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EUROPEAN GNSS (GALILEO) INITIAL SERVICES

SAR SERVICE

QUARTERLY PERFORMANCE REPORT

JULY - SEPTEMBER 2019



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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 July, August and September 2019. Following the declaration of Initial Services in December 2016, a new edition is published after each quarter, in order to provide the public with 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: Provides an introduction to this report, including the status of the Galileo constellation for the Search and Rescue Service over the quarterly reporting period.

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 1 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.

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	421	A03	Available
GSAT-0216	25	425	A07	Available
GSAT-0217	27	427	A04	Available
GSAT-0218	31	431	A01	Available
GSAT-0219	36	436	B04	Available
GSAT-0220	31	413	B01	Available
GSAT-0221	15	415	B02	Available
GSAT-0222	33	433	B07	Available

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

¹ Galileo satellite GSAT-0104 SART is active and used in operations only for SAR/Galileo Initial Service.

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

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	www.gsc-europa.eu/system-status/Constellation-Information
Reference Constellation Orbital and Technical Parameters	www.gsc-europa.eu/system-service-status/orbital-and-technical-parameters
Incident Reporting	www.gsc-europa.eu/helpdesk (Report a Galileo Incidents)
Interactive support to users	www.gsc-europa.eu/helpdesk (Raise your questions)

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 exceeded the Detection and Location Minimum Performance Level (MPL) targets specified in the [SAR-SDD] with significant margins.

The following dashboard summarises the compliance with the MPLs, using the colour coding defined in the legend below Table 3.





SAR/ MPLs		Target Value	July-19	August-19	September-19	
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	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-0220
GSAT-0104	GSAT-0205	GSAT-0209	GSAT-0213	GSAT-0217	GSAT-0221
GSAT-0201	GSAT-0206	GSAT-0210	GSAT-0214	GSAT-0218	GSAT-0222
GSAT-0202	GSAT-0207	GSAT-0211	GSAT-0215	GSAT-0219	-

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 MPLs are computed based on 5 SAR/Galileo 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 **99.9%**, where the MPL target is 99%.

Excellent values are achieved for the **Performance of Location Probability**, with monthly values higher than **99.6%** for single burst, 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** surpasses the targets with monthly values higher than **97.3%** for single burst and **99.4%** for multi-burst transmissions with an accuracy better than 5km, while the MPLs are 70% and 95% respectively. The **Performance of Location Accuracy** within 2km for multi-burst transmissions attained values over **94.1%**, which is 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 remains at excellent levels with annually normalised values better than **97.8%** and **99.2%** respectively, always above the MPL targets of 95% in “Nominal” and 97.5% in “Nominal + Degraded” modes.

The **Availability of the SAR Transponders** achieved excellent levels of performance reaching satellite monthly availability of **100%**.

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 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 valid message detection probability for each Reference Beacon, which generally achieved 100% with 99.9% as the worst performance value observed during the reporting period, always above the MPL target specified at 99%³.

³ Ref.: [SAR-SDD], §5.1.1 (Table 9)

