



EUROPEAN GNSS (GALILEO) INITIAL SERVICES

SAR/GALILEO Initial Service Quarterly Performance Report

January-February-March 2017



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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 January, February and March 2017. 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) as 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 sections.

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 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. 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
GSAT-0201	18	418	Ecc*	Available
GSAT-0202	14	414	Ecc*	Available
GSAT-0203	26	426	B08	Available
GSAT-0204	22	422	B03	Available
GSAT-0205	24	424	A08	Available
GSAT-0206	30	430	A05	Available
GSAT-0208	8	408	C07	Available
GSAT-0209	9	409	C02	Available
GSAT-0210	1	401	A02	Available
GSAT-0211	2	402	A06	Available

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

* Although the 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	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 (1/2)

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 on the Galileo Help Desk.

2 EXECUTIVE SUMMARY

During this first quarterly reporting period after declaration of Initial Services, the measured SAR/Galileo Initial Service performance figures generally exceed the Minimum Performance Level (MPL) targets specified in the [SAR-SDD] with significant margins. Nevertheless, several MPLs are not yet met. The following dashboards summarise the compliance with MPLs, using the colour coding defined in the legend below Table 3.

The detection and localisation performance KPIs are computed based on 5 reference beacons (REFBE) located on the SAR/Galileo Coverage (SGC) as defined in the [SAR-SDD].

SAR/GALILEO INITIAL SERVICE MPLs			Target Value	Jan-17	Feb-17	Mar-17	
Detection and Localisation Service	Probability	Valid Message Detection Probability after 1 burst	≥ 99%	Green	Green	Green	
		Location Probability after 1 transmitted burst	≥ 75%	Green	Green	Green	
		Location Probability after 12 transmitted bursts	≥ 98%	Green	Green	Green	
	Accuracy	Location accuracy after 1 transmitted burst within 5 km	≥ 70%	Green	Green	Green	
		Location accuracy after 12 transmitted bursts within 5km	≥ 95%	Green	Green	Green	
		Location accuracy after 12 transmitted bursts within 2km	≥ 80%	Green	Green	Green	
Infrastructure Availability	MEOLUT	Maspalomas/ EU MEOLUT Availability [over 12 months]	Nominal	≥ 95%	Orange	Green	Orange
			Nominal + Degraded	≥ 97.5%	Green	Green	Orange
		Spitzbergen/EU MEOLUT Availability [over 12 months]	Nominal	≥ 95%	Green	Green	Green
			Nominal + Degraded	≥ 97.5%	Green	Green	Orange
		Larnaca/EU MEOLUT Availability [over 12 months]	Nominal	≥ 95%	Green	Red	Red
			Nominal + Degraded	≥ 97.5%	Orange	Red	Red
Satellites	Average SAR Transponder Availability		≥ 90%	Green	Green	Green	

Table 3: MPL Fulfilment Status Dashboard

Allocation of Satellites in previous table

GSAT-0103	GSAT-0104	GSAT-0201	GSAT-0202
GSAT-0203	GSAT-0204	GSAT-0205	GSAT-0206
GSAT-0208	GSAT-0209	GSAT-0210	GSAT-0211

Legend

	MPL measurement not available
	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)
N/A	MPL available but evaluation N/A

The detection and localisation performance KPIs are computed based on 5 reference beacons (REFBE) located on the SAR/Galileo Coverage (SGC) defined in the [SAR-SDD].

Performance of the Detection and Location Service is provided for the Worst Reference Beacon Location for each of the individual performance parameters.

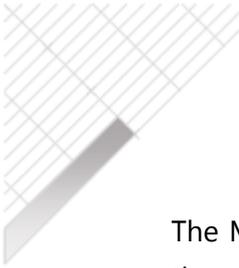
Performance of the Detection Service is above expectations, with monthly values of the detection probability of a single burst on the order of 99.5%, where the MPL is 99% for a "Valid" message.

Performance of Location Probability is above expectations, with monthly average values on the order of 95.5% for single burst location probability, where the MPL is 75%, and 99.6% for the multi-burst location probability, where the MPL is 98%.

The performance of Location Accuracy is also above expectations, with average monthly values on the order of 96.2% and 97.5% for the probability to locate with an accuracy of 5km respectively in single burst and multi-burst mode, while the MPLs are respectively 70% and 95%. Probability of location to within 2 km accuracy in multi-burst mode is on the order of 89.1%, while the MPL is 80%.

The availability performance of the SAR/Galileo Ground Segment provided in Table 3 provides information about the monthly trend of the MEOLUT availability. The Minimum Performance Levels for the MEOLUT availability are defined for a period of 12 continuous months. It is therefore not possible to report at this stage the exact compliance status with respect to this performance level and the colours in Table 3 are only provided to give an assessment of the monthly performance with regards to the annual threshold level.

The MEOLUTs of Maspalomas and Spitzbergen have shown good availability during the period January 2017-March 2017 with an average availability of respectively 92.6% and 97.6% in "Nominal" mode where the MPL is 95% (over 12 months) and of 98.8% and 98.2% in "Nominal + Degraded" mode where the MPL is 97.5% (over 12 months).



