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EUROPEAN GNSS (GALILEO) INITIAL SERVICES

SAR/GALILEO SERVICE

QUARTERLY PERFORMANCE REPORT

APRIL - JUNE 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 April, May and June 2018. Following the declaration of Initial Services in December 2016, a new edition will be published after each quarter, in order to provide the public with actual performance statistics of the Galileo SAR 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.

1.1 GALILEO CONSTELLATION STATUS FOR SAR/GALILEO

Table 1a provides 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. It should be noted that the Galileo satellites GSAT-0101 and GSAT-0102 do not include a Search and Rescue payload and are therefore not include in the constellation status.

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*	Available
GSAT-0202	14	414	Ecc*	Available
GSAT-0203	26	426	B08	Available
GSAT-0204	22	422	B03	Not Available[2]
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

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

* 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.

Four (4) new Galileo satellites were successfully launched on 12/12/2017 (see NAGU 2017047).

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

[2] Galileo satellite GSAT-0204 was removed from active service on 08/12/2017 for the purpose of constellation management (ref. NAGU: 2017045). Therefore its performance is not reported in the Dashboard (ref.: Table 3).

Satellite Code	SV ID (PRN)	CCSDS ID [hex]	Orbital Slot	Status
GSAT-0215	21	2C5	A03	Under commissioning
GSAT-0216	25	2C6	A07	Under commissioning
GSAT-0217	27	2C7	A01	Under commissioning
GSAT-0218	31	2C8	A04	Under commissioning

Table 1b: Additional Galileo Satellites under Commissioning (status as of 30 June 2018)

Note that performance for these satellites will be reported in the next reporting period, 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/GALILEO INITIAL SERVICE MPLs				Target Value	Apr-18	May-18	Jun-18
Detection and Location Service	Probability	Valid Message Detection Probability after 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 [3]

[3] An integration window of 130 [s] is considered instead of 90 [s] described in the [SAR-SDD] §5.1.2 for the computation of the location probability after 1 transmitted burst.

GSAT-0103	GSAT-0104	GSAT-0201	GSAT-0202
GSAT-0203	GSAT-0204	GSAT-0205	GSAT-0206
GSAT-0207	GSAT-0208	GSAT-0209	GSAT-0210
GSAT-0211	GSAT-0212	GSAT-0213	GSAT-0214

Allocation of Satellites in the dashboard above

Legend

	MPL measurement not available
	MPL measurement not provided. Satellite available (constellation spare)
	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].

The performance of the Detection and Location service is provided for the worst Reference Beacon Location for each of the individual performance parameters.

The **Performance of the Detection Service** is above expectations, with monthly average values of a valid message detection probability after a single transmitted burst of **99.9%,** where the MPL target is 99%.

Performance of Location Probability is above expectations, with monthly values higher than **95.9%** for single burst location probability, where the MPL target is 75%, and **99.7%** after 12 transmitted bursts (multi-burst), where the MPL target is 98%.

The **Performance of Location Accuracy** is also above expectations, with monthly values higher than **95.9%** for single burst and **97.2%** 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 achieved values over **81.8%,** while the MPL is 80%. The slight degradation is explained by the non-availability of suitable calibration transmissions during the months of May and June 2018.

The **Availability Performance of the SAR/Galileo MEOLUT Facilities**, reported as defined in the [SAR-SDD] with an incremental average process over a period of 12 continuous months, reach the MPL target values of 95% in "Nominal" mode and 97.5% in "Nominal + Degraded" mode, with average values higher than **97%** and **97.7%**.

The **Availability of the Search and Rescue Repeaters** remain at excellent levels of performance with a measured average of **100%**, significantly above the minimum expected MPL availability target of 90%.

3 SAR/GALILEO INITIAL SERVICE 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 always above the MPL target specified at 99% [4].