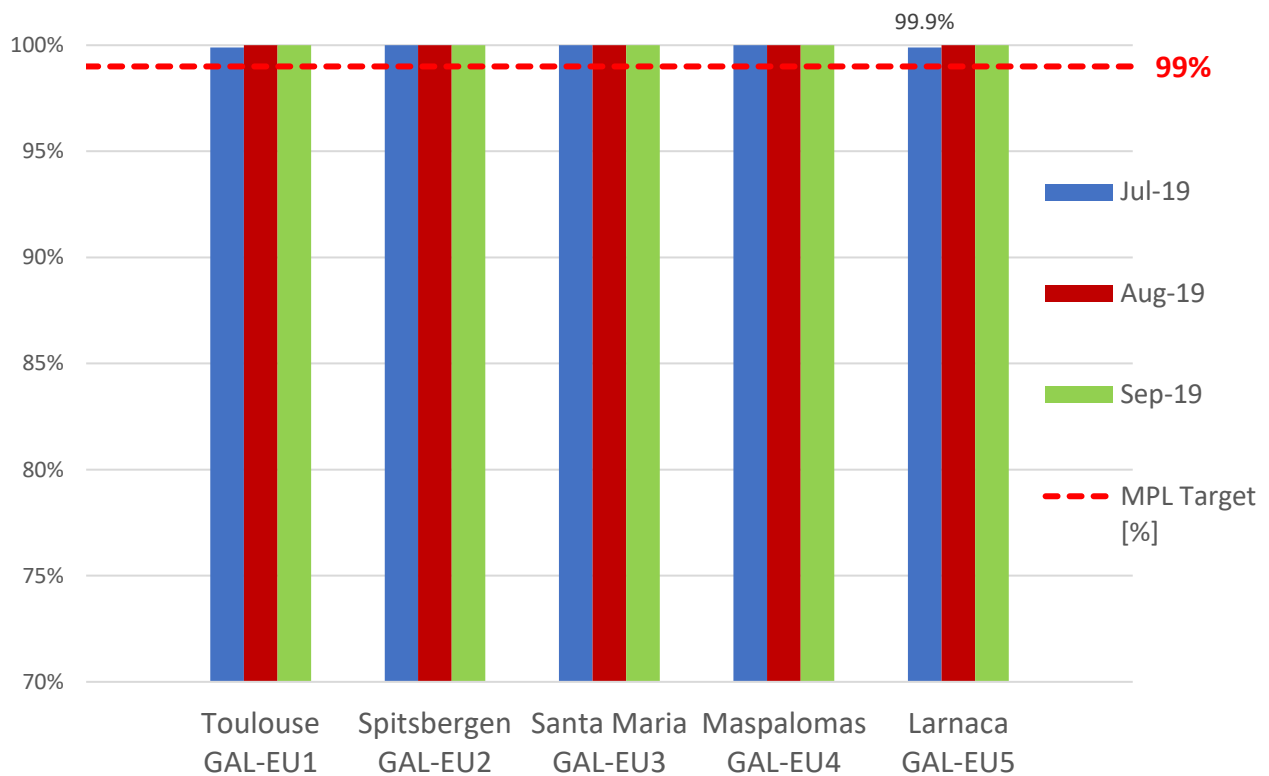


Figure 1: Per Reference Beacon Valid Message Detection Probability [%]

3.2 LOCATION PROBABILITY

The location probability performance is computed for each Reference Beacon after 1 transmitted burst (single-burst) and after 12 transmitted bursts (multi-burst). The detailed computation process for this performance parameter is described in the [SAR-SDD]⁴ and the MPLs specified at 75%⁵ are valid when the SAR/Galileo MEOLUT 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 **99.6%**, a best value of **100%** and an average over the reporting period above **99.9%**.

The multi-burst location probability, displayed in Figure 3 below, is always 100% for each of the REFBE, thus meeting the defined [SAR-SDD]⁶ MPL target of 98%.

⁴ 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

⁵ Ref.: [SAR-SDD], §5.1.2 (Table 10)