The MEOLUT of Larnaca experienced some performance degradation due to interference during the period February and March 2017, which led to a reduced availability of the MEOLUT during these months. The source of this interference has been investigated and was found to be in the uplink (protected) frequency band. Mitigation measures have been put into place. The average availability of Larnaca MEOLUT was 77.3% in "Nominal" mode and 78.6% in "Nominal + Degraded" mode while the respective MPLs are 95% and 97.5%.

Availability of the Search and Rescue Transponders was significantly above expectations during the period January 2017 – March 2017, as the measured availability for most cases was 100% while the MPL is 90%. As the single exception, satellite GSAT-0205 experienced some outage in March 2017 and reported an availability of 97% during that month, which is still comfortably within the specified MPL.

The Galileo Programme expects four additional SAR Transponders to be available for MEOSAR operations as of summer 2017. These satellites (GSAT-0207, 0212, 0213 and 0214) were launched on 17 November 2016 and are currently finalising their in-orbit test campaign.

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.
- ◇ Localization Probability in section 3.2
- ◇ Localization 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].

The following figure shows the monthly single burst detection probability for each of the SAR/Galileo Reference Beacons (REFBE).

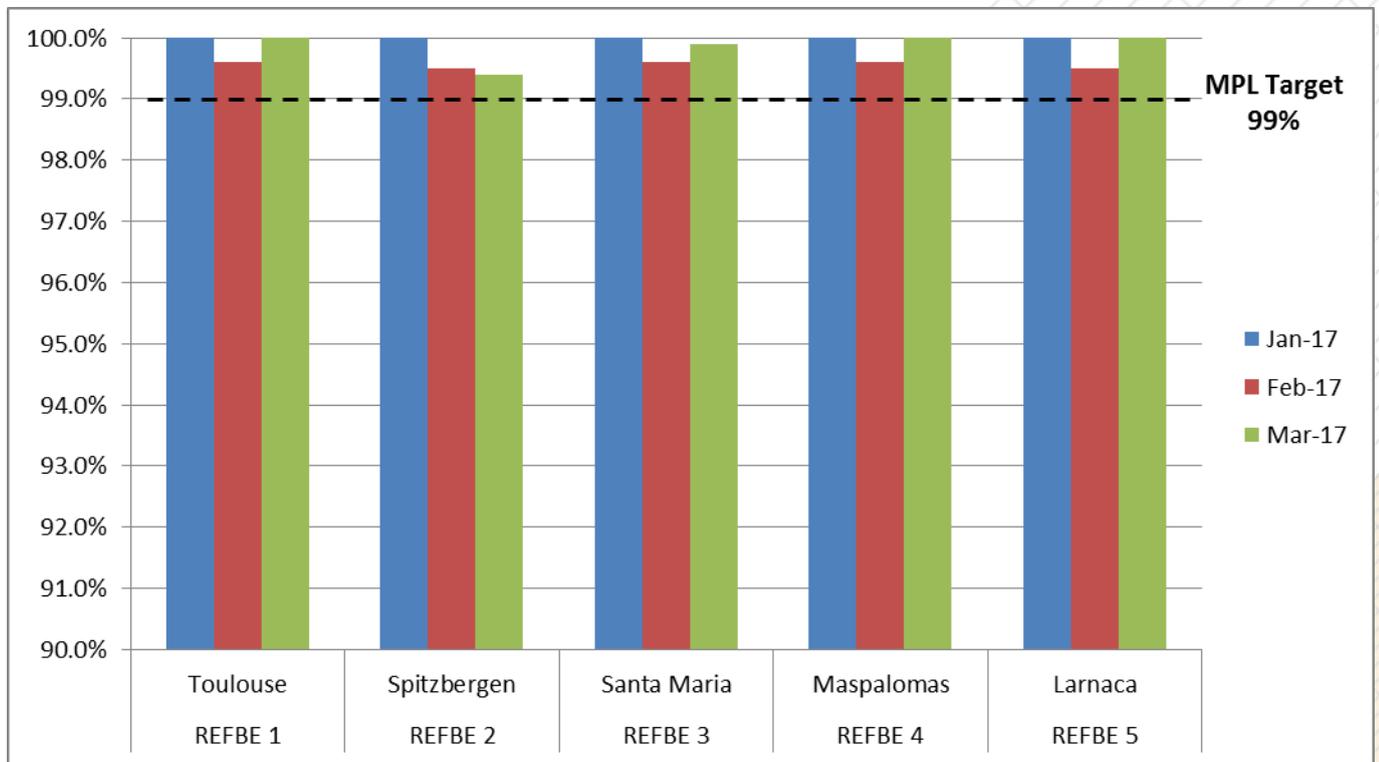


Figure 1: Per Reference Beacon Single Burst Detection Probability

The detection probability for each of the Reference Beacons is always above the Minimum Performance Level of 99% ¹.

3.2 LOCATION PROBABILITY

The location probability performance is computed for each Reference Beacon after 1 transmitted burst and after 12 transmitted bursts (multi-bursts). The detailed computation process for this performance parameter is described in the [SAR-SDD]. The Minimum Performance Levels defined in the [SAR-SDD] are valid when the MEOLUT is in nominal mode.

The following figure shows the monthly single burst location probability for each of the SAR/Galileo Reference Beacons. The single burst location probability for each of the Reference Beacons is always above the Minimum Performance Level from [SAR-SDD], specified as 75% ².

