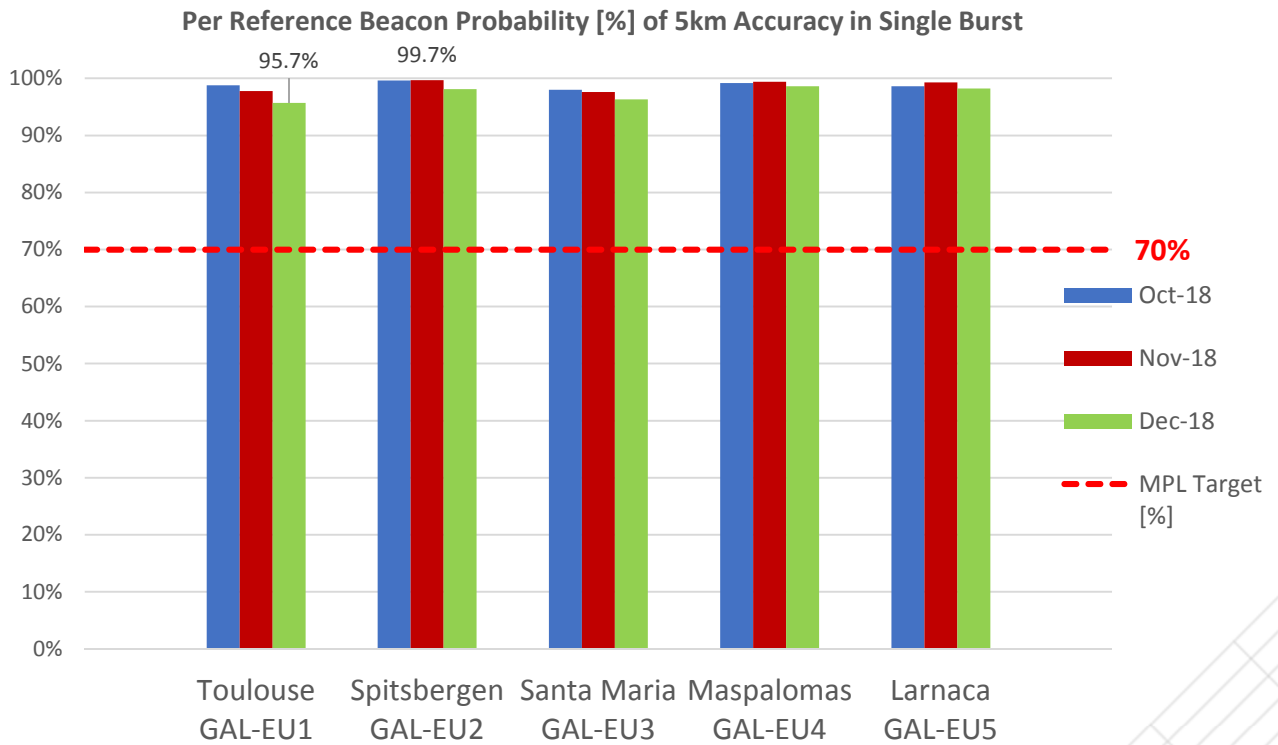


Figure 4: Per Reference Beacon Probability of 5km Accuracy in Single Burst
 The probability of achieving a location with 5km accuracy in multi-burst mode for each of the SAR/Galileo Reference Beacons is shown in Figure 5. The values achieved attain an average of 99.6%, which is always better than the [SAR-SDD] MPL specified as 95%, with the best performing REFBE reaching **99.8%** and the worst performing achieving **99.2%**.

