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EUROPEAN GNSS (GALILEO)

SAR SERVICE

QUARTERLY PERFORMANCE REPORT

JANUARY – MARCH 2020



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1 INTRODUCTION

This document is the first edition of the *Galileo Enhanced Service Search and Rescue Service (SAR/GALILEO) Public Performance Report* for the period of January, February and March 2020. Following the declaration of the SAR/Galileo Enhanced Services in January 2020, issue 2.0 of [SAR-SDD] was published, which:

- Defines new MPLs:
 - o SAR/Galileo Forward Link Service (FLS) Availability with target **99%**;
 - o SAR/Galileo Return Link Service (RLS) Availability with target **95%**;
 - o Galileo System Return Link Message (RLM) Delivery latency < 15 [min] with target **99%**;
 - o Galileo System Return Link Message (RLM) Reception Probability, with target **99%**;
- removes MPLs formerly reported:
 - o Location Accuracy within 2 [km], with Multiple Burst, reported now as a metric;
 - o MTCF Element Availability;
 - o SARN Availability;
- sets new performance targets for existing MPLs:
 - o Location Probability with Single Burst with new target **90%** (previously 75%);
 - o Location Accuracy within 5 [km], with Single Burst with new target **90%** (previously 70%).
 - o Availability of the SAR Transponders with new target **95%** (previously 90%).

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

- ◇ Forward Link Service, Detection and Location Performance;
- ◇ Return Link Service, RLM Delivery Latency and Reception Probability Performance;
- ◇ European MEOLUT and Space Segment 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 Forward Link Service.

Section 4: Provides the detailed performance of the SAR/Galileo Return Link Service.

Section 5: Provides the detailed performance for the SAR/Galileo Space Segment infrastructure availability.

Section 6: Provides supplementary performance metrics of interest, not subject to MPL.

Section 7: The cited reference documents are listed.

Table 1 provides the status of the relevant SAR/Galileo space constellation, 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-0204	22	422	B03	Under Testing ³
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 FLS 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 Services

³ Galileo satellite GSAT-0204 SART was Operational from 03/03 for monitoring purposes, until further notice.

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 Incident)
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 reported period, the measured SAR/Galileo Service performance figures exceeded the Minimum Performance Level (MPL) targets specified in the [SAR-SDD] with significant margins except for the SAR transponder availability for GSAT0214 and GSAT0103 during February and March respectively.

The following dashboards (Table 3a, Table 3b) summarise the compliance with the MPLs, using the colour coding defined in the subsequent legend.

SAR MPLs		Target Value	Element	Jan-20	Feb-20	Mar-20	
Service	Detection (Probability)	Valid	>99%	GAL-EU1 - Toulouse			
				GAL-EU2 - Spitsbergen			
				GAL-EU3 - Santa Maria			
				GAL-EU4 - Maspalomas			
				GAL-EU5 - Larnaca			
	Localization (Quality)	5 km [1-12 B]	>95%	GAL-EU1 - Toulouse			
				GAL-EU2 - Spitsbergen			
				GAL-EU3 - Santa Maria			
				GAL-EU4 - Maspalomas			
				GAL-EU5 - Larnaca			
		5 km [SB]	>90%	GAL-EU1 - Toulouse			
				GAL-EU2 - Spitsbergen			
				GAL-EU3 - Santa Maria			
				GAL-EU4 - Maspalomas			
				GAL-EU5 - Larnaca			
		L.Prob [SB]	>90%	GAL-EU1 - Toulouse			
				GAL-EU2 - Spitsbergen			
				GAL-EU3 - Santa Maria			
				GAL-EU4 - Maspalomas			
				GAL-EU5 - Larnaca			
L.Prob.[1-12 B]	>98%	GAL-EU1 - Toulouse					
		GAL-EU2 - Spitsbergen					
		GAL-EU3 - Santa Maria					
		GAL-EU4 - Maspalomas					
		GAL-EU5 - Larnaca					
RLM Delivery	Latency ≤ 15 [min]	>99%	Worst case of all REFBEs				
RLM Reception	Probability	>99%	Worst cas of all REFBEs				

Table 3a: MPL Fulfilment Status Dashboard (Quality)