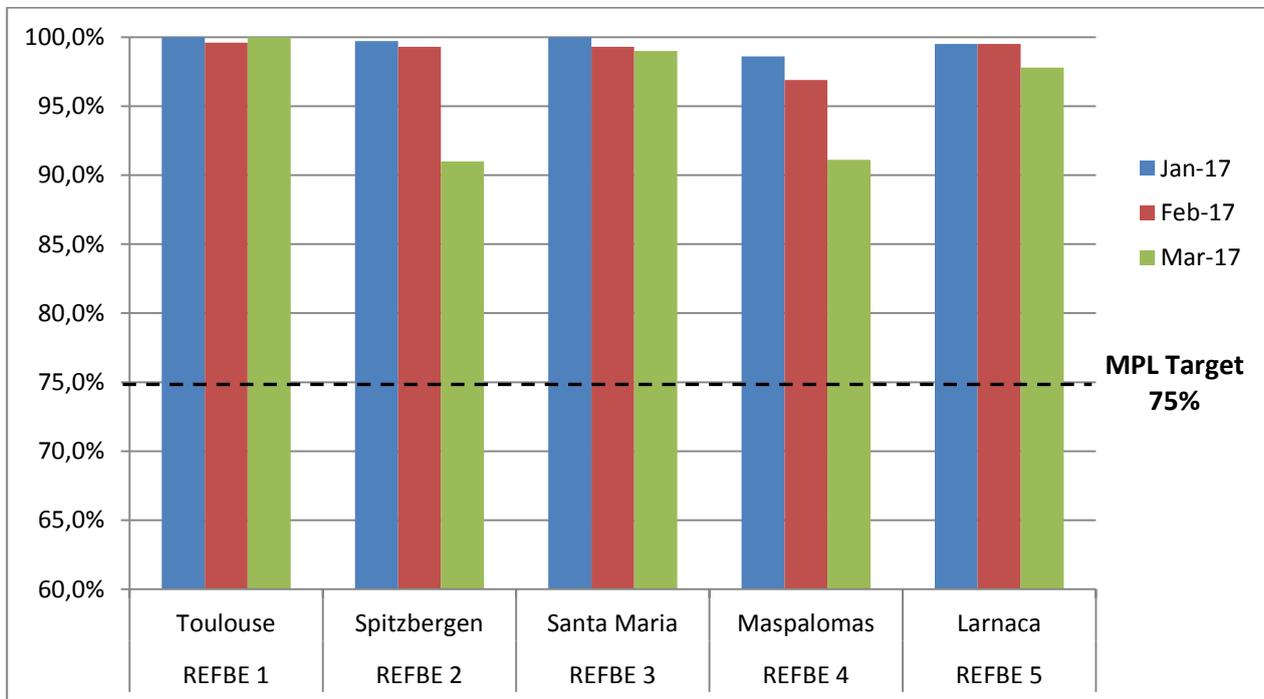


Figure 2: Per Reference Beacon Single Burst Location Probability

¹ Ref.: [SAR-SDD] , §5.1.1 (Table 9)

² Ref.: [SAR-SDD] , §5.1.1 (Table 10)

The following figure shows the monthly multi-burst (12 bursts – 10 minutes) location probability for each of the SAR/Galileo Reference Beacons. The multi-burst location probability for each of the Reference Beacons is always above the Minimum Performance Level from [SAR-SDD], specified as 98%³.