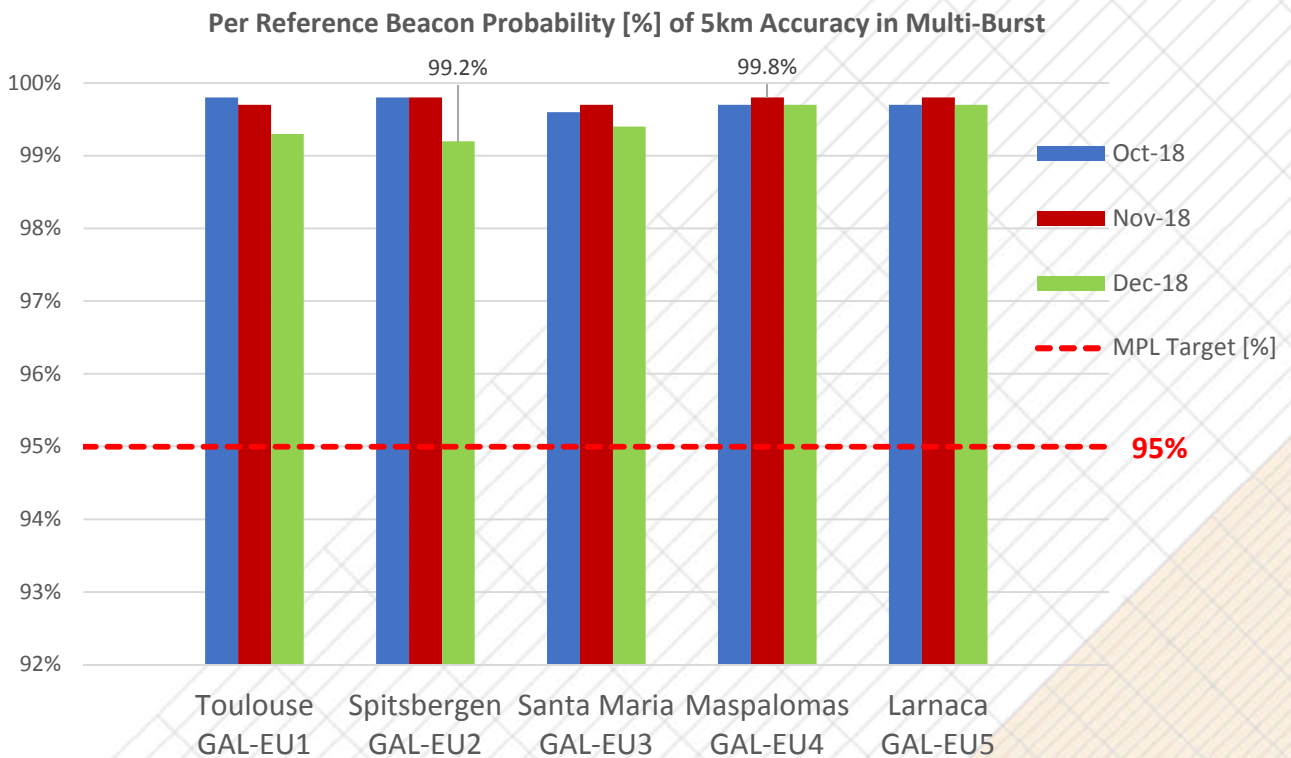


Figure 5: Per Reference Beacon Probability of 5km Accuracy in Multi-Burst

Compliance with the multi-burst location accuracy within 2km [SAR-SDD] MPL specified at 80%⁸, is always achieved during the reporting period as displayed in Figure 6. The performance achieved is always better than the MPL target value, with an average of **95.6%**, best performing REFBE reaching **96.8%** and worst attaining **93.3%**.