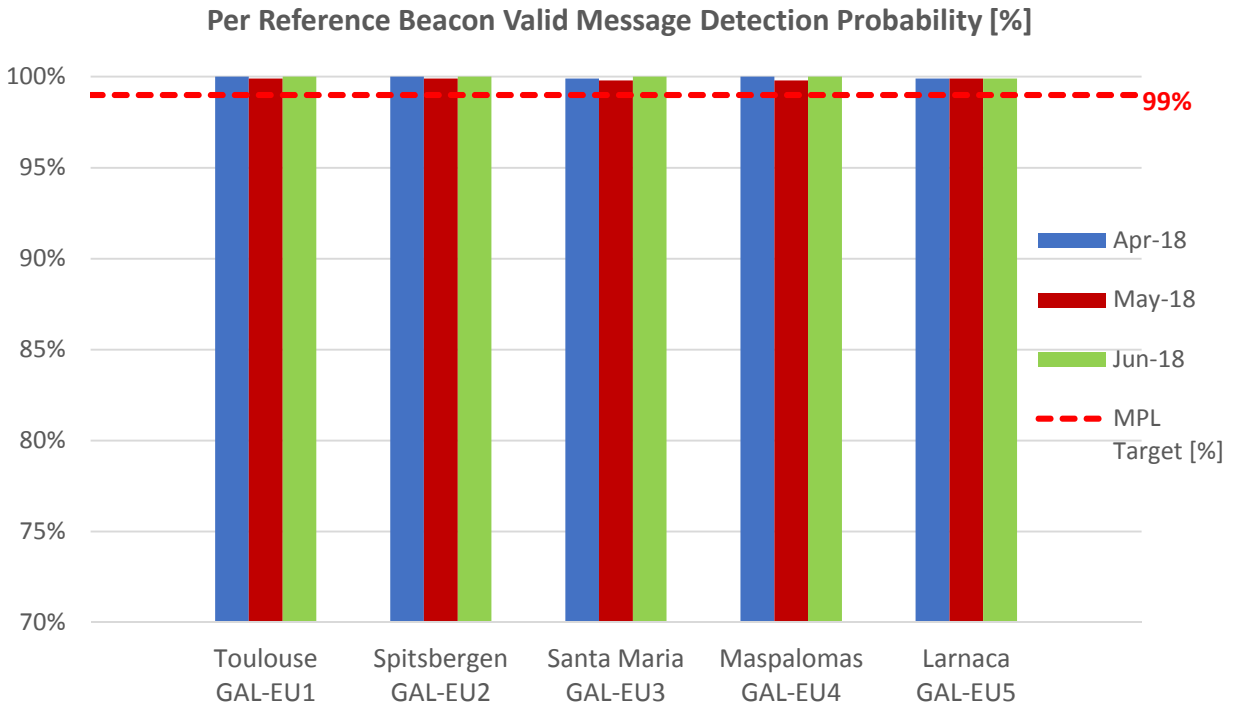


Figure 1: Per Reference Beacon Single Burst Detection Probability

[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 and after 12 transmitted burst. The detailed computation process for this performance parameter is described in the [SAR-SDD]. The Minimum Performance Levels specified as 75% [5] defined in the [SAR-SDD] are valid when the SAR/Galileo MEOLUTs are in nominal mode.

Figure 2 below shows the monthly single burst location probability above the MPL for each of the SAR/Galileo Reference Beacons.