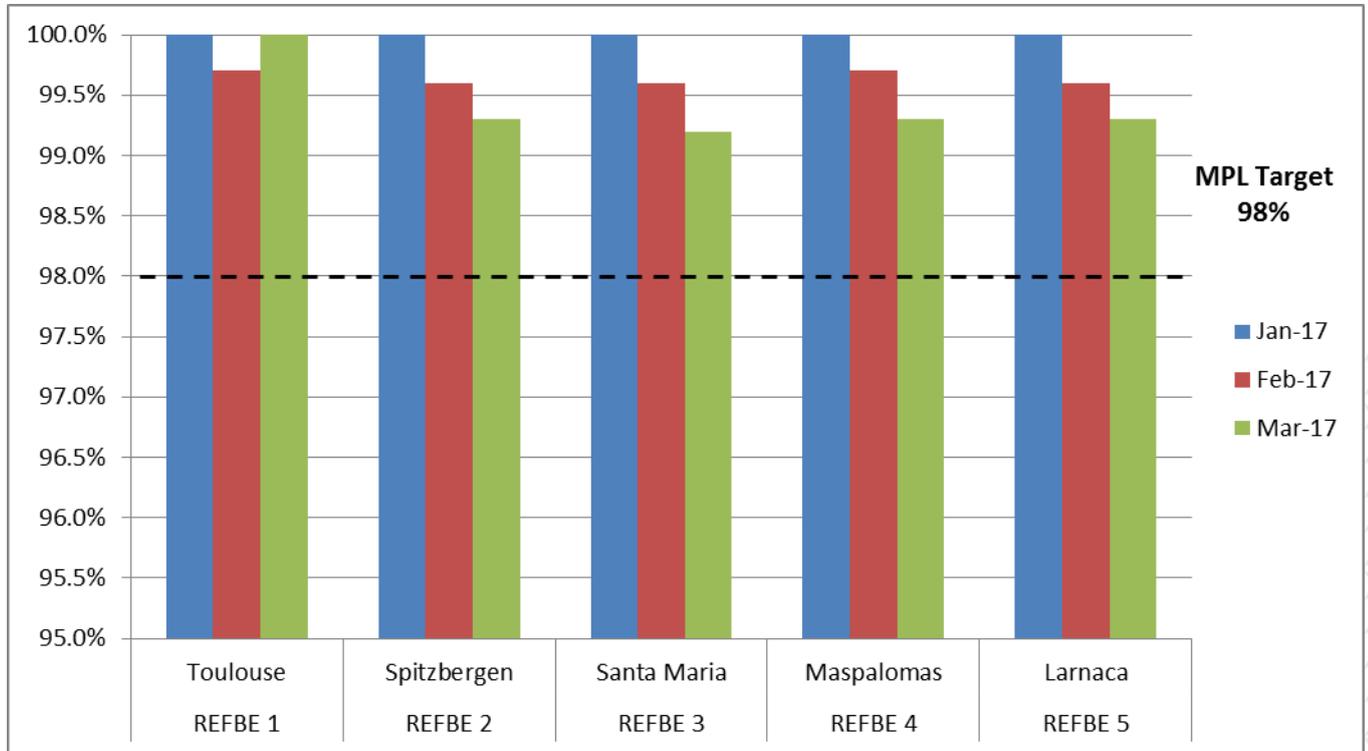


Figure 3: Per Reference Beacon Multi-Burst Location Probability (10 min).

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 Reference Beacon after 1 transmitted burst and after 12 transmitted bursts (multi-bursts) for the 5 km threshold and in multi-bursts only for the 2km threshold. The detailed computation process for this performance parameter is described in the [SAR-SDD]. The Minimum Performance Levels defined in the [SAR-SDD] are valid when the MEOLUT is in nominal mode.

It should be noted that no performance value could be provided for the Spitzbergen beacon over this reporting period due to recurring frequency instability of this beacon, leading to deteriorated accuracy values that are not representative of the actual service performance.

The following figure shows the monthly probability of achieving a location with 5 km accuracy with a single burst from each of the SAR/Galileo Reference Beacons (with the exception of the Spitzbergen Reference Beacon). The probability of achieving 5km accuracy in single burst location

³ Ref.: [SAR-SDD] , §5.1.1 (Table 10)

for each of the Reference Beacons is always above the Minimum Performance Level from [SAR-SDD], specified as 75% ⁴.