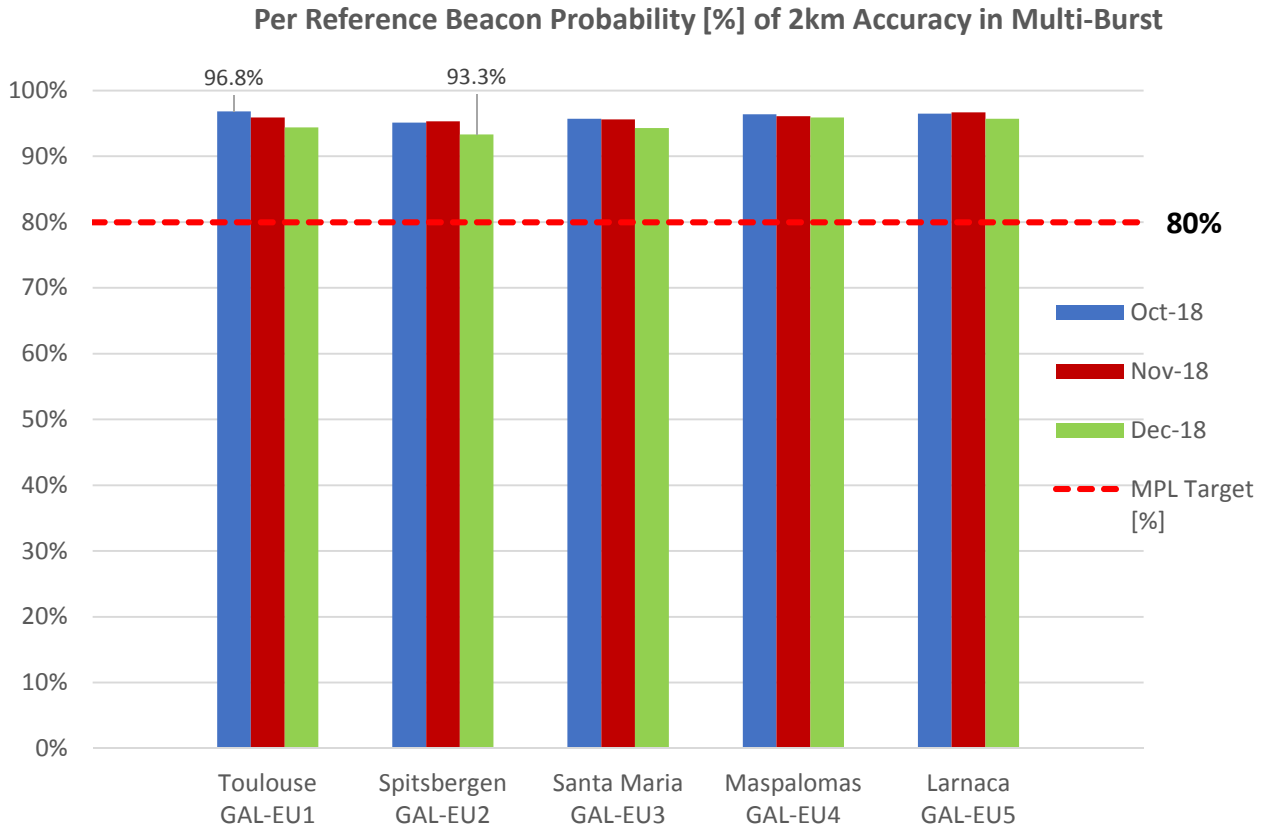


Figure 6: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst

⁸ Ref.: [SAR-SDD] , §5.1.2 (Table 10)

4 INFRASTRUCTURE AVAILABILITY PERFORMANCE

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

- ◇ Availability of the SAR/Galileo Ground Segment in section 4.1
- ◇ Availability of the SAR/Galileo Space Segment in section 4.2
- ◇ Availability of the SAR/Galileo Server in section 4.3

4.1 AVAILABILITY OF THE SAR/GALILEO GROUND SEGMENT

The Minimum Performance Levels for the availability of the SAR/Galileo Ground Segment Infrastructure (MEOLUT Local Facility, MTCF and SARN) are defined in the [SAR-SDD]⁹.

The MEOLUT Local Facility availability MPL is defined over a period of twelve months, with a sliding window moving one month ahead every month. Nevertheless, in

Figure 7 and Figure 8 below, the MEOLUT Local Facility monthly availability figures are also reported showing the performance trend over time.

During the reporting period, all EU MEOLUT Local Facilities show long-term normalised “Nominal” mode availability performance better than the MPL target specified at 95%, achieving in December 2018 **96.8%**, **98.6 %** and **98.3%** for Larnaca, Maspalomas and Spitsbergen respectively.

Figure 7 below also shows a reduced “Nominal” mode Larnaca/EU MEOLUT short-term availability during the month of October 2018 (92.5%), which is linked to the MEOLUT Facility planned annual maintenance combined with some antenna malfunctions.