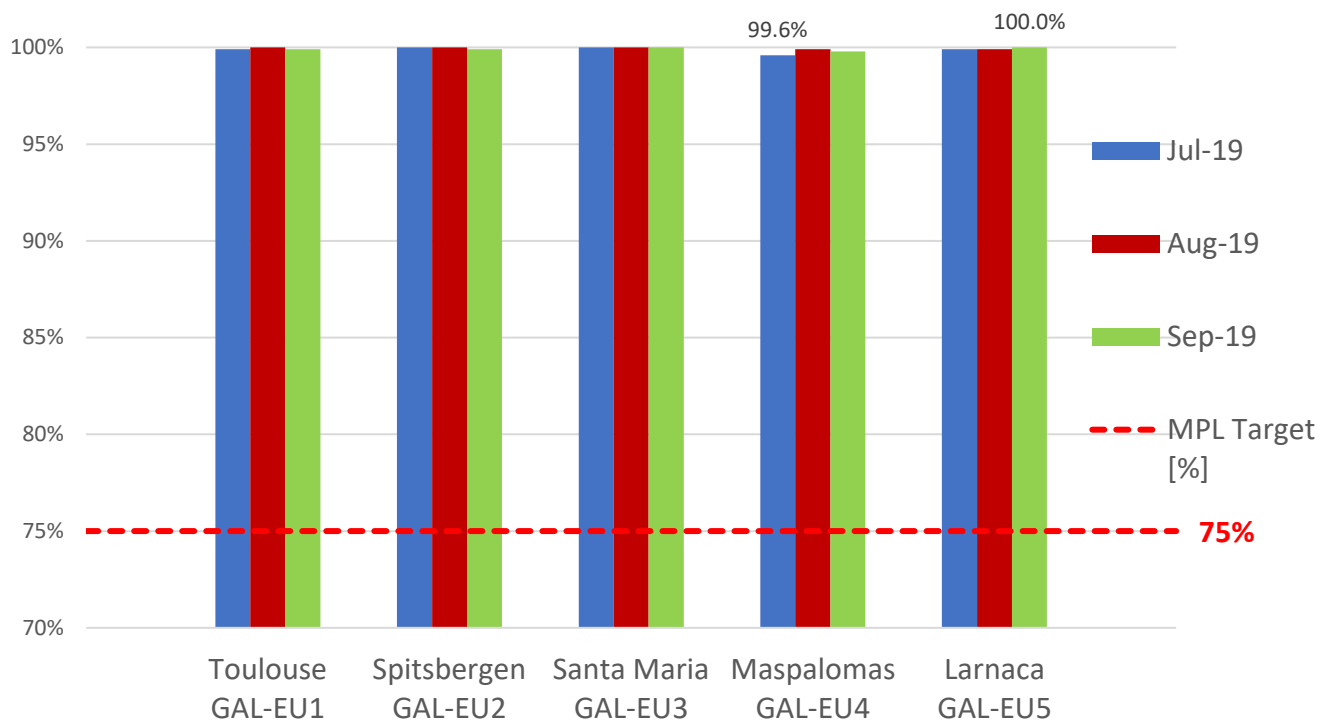


Figure 2: Per Reference Beacon Single Burst Location Probability [%]

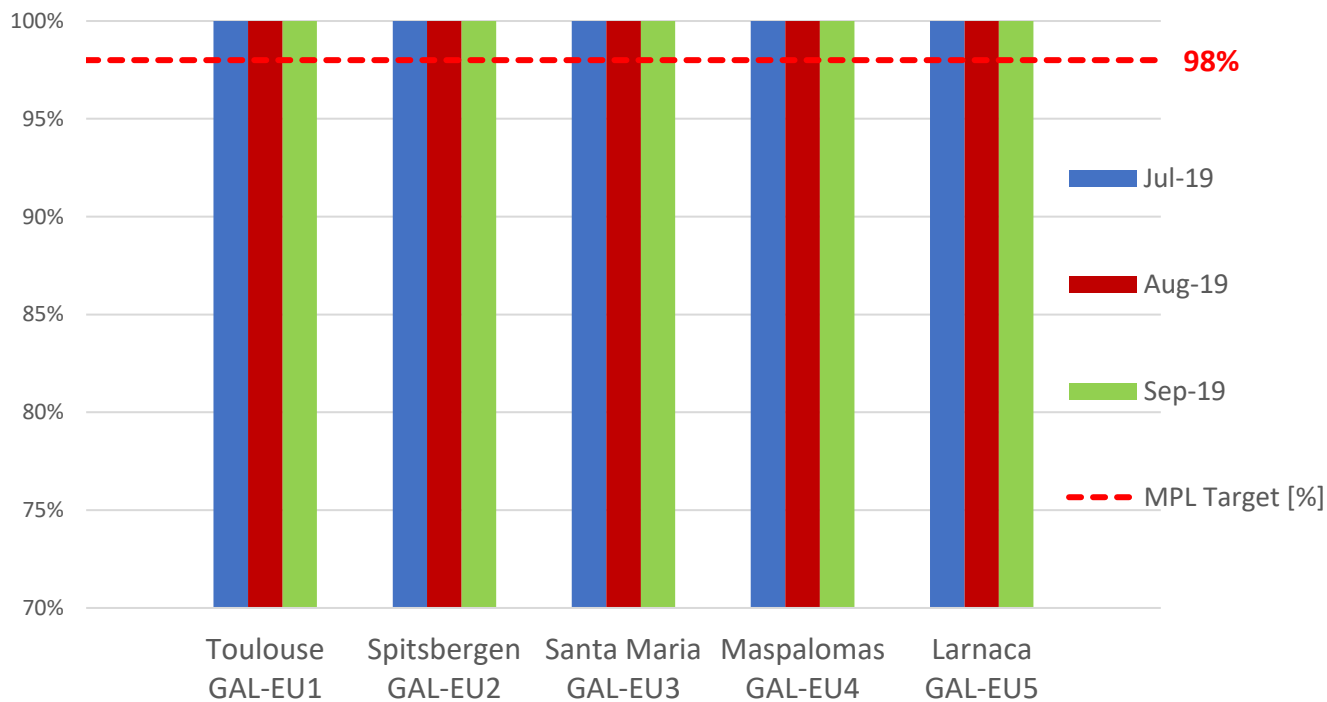


Figure 3: Per Reference Beacon Multi-Burst Location Probability [%]

3.3 LOCATION ACCURACY

The location accuracy performance is defined in the [SAR-SDD] as the probability to produce a location with an error bounded by a given threshold, namely 2km and 5km. The location accuracy MPLs specified in the [SAR-SDD]⁶ are valid when the MEOLUT is in Nominal mode and the results are presented per Reference Beacon in Figure 4, Figure 5 for the 5km error in single-burst and multi-burst and in Figure 6 for the 2km threshold in multi-burst only.