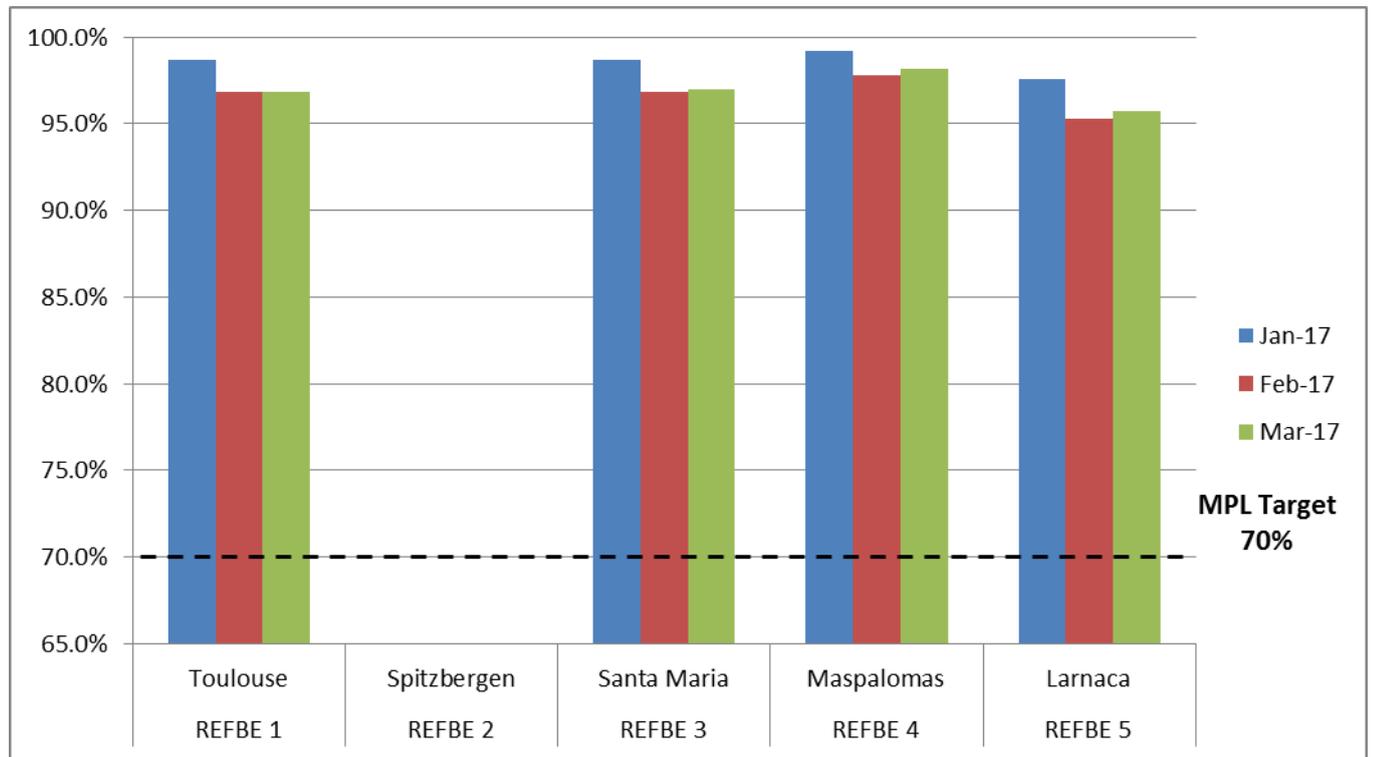


Figure 4: Per Reference Beacon Probability of 5km Accuracy in Single Burst

The following figure shows the monthly probability of achieving a location with 5 km accuracy in multi-burst mode (12 bursts – 10 minutes) for each of the SAR/Galileo Reference Beacons (with the exception of the Spitzbergen Reference Beacon). The probability of achieving 5km accuracy in multi-burst location for each of the Reference Beacons is always above the Minimum Performance Level from [SAR-SDD], specified as 95% ⁵.

⁴ Ref.: [SAR-SDD] , §5.1.1 (Table 10)

⁵ Ref.: [SAR-SDD] , §5.1.1 (Table 10)

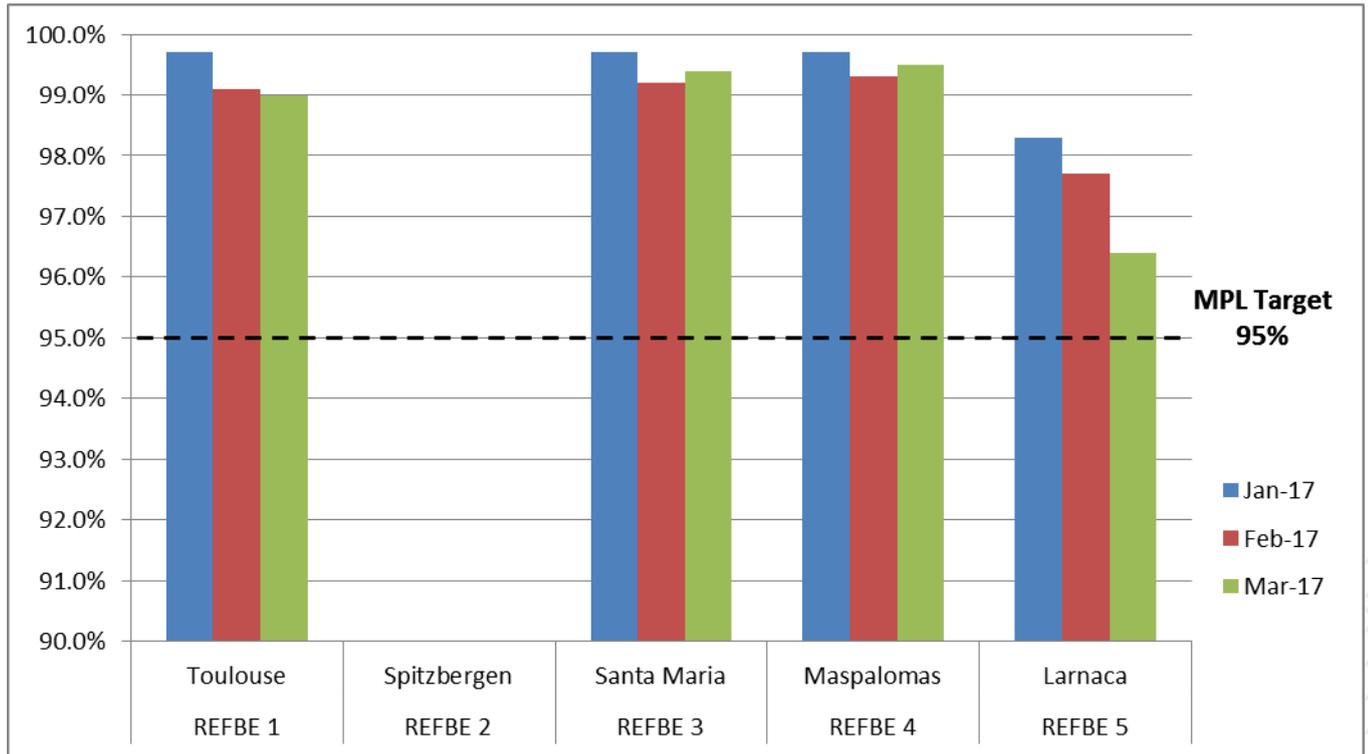


Figure 5: Per Reference Beacon Probability of 5km Accuracy in Multi-Burst

The following figure shows the monthly probability of achieving a location with 2 km accuracy in multi-burst mode (12 bursts – 10 minutes) for each of the SAR/Galileo Reference Beacons (with the exception of the Spitzbergen Reference Beacon). The probability of achieving 2km accuracy in multi-burst location for each of the Reference Beacons is always above the Minimum Performance Level from [SAR-SDD], specified as 80% ⁶.