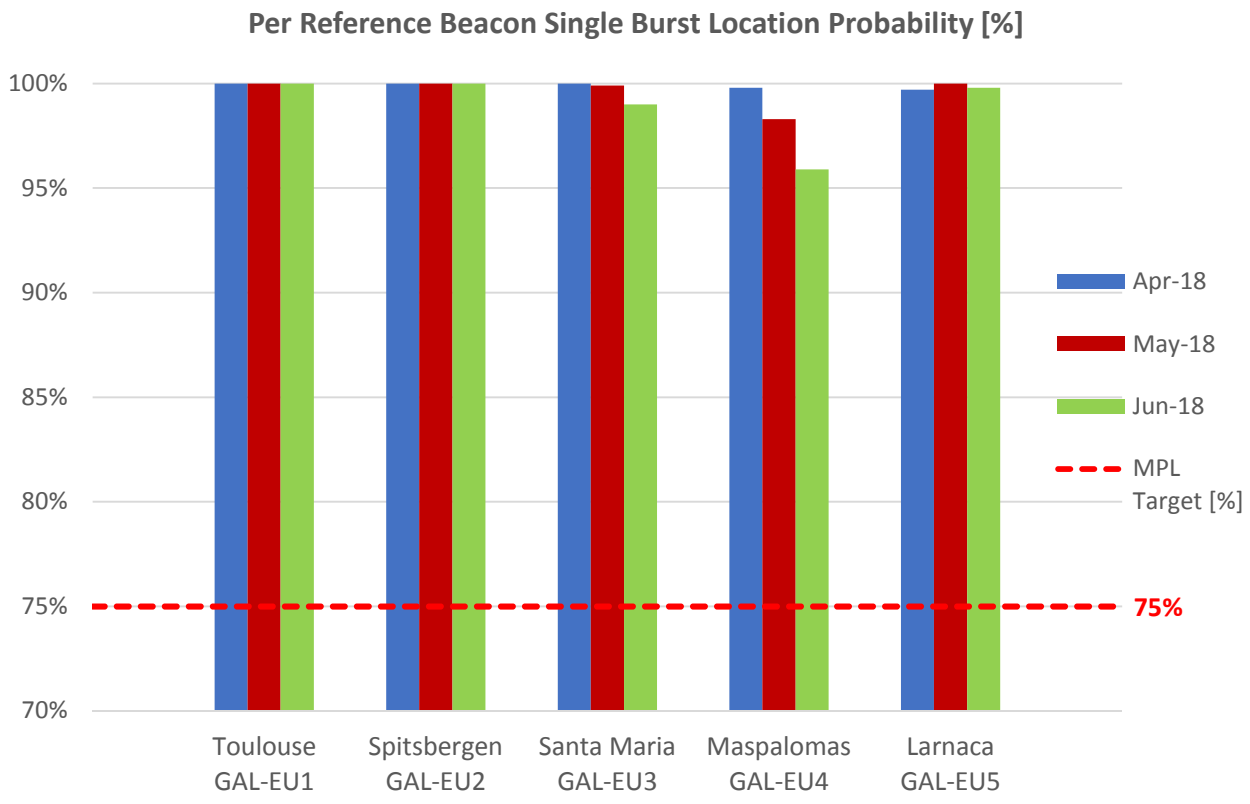


Figure 2: Per Reference Beacon Single Burst Location Probability

Figure 3 below, shows the monthly multi-burst location probability for each of the REFBE. The multi-burst location probability for each of the REFBE is in all cases 100% comfortably above the MPL level defined in the [SAR-SDD], specified as 98% [5]

[5] Ref.: [SAR-SDD] , §5.1.2 (Table 10)