The single-burst 5km location accuracy depicted in Figure 4 shows compliance by all REFBE to the [SAR-SDD] MPL target of 70%, with average values above **98.8%**, the worst performing REFBE achieving **97.3%** and the best performing above **99.6%**.

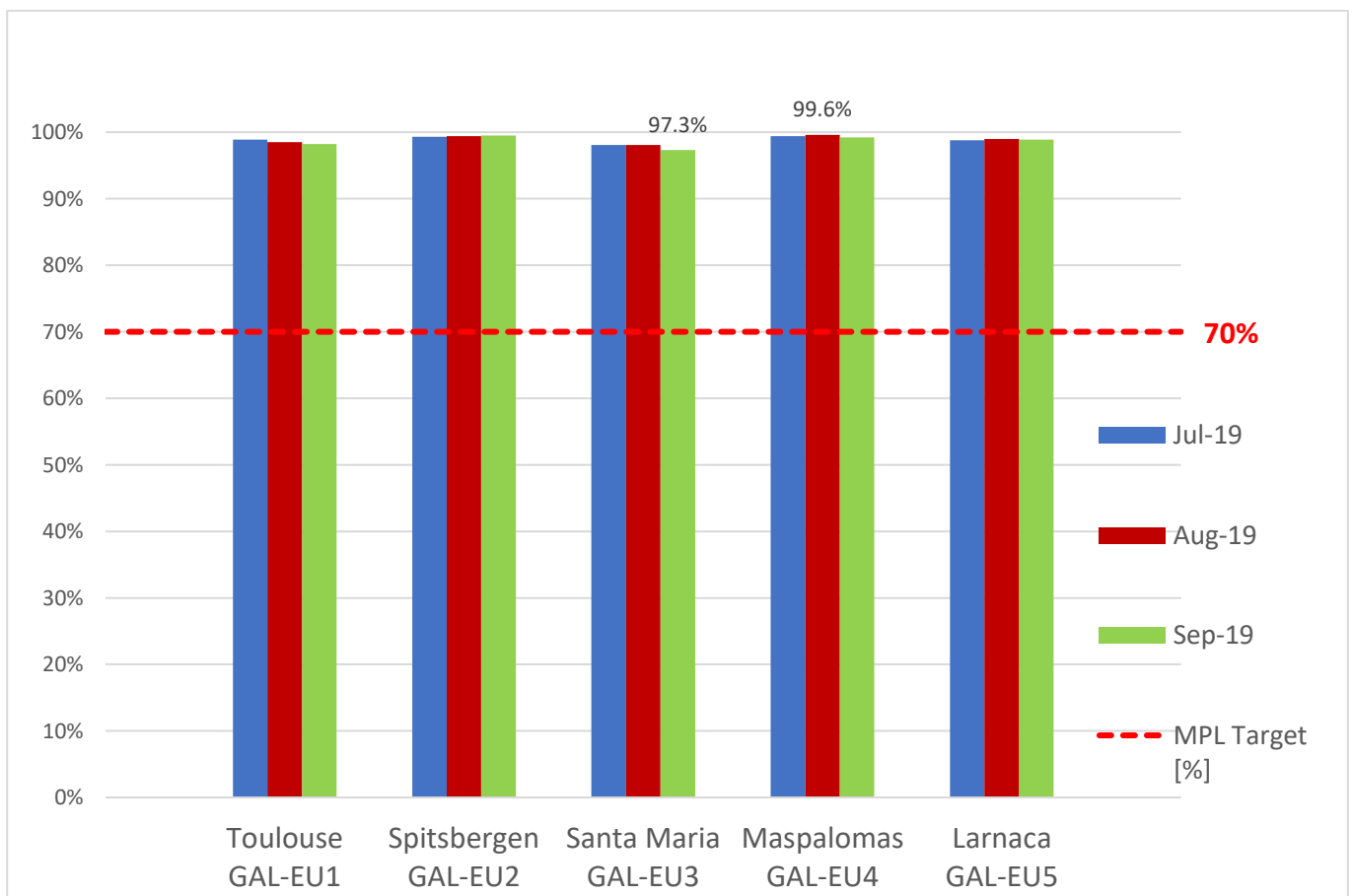


Figure 4: Per Reference Beacon Probability of 5km Accuracy in Single Burst [%]

⁶ Ref.: [SAR-SDD], §5.1.2 (Table 10)

The multi-burst location accuracy with 5km error, in Figure 5, achieved excellent levels of performance with average values for all Reference Beacons above **99.7%** comfortably exceeding the [SAR-SDD] MPL specified as 95%. The worst performing REFBE achieved **99.4%** and the best **99.9%**