Finally, in December 2018, all the EU MEOLUT Facilities were fitted with a new software version release that consequently, slightly degraded their short-term availability.

⁹ Ref.: [SAR-SDD] , §5.2.2 (Table 13, Table 14 and Table 15)

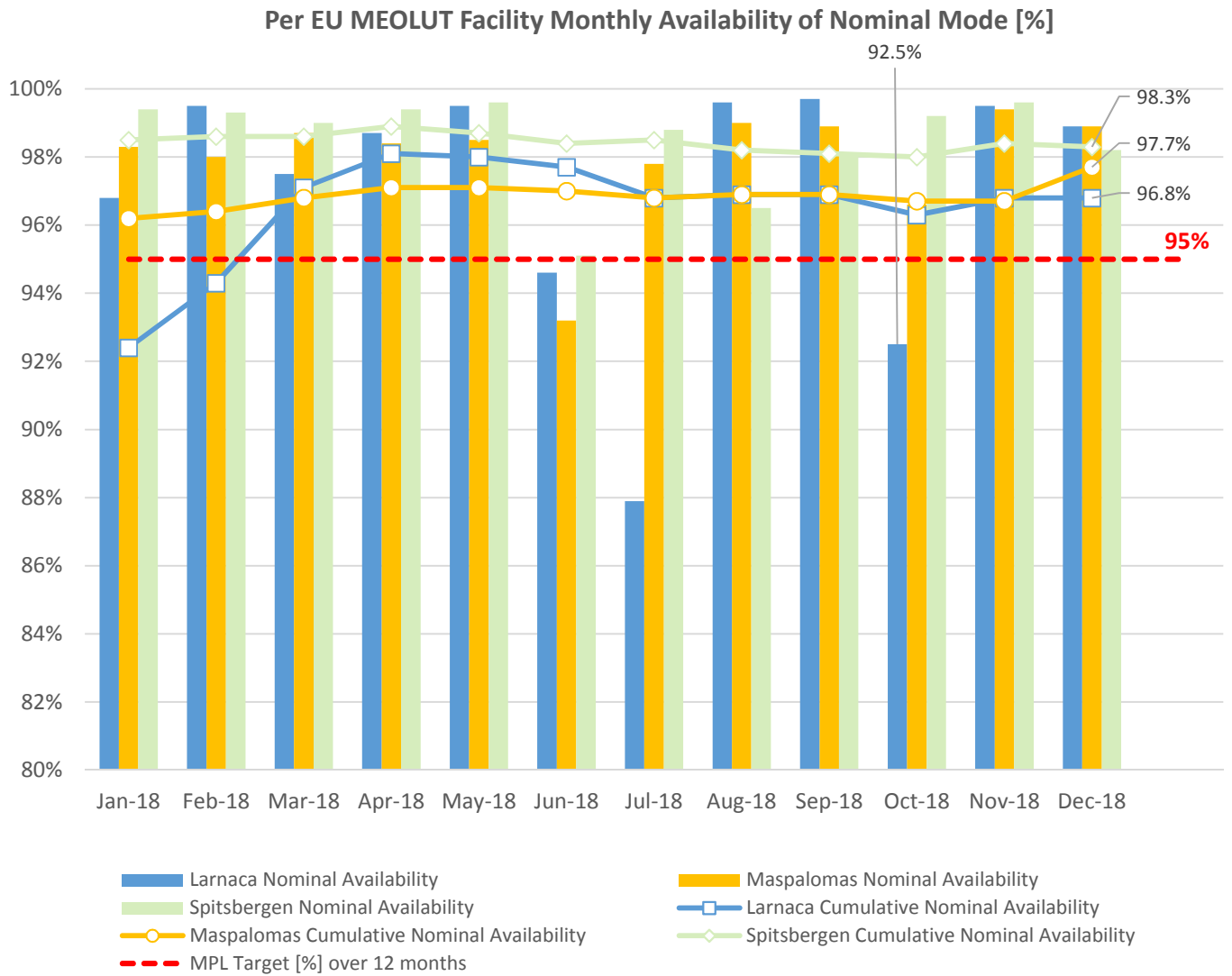


Figure 7: Per EU MEOLUT Facility Monthly Availability of Nominal Mode

The “Nominal + Degraded” availability mode is reported in Figure 8 below per European MEOLUT Facility with the annually normalised values obtained during the last twelve months of service, with MPL target specified at 97.5%.