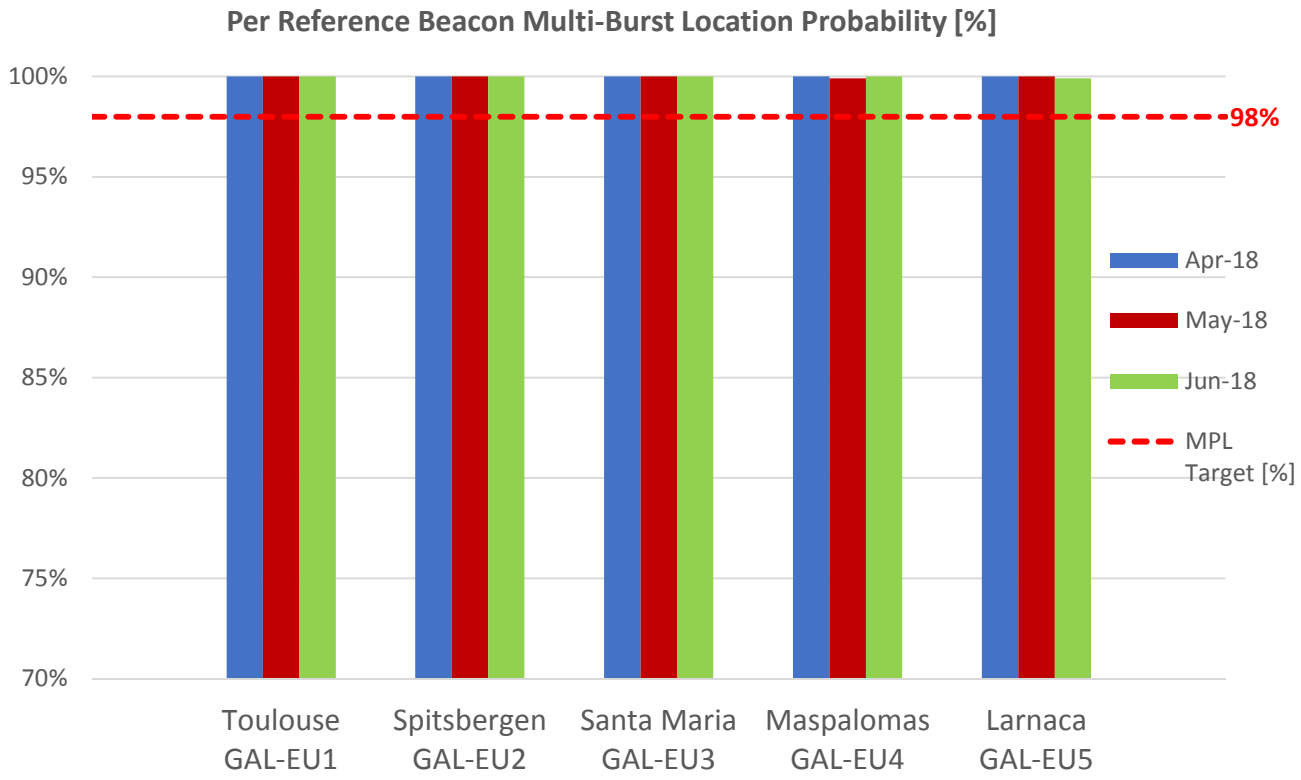


Figure 3: Per Reference Beacon Multi-Burst Location Probability

3.3 LOCATION ACCURACY

The location accuracy performance is defined in the [SAR-SDD] as the probability that a location is computed with an error bounded by a given threshold. These probabilities are computed for each 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 detailed computation process for this performance parameter is described in the [SAR-SDD]. The Minimum Performance Levels specified in the [SAR-SDD] [6] are valid when the MEOLUT is in nominal mode.

An unplanned event occurred during the month of May 2018 where the MEOLUT Local Facilities external calibration beacons were not fully operational. The non-availability of calibration transmissions, especially for geometries not experiencing co-visibility with Toulouse, caused a slight degradation of the location accuracy, as can be observed on the probability of 2km accuracy in multi-burst reported in Figure 6. Interim changes have been implemented in the SAR/Galileo operational configuration to mitigate the abnormal situation.

Figure 4 depicts compliance of all the SAR/Galileo REFBE to the single-burst location accuracy with 5km MPL specified in the [SAR-SDD] as 70%.

[6] Ref.: [SAR-SDD] , §5.1.2 (Table 10)