SAR MPLs		Target Value	Element	Jan-20	Feb-20	Mar-20	
SAR Transponder Availability	Per Satellite	>95%	GSAT-0103				
			GSAT-0104				
			GSAT-0201				
			GSAT-0202				
			GSAT-0203				
			GSAT-0205				
			GSAT-0206				
			GSAT-0207				
			GSAT-0208				
			GSAT-0209				
			GSAT-0210				
			GSAT-2011				
			GSAT-0212				
			GSAT-0213				
			GSAT-0214				
			GSAT-0215				
			GSAT-0216				
			GSAT-0217				
			GSAT-0218				
			GSAT-0219				
GSAT-0220							
GSAT-0221							
GSAT-0222							
SAR Ground Segment Availability	MEOLUT Status	Nominal	>95%				
			Larnaca				
			Maspalomas				
	MEOLUT Status	Nominal or Degraded	>97.5%	Larnaca			
				Maspalomas			
				Spitsbergen			
	Forward Link Service			>= 99%			
Return Link Service			>=95%				

Table 3b: MPL Fulfilment Status Dashboard (Availability)

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 SAR/Galileo Forward Link and Return Link Service MPLs are computed based on the five 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 REFBE location for each of the applicable individual performance parameters.

The **Availability of the SAR/Galileo Forward Link Service** was **99.9%** for the reported period, above the defined MPLs of 99%.

The **Availability 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 **99.3%** and **99.5%** respectively, always above the MPL targets of 95% in “Nominal” and 97.5% in “Nominal + Degraded” modes.

The **Performance of the Detection Service** is above expectations, with monthly values of a valid message detection probability after a single transmitted burst over **99.7%**, where the MPL target is 99%.

Excellent values are achieved for the **Performance of Location Probability**, with monthly values higher than **99.3%** for single burst, where the MPL target is 90%, and **99.7%** 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 **98.6%** for single burst and **99.1%** for multi-burst transmissions with an accuracy better than 5km, while the MPLs are 90% and 95% respectively.

The **Availability of the SAR/Galileo Return Link Service** was **100%** for the reported period with an MPL set to 95%.⁴

The **RLS Delivery Latency within 15 min** was **99.94%** in average over the reported period for an MPL set to 99%.

The **RLS Reception Probability** was **99.76%** in average over the reported period for an MPL set to 99%.

The **Availability of the SAR Transponders** achieved excellent levels of performance reaching satellite transponder monthly availability of **100%** for almost all space vehicles, except for GSAT-0214 in February, and for GSAT-0103 in March.

⁴ The interface between Cospas-Sarsat and Galileo RLS infrastructure was unavailable for the RLS 11/03/2020 between 12:30 UTC until 13:50 UTC.

3 SAR/GALILEO FORWARD LINK SERVICE PERFORMANCES

This section reports the following detailed performance figures for the SAR/Galileo Forward Link Service:

- ◇ Service availability in section 3.1;
- ◇ European MEOLUT facility availability in section 3.2;
- ◇ Detection Probability in section 3.3;
- ◇ Location Probability in section 3.4.1;
- ◇ Location Accuracy in section 3.4.2.

3.1 FORWARD LINK SERVICE AVAILABILITY

The MPL for the Forward Link Service availability is defined in the [SAR-SDD] ⁵.

The Forward Link Service availability MPL is defined over a period of twelve months (long-term), with a sliding window moving one month ahead every month. As there are not yet 12 months of data available, only the monthly availability is reported for now and until December 2020.

During the reported period, the monthly FLS availability was compliant with the MPL defined over 12 months.

SAR/Galileo FLS Availability	January 2020	February 2020	March 2020
MPL Target [99%]	99.9%	100%	100%

Table 4: Forward Link Service Monthly Availability, January – March 2020

3.2 EUROPEAN MEOLUT FACILITY AVAILABILITY

The MPLs for the availability of the SAR/Galileo European MEOLUT Facility are defined in the [SAR-SDD] ⁶ over a period of twelve months (long-term), with a sliding window moving one month ahead every month. However, Figure 1 and Figure 2 below, also report the EU MEOLUT Local Facility monthly availability (short-term) figures 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 March

⁵ Ref.: [SAR-SDD], §5.1.1 (Table 9)

⁶ Ref.: [SAR-SDD], §5.1.2 (Table 10)

2020 values of respectively **99.4%**, **99.4%** and **99.5%** for Larnaca, Maspalomas and Spitsbergen EU MEOLUT Facilities.