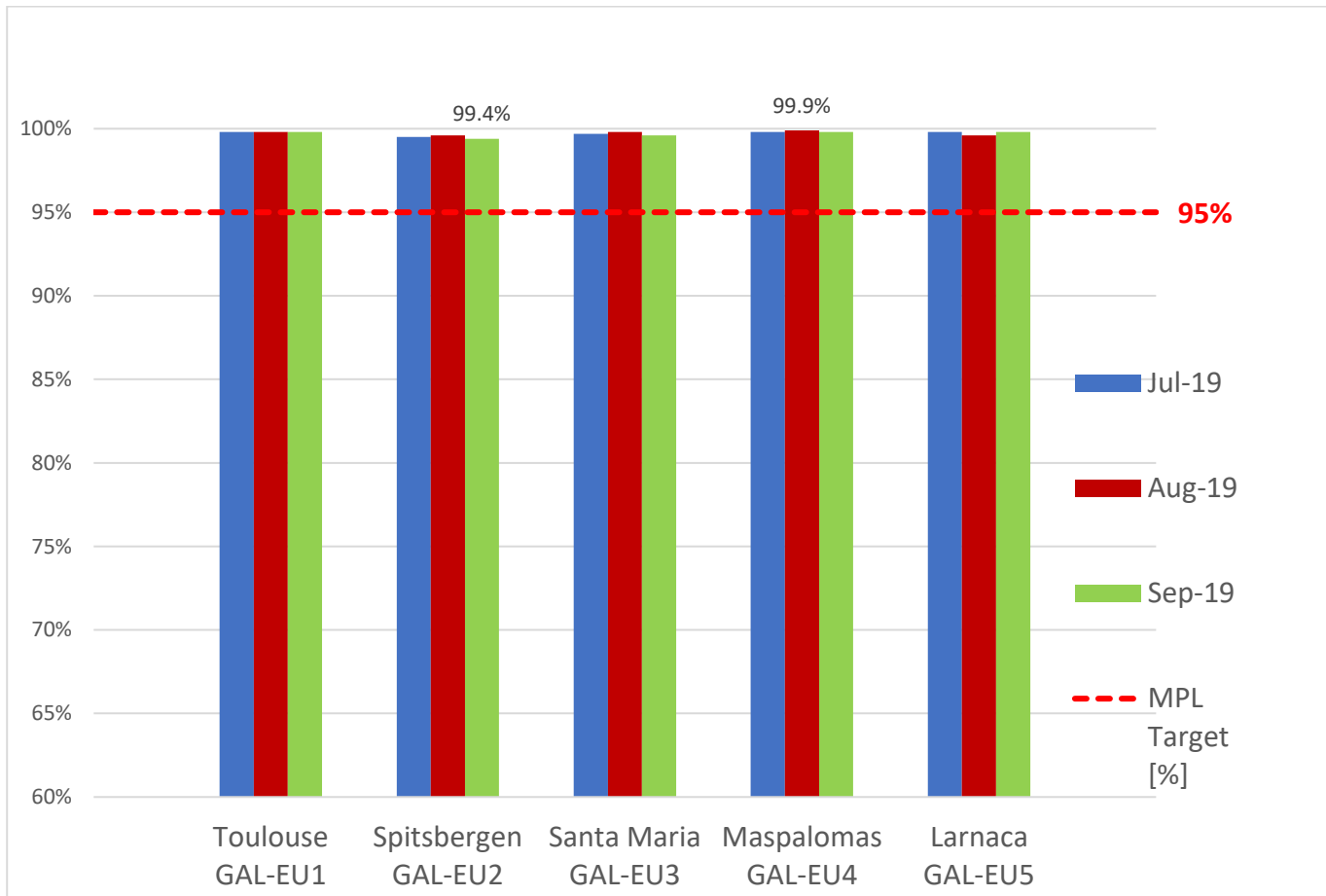


Figure 5: Per Reference Beacon Probability of 5km Accuracy in Multi-Burst [%]

Compliance with the multi-burst location accuracy within 2km [SAR-SDD] MPL specified at 80%⁷, is also met during the reporting period as displayed in Figure 6. The performance achieved is always better than the MPL, with an average of **96.3%**, the best performing REFBE reaching **97.1%** and the worst one attaining **94.1%**.