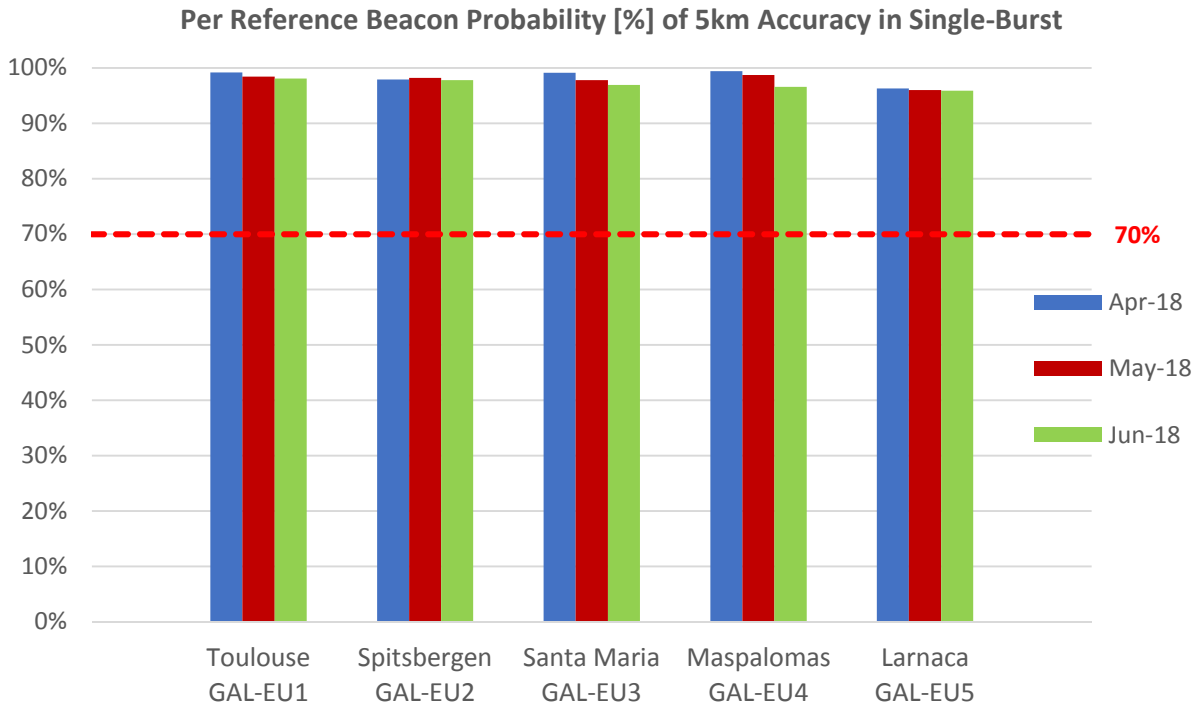
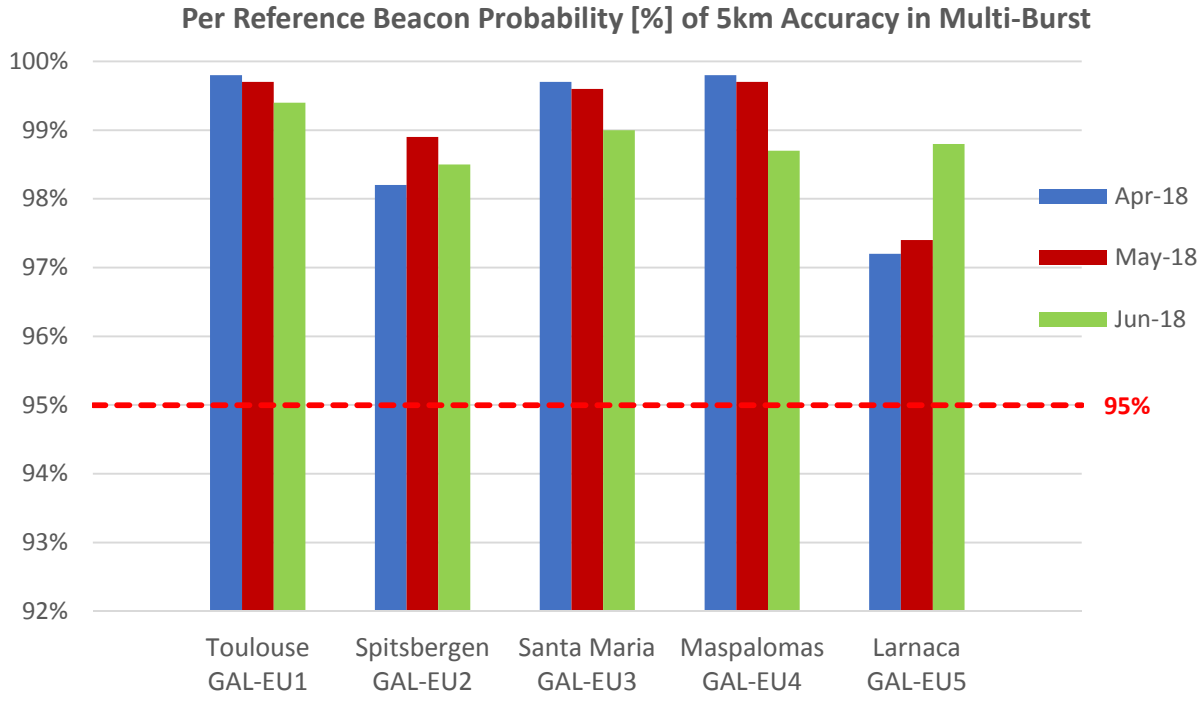


Figure 4: Per Reference Beacon Probability of 5km Accuracy in Single Burst

Figure 5 shows the monthly probability of achieving a location with 5km accuracy in multi-burst mode for each of the Reference Beacons. The probability of achieving 5km accuracy in multi-burst location for each of the Reference Beacons is compliant with the [SAR-SDD/MPL specified as 95%[7].



[7] Ref.: [SAR-SDD] , §5.1.2 (Table 10)

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

Figure 6 shows the monthly probability of achieving a location with 2km accuracy in multi-burst mode for each of the SAR/Galileo Reference Beacons. Although the performance achieved is always above the Minimum Performance Level from [SAR-SDD], specified as 80% [8], as mentioned in section 3.3, the slight degradation is explained by the non-availability of suitable calibration means in co-visibility of the SGS REFBEs.