The cumulative values always exceed the MPL for all the three European MEOLUTs during the reporting period with Larnaca, Maspalomas and Spitsbergen reaching **98.8%**, **98.6%** and **99%** respectively in December 2018.

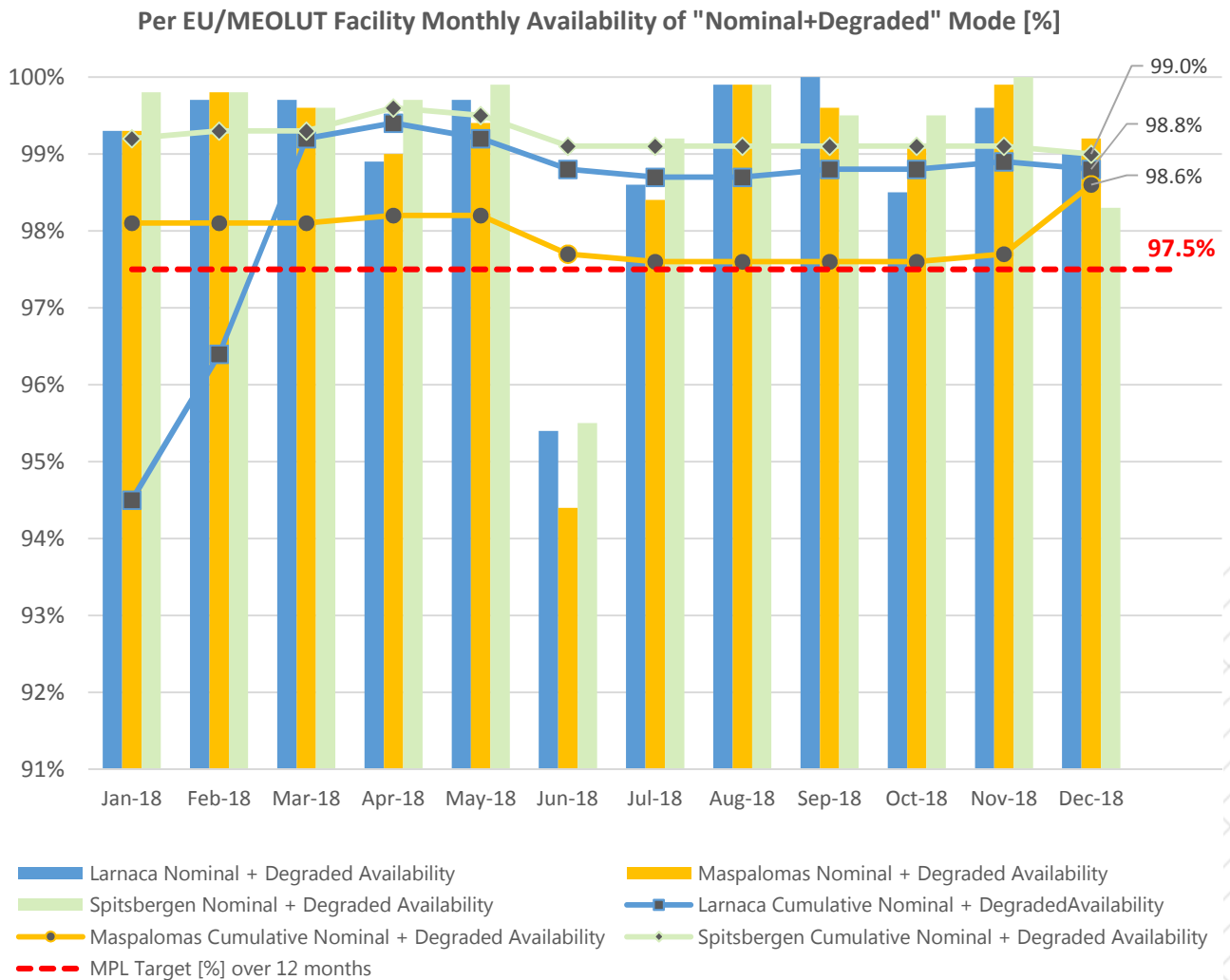


Figure 8: Per EU/MEOLUT Facility Monthly Availability of "Nominal+Degraded" Mode

The MEOLUT Tracking Coordination Facility (MTCF) and SAR Network (SARN) cumulative availability over the last twelve months of service are reported in Table 4 below.

Other SAR/Galileo Ground Segment Elements	Target Value (over 12 months)	Oct-18	Nov-18	Dec-18
MTCF Availability	≥ 99.95%	98.61%	99.13%	99.37%
SARN Availability	≥ 99.40%	99.72%	99.72%	99.71%

Table 4: MTCF and SARN Cumulative Availability, October–December 2018

The MTCF cumulative availability does not achieve the required MPL target value, which is specified as 99.95% over a period of one year. The MTCF is considered not available when one or more of the functions needed for the TOA/FOA exchange process and the Tracking Plan computation are not available. It should be noted that even if the MTCF is not available (e.g. not operational), it does not necessarily have an impact on the SAR/Galileo Service performance.

Table 5 below presents, for information, the MTCF and SARN monthly availability values over the reporting period.

Other SAR/Galileo Ground Segment Elements	Oct-18	Nov-18	Dec-18
MTCF Availability	100%	100%	99.9%
SARN Availability	99.95%	99.7%	100%

Table 5: MTCF and SARN Monthly Availability, October – December 2018

4.2 AVAILABILITY OF THE SAR/GALILEO SPACE SEGMENT

During the period of July to September 2018, all SAR Transponders achieved an average availability of 99.8%. All GSAT SAR transponders obtained **100%** availability except for GSAT-0208, which only achieved **88.8%** in October 2018 due to an observed on-board event spanning from the 29th of September until the 4th of October.