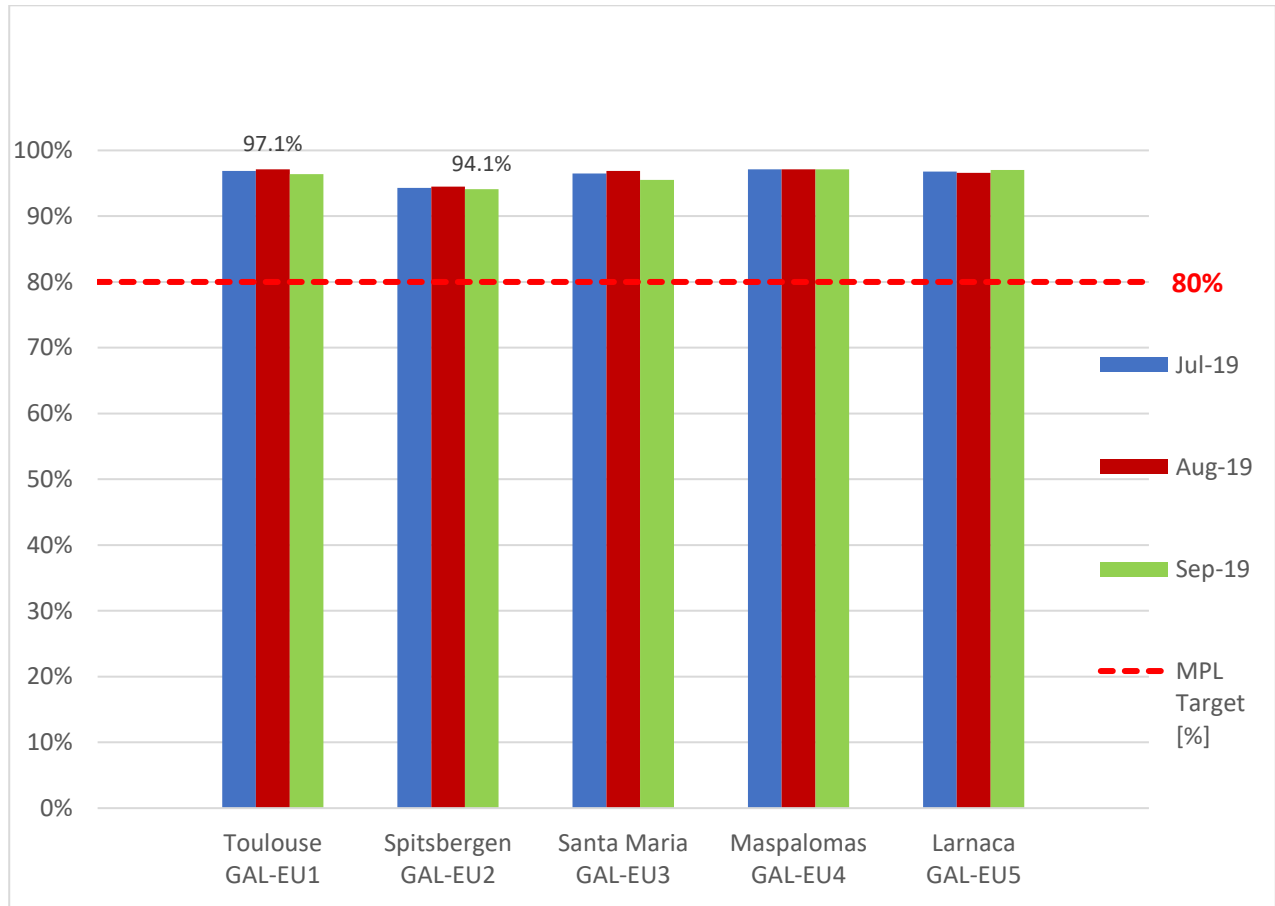


Figure 6: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst [%]

⁷ 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]⁸.

The MEOLUT Local Facility availability MPL is defined over a period of twelve months (long-term), with a sliding window moving one month ahead every month. Nevertheless, in Figure 7 and Figure 8 below, the MEOLUT Local Facility monthly availability (short-term) figures are also reported, showing the performance trend over time.

During the reporting period, all EU MEOLUT Local Facilities show a long-term normalised “Nominal” mode availability performance compliant with the MPL target specified at 95%, achieving in September 2019 values of respectively **97.8%**, **99.0%** and **99.1%** for Larnaca, Maspalomas and Spitsbergen EU MEOLUT Facilities.