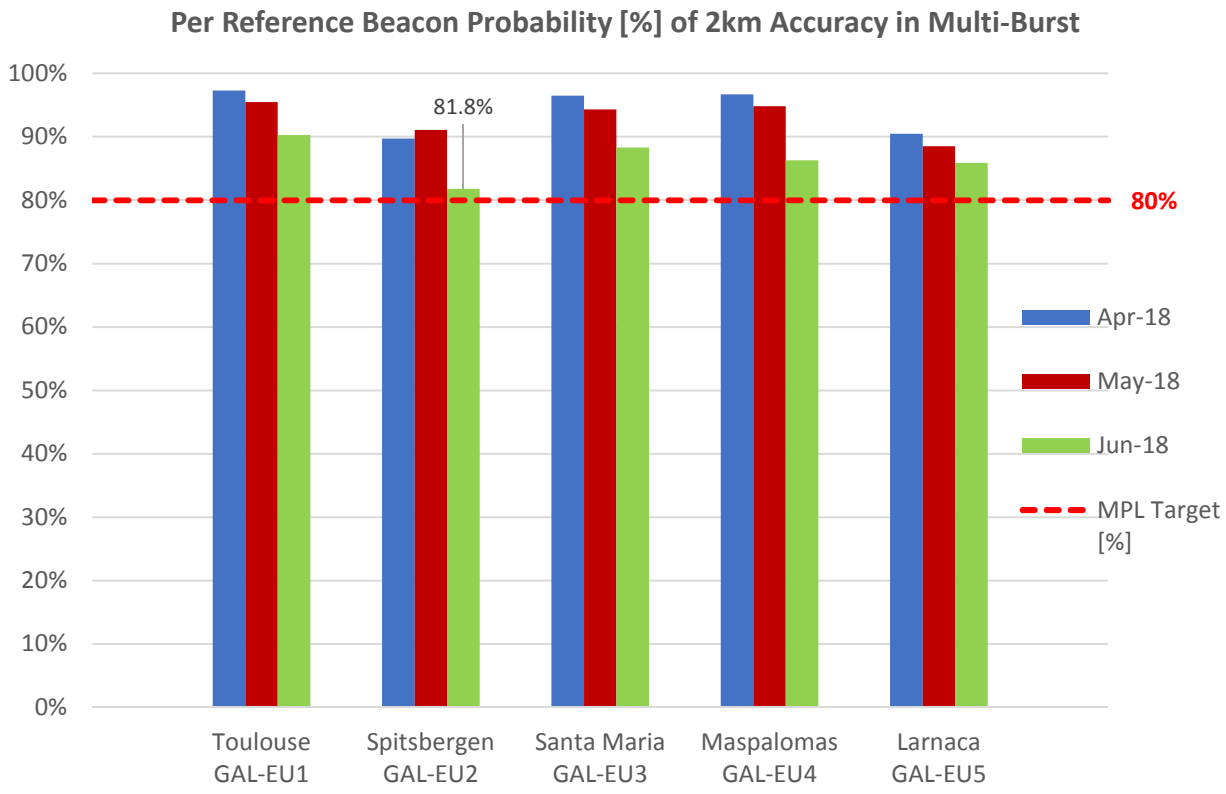


Figure 6: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst

[8] Ref.: [SAR-SDD] , §5.1.1 (Table 10)

4 SAR/GALILEO 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 Minimum Performance Level 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 availability figures are also reported for each month in order to assess the performance trend over time.

All MEOLUT Local Facilities show long-term normalized "Nominal" mode availability performance better than the MPL target, which is specified as 95%. Note that in June, the maintenance undertaken by all MEOLUT Local Facilities slightly degraded the short-term availability of Larnaca, Maspalomas and Spitsbergen. MEOLUT Local Facilities short-term availability performance is illustrated in Figure 7 below.