⁶ Ref.: [SAR-SDD] , §5.1.1 (Table 10)

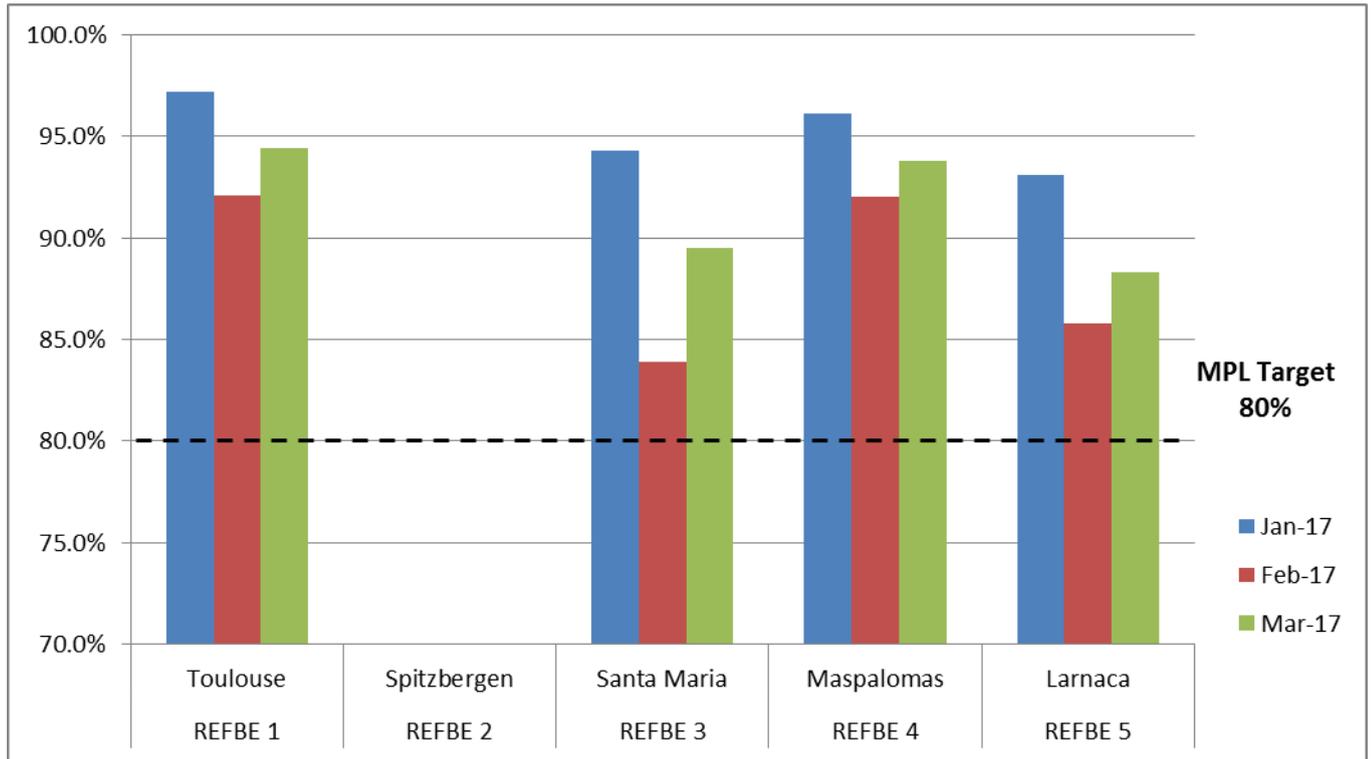


Figure 6: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst

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

Minimum Performance Levels for the availability of the SAR/Galileo Ground Segment Infrastructure are defined in the [SAR-SDD]⁷

The MEOLUT Local Facility availability Minimum Performance Level is defined over a period of 12 months, with a sliding window moving one month ahead every month. At this point in time, key performance indicators can only be reported over a first period of three months. In the figures below, the performance levels are reported for each month in order to assess the overall trend of performance over time.

As indicated in Section 2, the Larnaca MEOLUT Local Facility suffered some degradation due to uplink interference during the months of February 2017 – March 2017. The situation was recovered during the month of April 2017.

The figure below presents the availability of each of the MEOLUT Local Facilities in nominal mode during the months January – March 2017. The Maspalomas and Spitzbergen MEOLUT Local Facilities show monthly availability in nominal mode close to or above the Minimum Performance Level, with an average availability over three months of 92.6% and 97.6% respectively while the MPL is defined at 95%.