4.3 AVAILABILITY OF THE SAR/GALILEO SERVER

The current version of the [SAR-SDD] does not define specific MPLs for the SAR/Galileo Orbit Data Server availability, nonetheless the service achieved an average availability of 94.21% during the reporting period.

The monthly average availability of orbital data for all Galileo satellites equipped with SAR Transponders and declared available for service is shown in Table 6 below for information.

Other SAR/Galileo Ground Segment Elements	Target Value	Oct-18	Nov-18	Dec-18
SAR/Galileo Orbit Data Server Availability	N/A	90.59%	92.36%	99.80%

Table 6: SAR/Galileo Orbit Data Server Monthly Availability, October–December 2018

5 REFERENCES

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

[SAR-SDD] *European GNSS (Galileo) SAR/GALILEO Initial Service Definition Document (SAR-SDD), Issue 1.0, European Union, December 2016.*

The [SAR-SDD] defines the SAR/Galileo Initial Service and its associated Minimum Performance Levels (MPLs).

6 LIST OF ACRONYMS

Acronym	Definition
C/S	Cospas-Sarsat
EU	European Union
FOA	Frequency of Arrival
GPS	Global Positioning System
GSA	European GNSS Agency
GSAT	Galileo Satellite
GNSS	Global Navigation Satellite System
GSC	European GNSS Service Centre
IS	(Galileo) Initial Services
KCP	KPI Collection Platform
KPI	Key Performance Indicator
MEOLUT	Medium Earth Orbit Local User Terminal
MPL	Minimum Performance Level
MTCF	MEOLUT Tracking Coordination Facility
NAGU	Notice Advisory to Galileo Users
REFBE	SAR/Galileo Reference Beacon
SAR	Search and Rescue
SART	Search and Rescue Transponder
SARN	SAR Network
SDD	Service Definition Document
SGC	SAR/Galileo Coverage
SGS	SAR/Galileo Ground Segment
SIS	Signal in Space
TOA	Time of Arrival

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