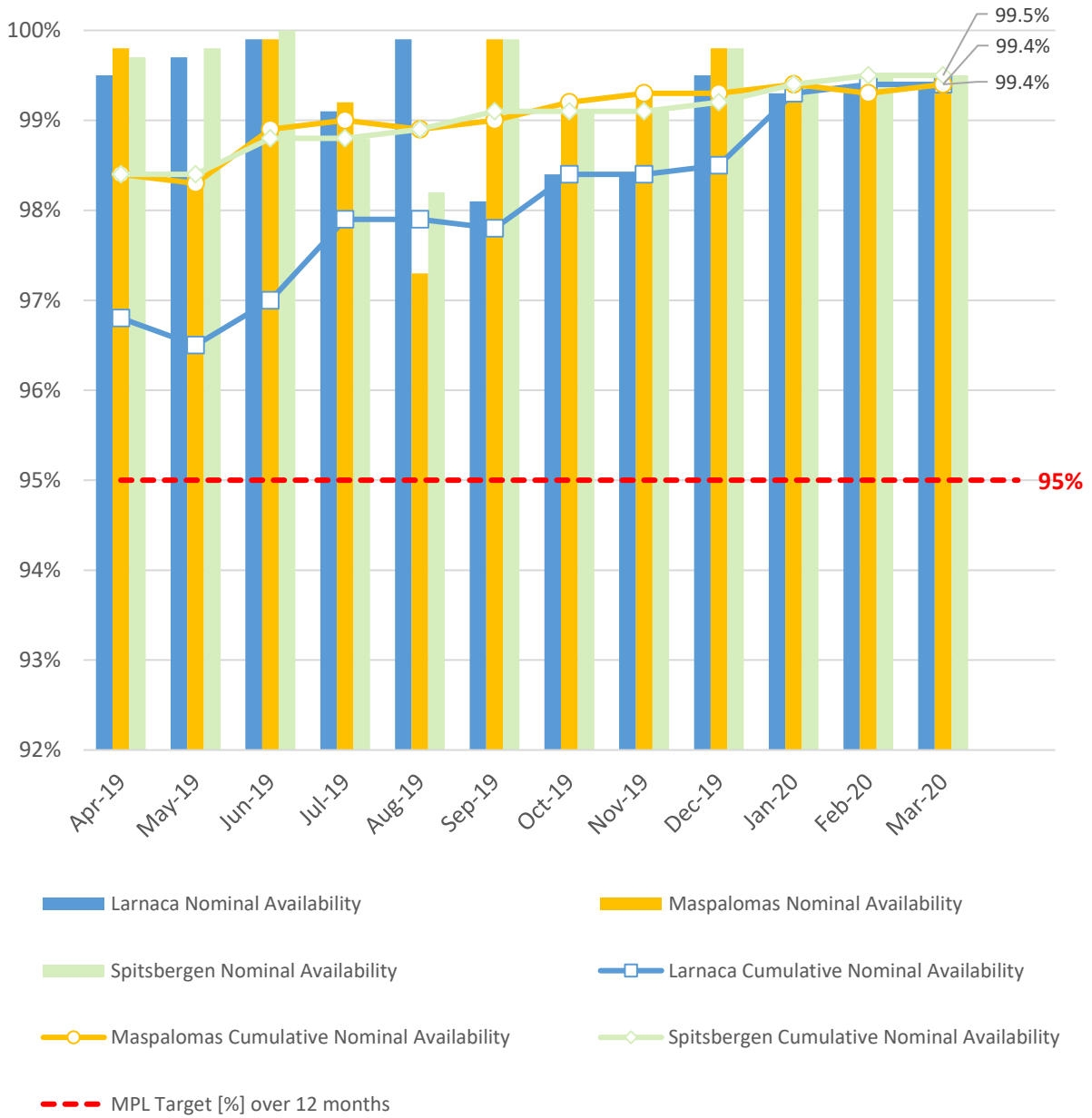


Figure 1: Per MEOLUT Facility Monthly Availability of Nominal Mode [%]

The "Nominal + Degraded" availability mode is reported in Figure 2 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 all 99.6% in March 2020.