⁷ Ref.: [SAR-SDD] , §5.2.2 (Table 13, Table 14 and Table 15)

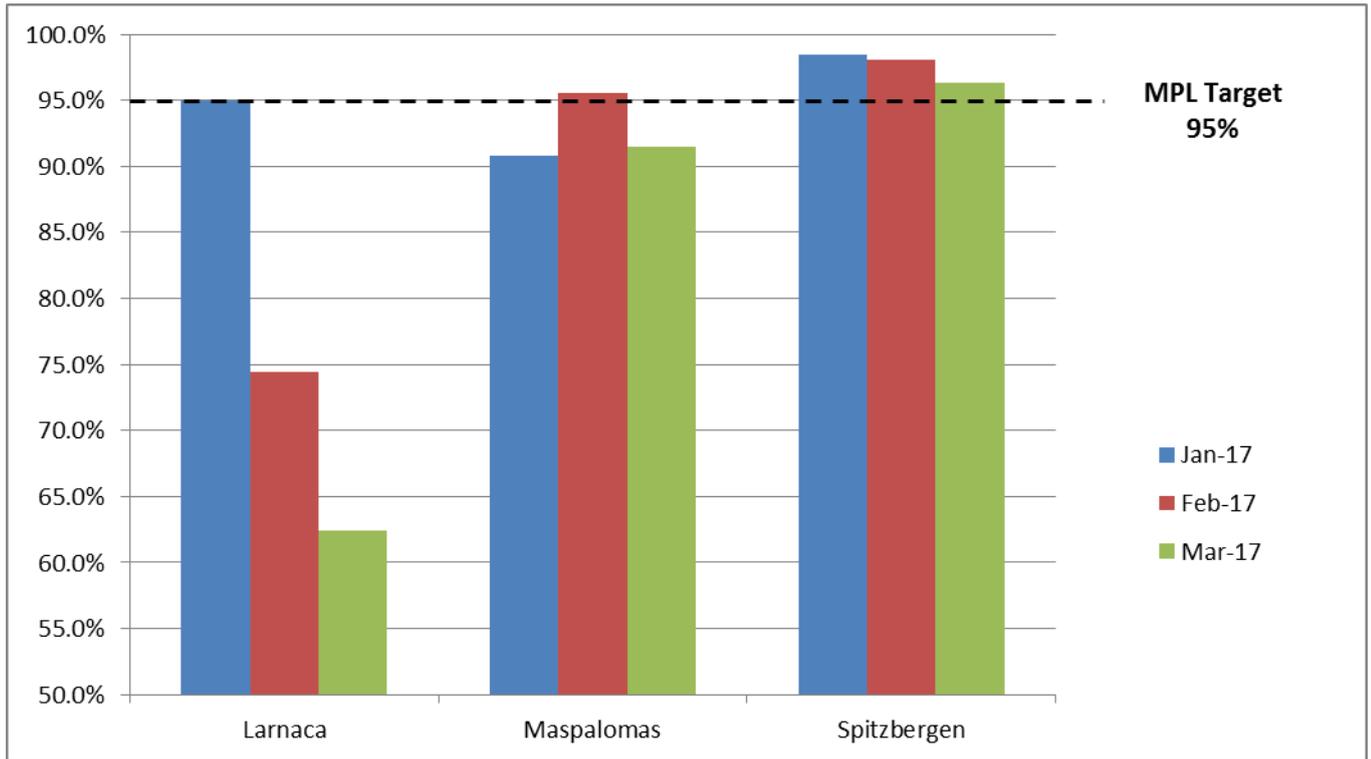


Figure 7: Per MEOLUT Availability of Nominal Mode over the reporting period

The figure below presents the availability of each of the MEOLUT Local Facilities in "Nominal+ Degraded" mode during the months January – March 2017. The Maspalomas and Spitzbergen MEOLUT Local Facilities show monthly availability in "Nominal + Degraded" Mode close to or above the Minimum Performance Level, with an average availability over three months of 98.7% and 98.2% respectively while the MPL is defined at 97.5%.