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

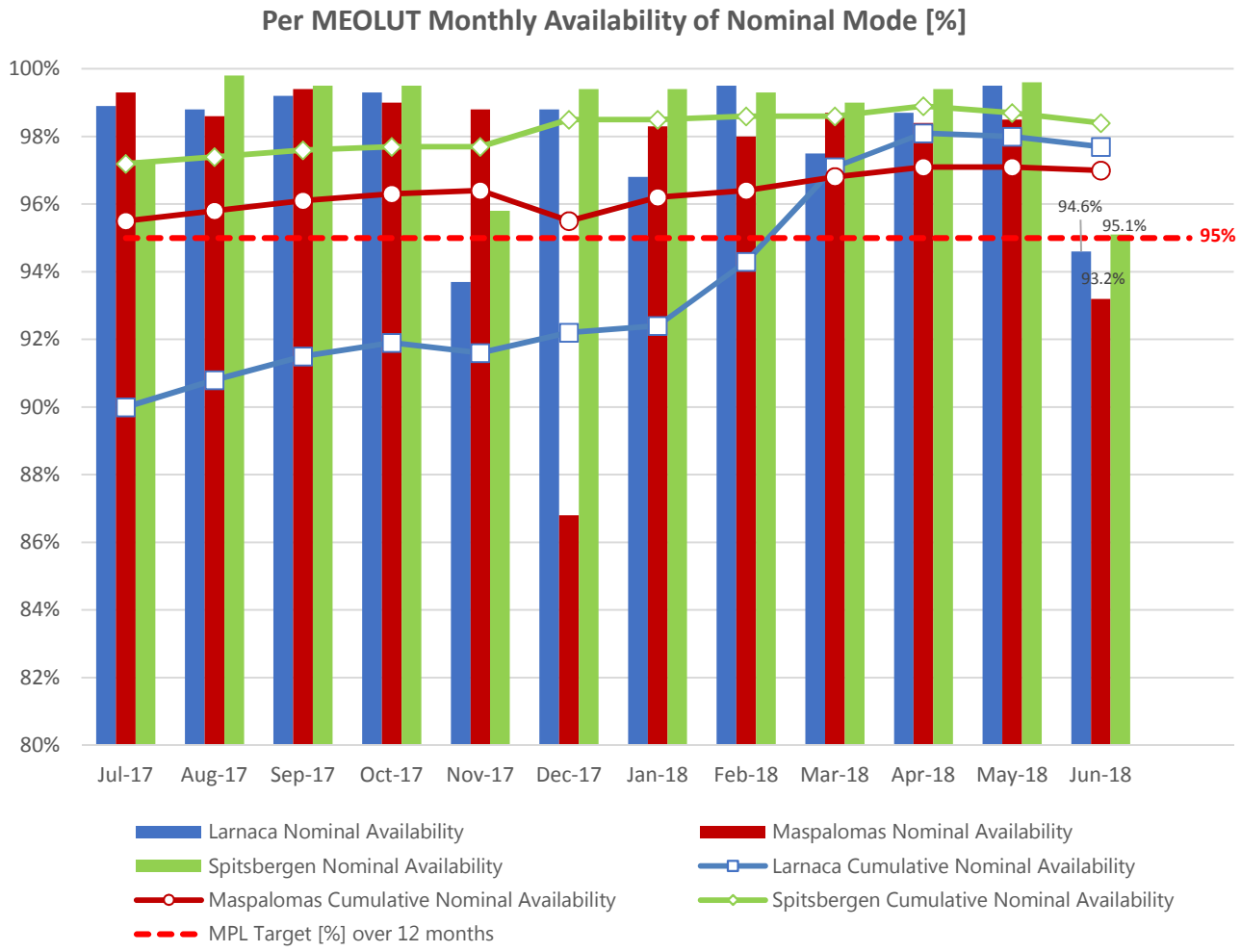


Figure 7: Per MEOLUT Monthly Availability of Nominal Mode

Figure 8 below presents the availability of each of the MEOLUT Local Facilities in "Nominal + Degraded" mode during the last twelve months of Service which is specified as 97.5%. The Larnaca, Maspalomas and Spitsbergen MEOLUT Local Facilities show April and May availability in "Nominal + Degraded" Mode above the MPL. As explained above, the maintenance activities during the month of June 2018 caused a limited monthly availability degradation.

On the other hand, the cumulative average availabilities over the last twelve months exceed the MPL for all the MEOLUT Local Facilities with Larnaca (98.8%), Maspalomas (97.7%) and Spitsbergen (99.1%).