⁸ Ref.: [SAR-SDD], §5.2.2 (Table 13, Table 14 and Table 15)

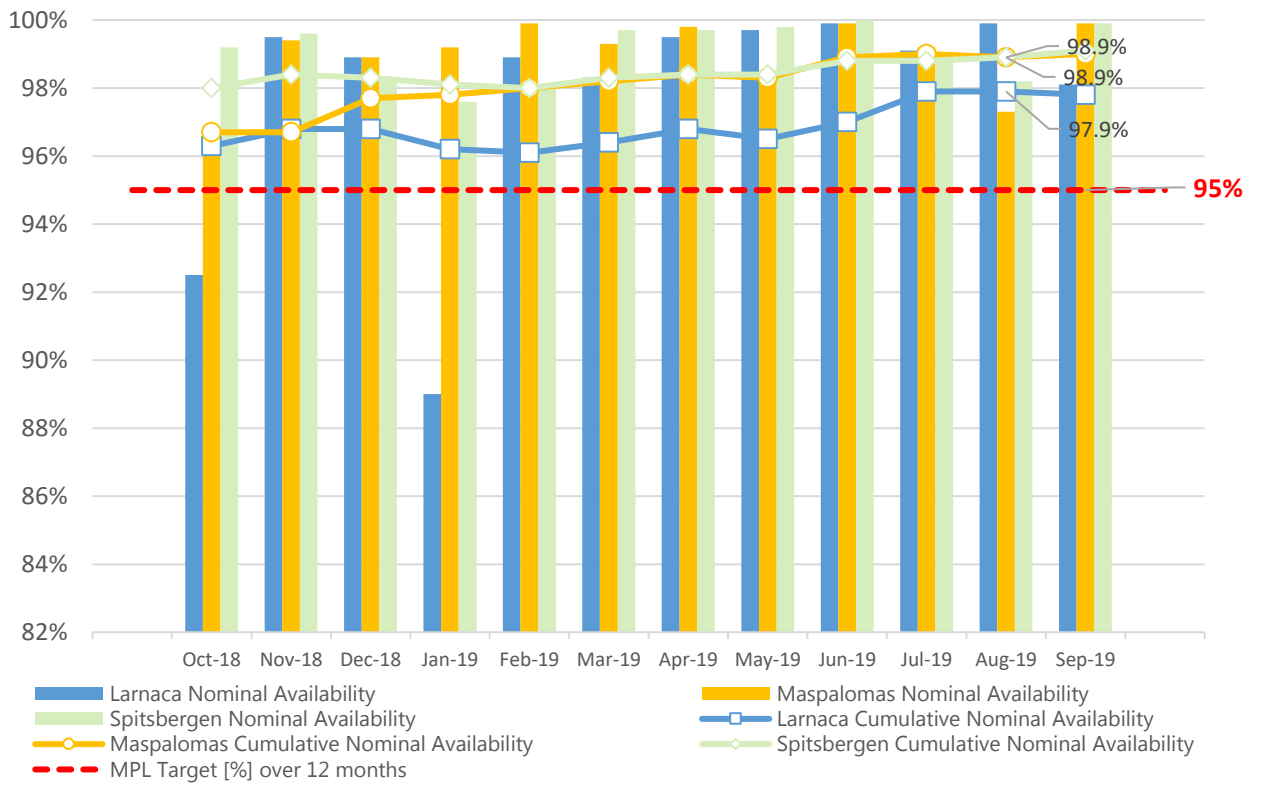


Figure 7: Per MEOLUT Facility Monthly Availability of Nominal Mode [%]

The “Nominal + Degraded” availability mode is reported in Figure 8 below with annually normalised values obtained per European MEOLUT Facility during the last twelve months of service, with an MPL target specified at 97.5%. The cumulative values always exceed the MPL for all the three European MEOLUT Facilities during the reporting period with Larnaca, Maspalomas and Spitsbergen reaching respectively **99.2%**, **99.5%** and **99.2%** in September 2019.