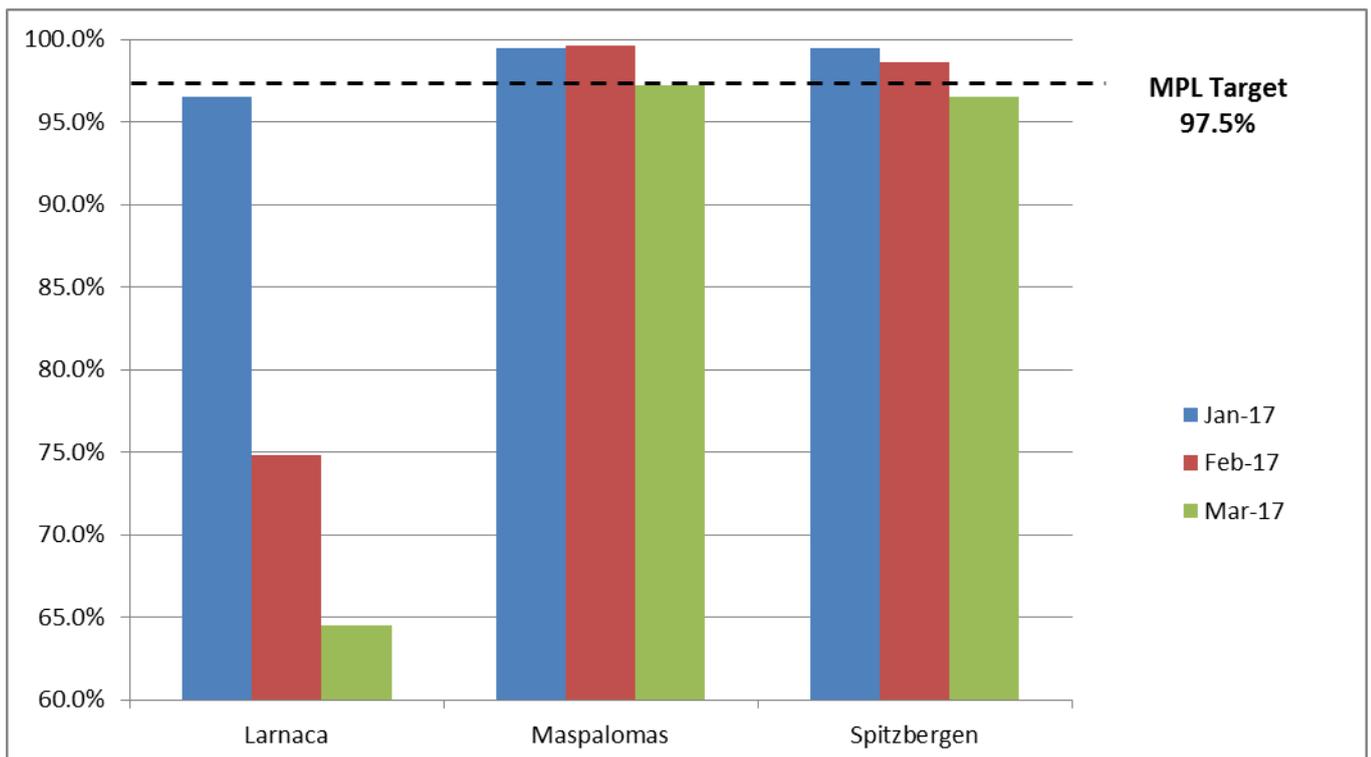


Figure 8: Per MEOLUT Availability of "Nominal + Degraded" Mode over the reporting period

The MEOLUT Tracking Coordination Facility (MTCF) and SAR Network (SARN) availability during the period January – March 2017 is provided in the Table 1. The availability Minimum Performance Level for these elements is defined over a period of 12 months, with a sliding window moving one month ahead every month. At this point in time, key performance indicators can only be reported over a first period of three months. In the Table below, the performance levels are reported for each month in order to assess the overall trend of the performance over time.

The average availabilities over the first three months are:

- 99.7% for the MTCF availability which is slightly below the MPL of 99.9%
- 99.8% for the SARN availability which is above the MPL of 99.4%

Other SAR Ground Segment Components	Target Value	Jan-17	Feb-17	Mar-17
MTCF Availability [12 months]	≥ 99.9%	100%	99.7%	99.3%
SARN Availability [12 months] Worst Case Connection	≥ 99.4%	100%	≥ 99.6%	≥ 99.0%

Table 1: MTCF and SARN Availability over January – March 2017

4.2 AVAILABILITY OF THE SAR/GALILEO SPACE SEGMENT

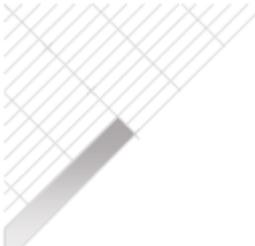
During the period of January – March 2017, all SAR Transponders achieved an availability of 100% each month, with the exception of the transponder GSAT0205 (C/S ID 424) for which the availability dropped to 87.5% during the month of March 2017 following a general payload outage on the satellite, announced by NAGU NUMBER: 2017007 on the GSC website.

4.3 AVAILABILITY OF THE SAR/GALILEO SERVER

During the period January – March 2017, the SAR/Galileo server located in the GSA headquarters has calculated orbital data of the SAR satellites. There is currently no commitment from the Galileo Programme on the Minimum Performance Level for the availability of this SAR/Galileo server. However, this server service has been provided with a high average availability during the period January – March 2017 of 99.3%. For information, monthly availability for this server is shown in the table below.

	Target Value	Jan-17	Feb-17	Mar-17
SAR/Galileo Orbit Data Server Availability	N/A	100%	97.91%	100%

Table 2: SAR/Galileo Orbit Data Server Availability January – March 2017



5 REFERENCES

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

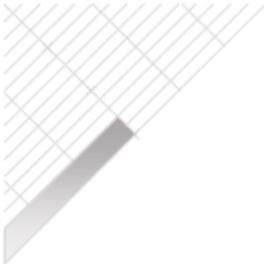
[SAR-SDD] European GNSS (Galileo) SAR/GALILEO Initial Service Definition Document (SAR-SDD), Issue 1.0, European Union, December 2016.

Previous documents are made available to users through the web portal of the European GNSS Service Centre (<http://www.gsc-europa.eu/>).

For an exhaustive description about Minimum Performance Levels (MPLs), the reader is referred to the [SAR-SDD], Section 5.

6 LIST OF ACRONYMS

Acronym	Definition
C/S	Cospas-Sarsat
GSC	European GNSS Service Centre
IS	(Galileo) Initial Services
MEOLUT	Medium Earth Orbit Local User Terminal
MPL	Minimum Performance Level
MTCF	MEOLUT Tracking Coordination Facility
NAGU	Notice Advisory to Galileo Users
REFBE	Reference Beacon
SARN	SAR Network
SDD	Service Definition Document
SGC	SAR/Galileo Coverage



End of Document