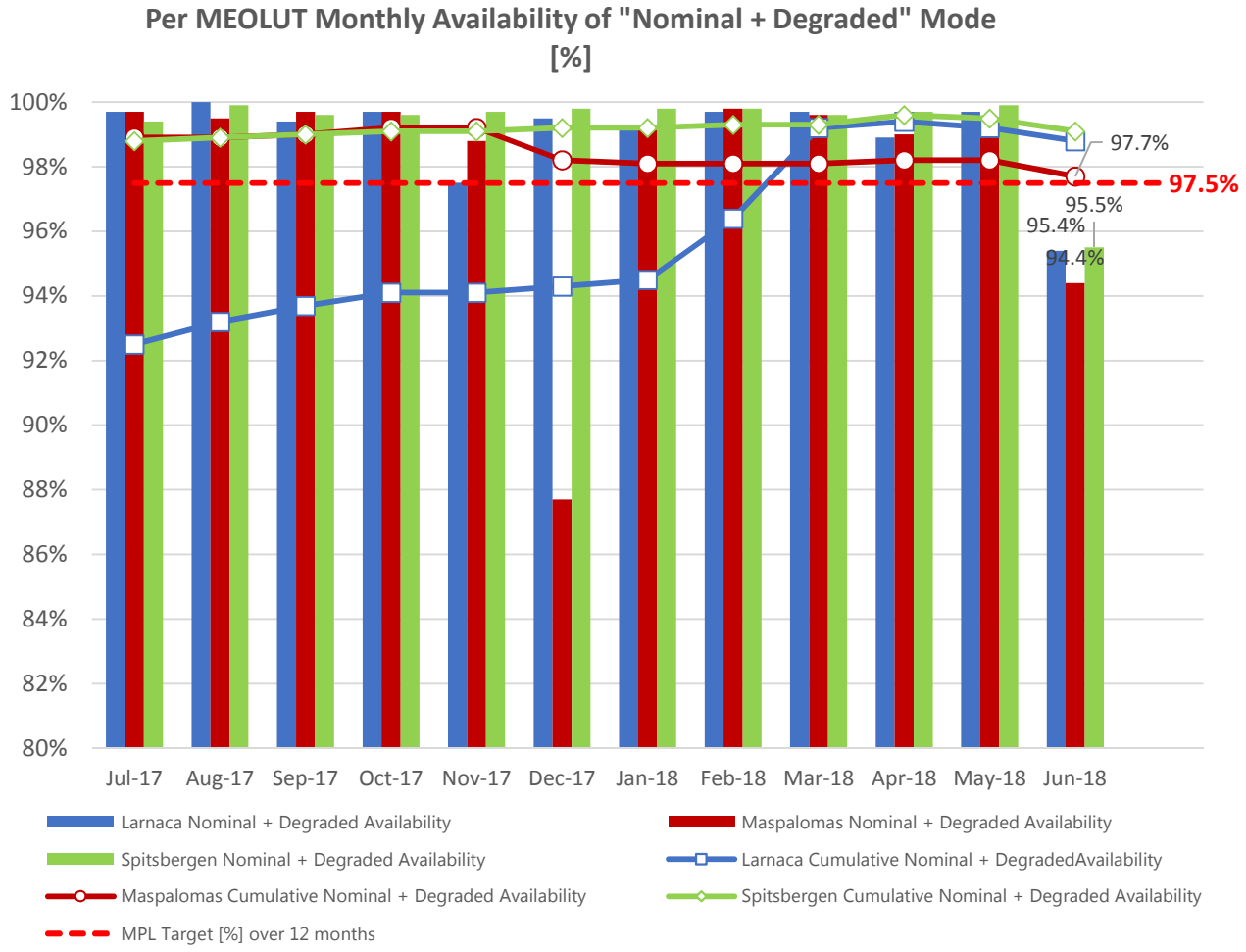


Figure 8: Per MEOLUT Monthly Availability of "Nominal + Degraded" Mode

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

Other SAR/Galileo Ground Segment Elements	Target Value (over 12 months)	April-18	May-18	June-18
MTCF Availability	≥ 99.95%	98.60%	98.60%	99.10%
SARN Availability	≥ 99.40%	99.60%	99.00%	100%

Table 4: MTCF and SARN Cumulative Availability, April – June 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 operationally available when one or both 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 in operational mode, it does not necessarily imply 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	Target Value (over 12 months)	April-18	May-18	June-18
MTCF Availability	≥ 99.95%	99.70%	99.60%	100%
SARN Availability	≥ 99.40%	99.96%	99.94%	99.70%

Table 5: MTCF and SARN Monthly Availability, April – June 2018

4.2 AVAILABILITY OF THE SAR/GALILEO SPACE SEGMENT

During the period of April to June 2018, all SAR Transponders achieved an availability of **100%** each month.

4.3 AVAILABILITY OF THE SAR/GALILEO SERVER

Note that the current version of the [SAR-SDD] does not define specific MPLs for the SAR/Galileo Orbit Data Server availability. Nevertheless, the service continues to maintain high average availability figures, with an average value of 97.6% during the period of April to June. The monthly availabilities over the reporting period are shown in the Table 6 below for information.

	Target Value	April-18	May-18	June-18
SAR/Galileo Orbit Data Server Availability	N/A	99.51%	97.80%	95.30%

Table 6: SAR/Galileo Orbit Data Server Monthly Availability, April – June 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

End of Document

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