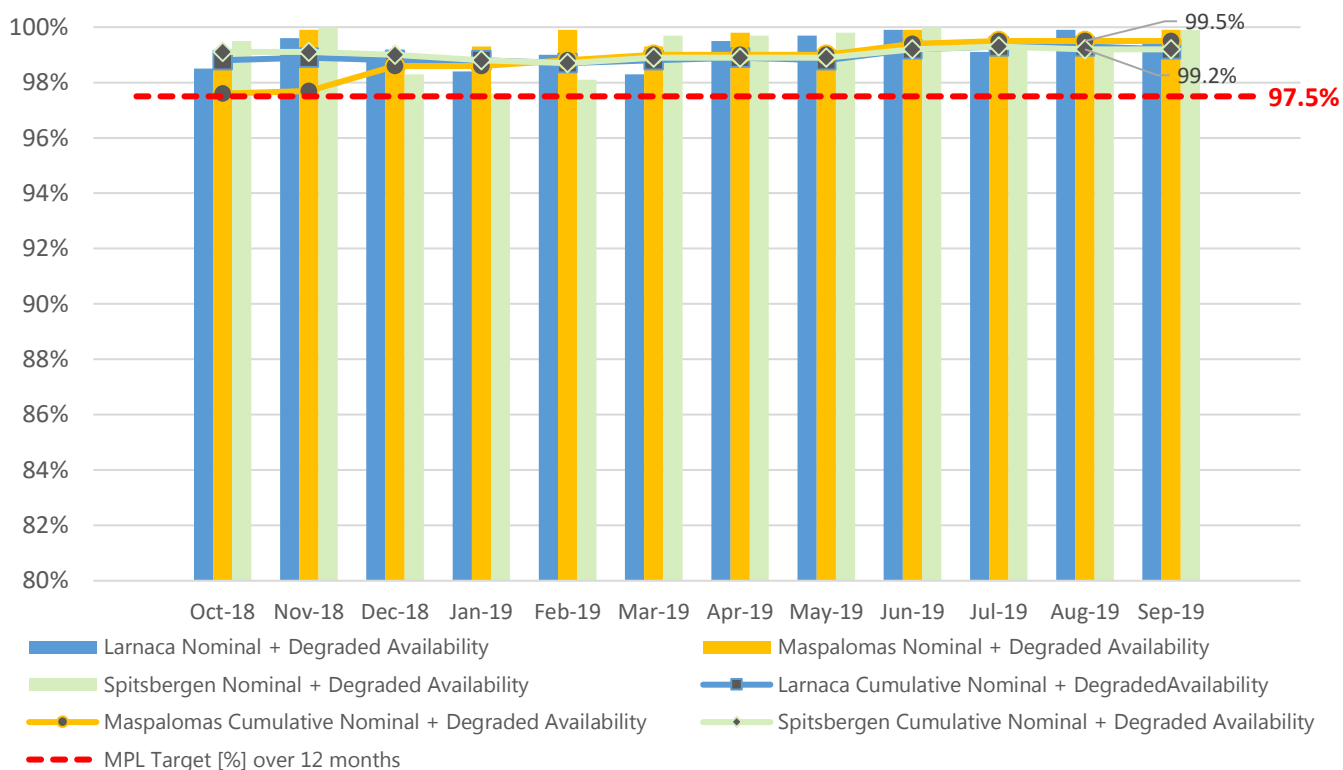


Figure 8: Per MEOLUT Facility Monthly Availability of "Nominal+Degraded" Mode [%]

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 Segment	SAR/Galileo Elements	Ground	Target Value (over 12 months)	July 2019	August 2019	September 2019
MTCF Availability			≥ 99.95%	74.29%	74.29%	74.77%
SARN Availability			≥ 99.40%	99.88%	99.88%	99.88%

Table 4: MTCF and SARN Cumulative Availability, July - September 2019

The MTCF cumulative availability does not achieve the required MPL target value, which is specified at 99.95% over a period of one year. The MTCF is considered not available when one or both of the functions needed for the TOA/FOA exchange process and the Tracking Plan computation are not available.

The interface misalignment affecting the MTCF TOA/FOA functionality was recovered on July 10th 2019, after which the MTCF availability trend recovered. It is recalled that this MTCF function is back-up for a capability already implemented by the EU MEOLUTs that operate nominally through the exchange of TOA/FOA measurements data from twelve coordinated antennas. Thus there was no impact on the SAR/Galileo Service performance reported in section 3.

4.2 AVAILABILITY OF THE SAR/GALILEO SPACE SEGMENT

All Galileo SAR transponders obtained an excellent availability performance of **100%**.

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, nevertheless the service achieved an average availability of 99.13% 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 5 below for information.

Other SAR/Galileo Ground Segment Elements	Target Value	July 2019	August 2019	September 2019
SAR/Galileo Orbit Data Server Availability	N/A	98.39%	100%	99.01%

Table 5: SAR/Galileo Orbit Data Server Monthly Availability, July – September 2019

5 REFERENCES

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

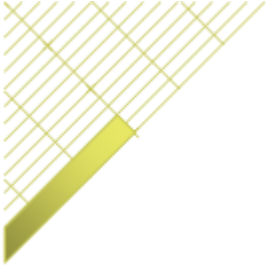
[SAR-SDD] *European GNSS (Galileo) SAR/GALILEO Initial Service Definition Document (SAR-SDD), Issue 1.0, European Union, December 2016.*

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

Acronym	Definition
SGC	SAR/Galileo Coverage
SGS	SAR/Galileo Ground Segment
SIS	Signal in Space
TOA	Time of Arrival



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