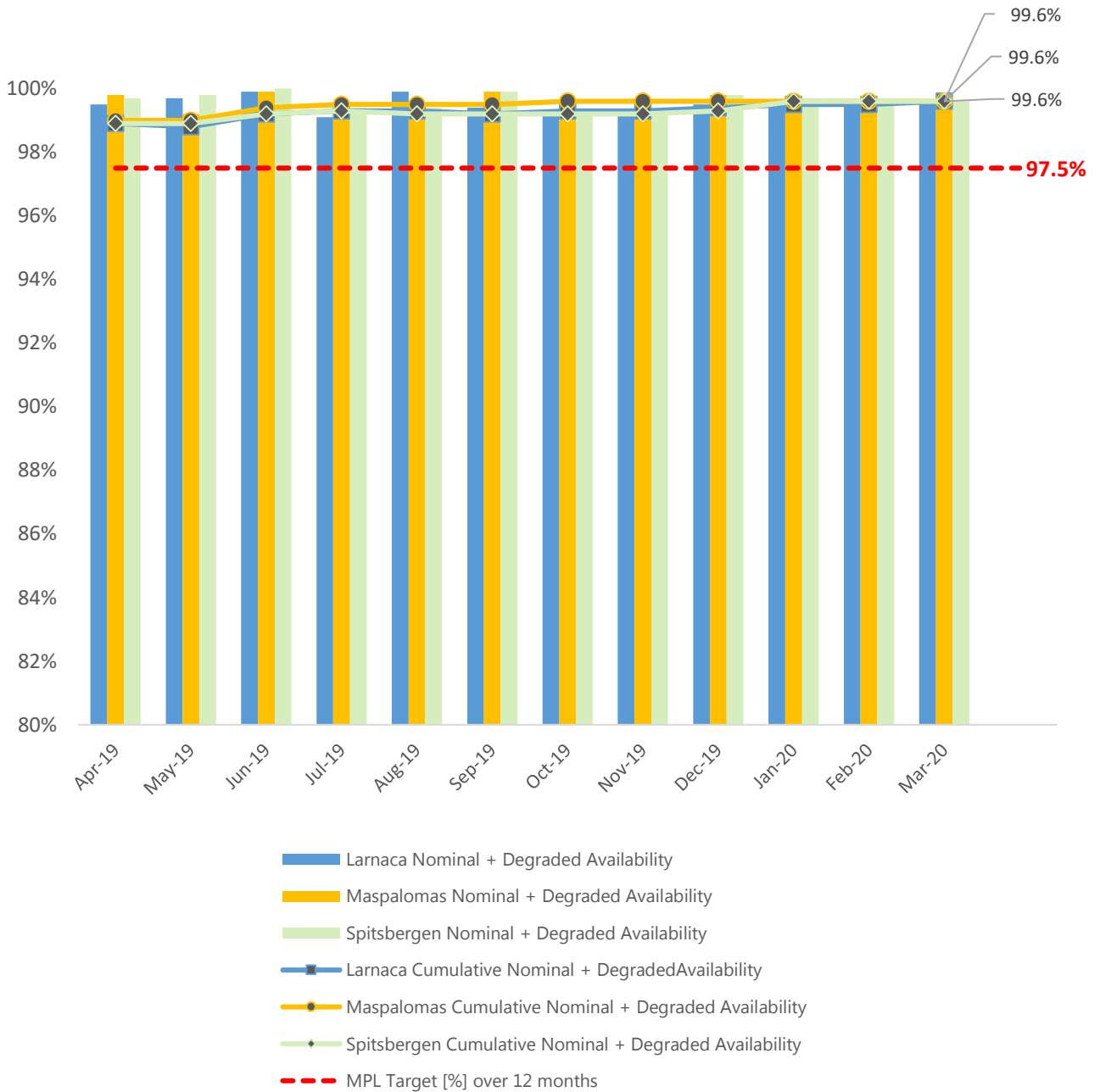


Figure 2: Per MEOLUT Facility Monthly Availability of "Nominal + Degraded" Mode [%]

3.3 DETECTION PERFORMANCES

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 MPLs specified at 99%⁷ is valid whether the SAR/Galileo MEOLUT Facilities are in Nominal or Degraded Mode. Figure 3 below shows the monthly valid message detection probability for each Reference Beacon, which generally achieved **100%** with the exception of the Larnaca reference beacon in January 2020, with **99.7%**.

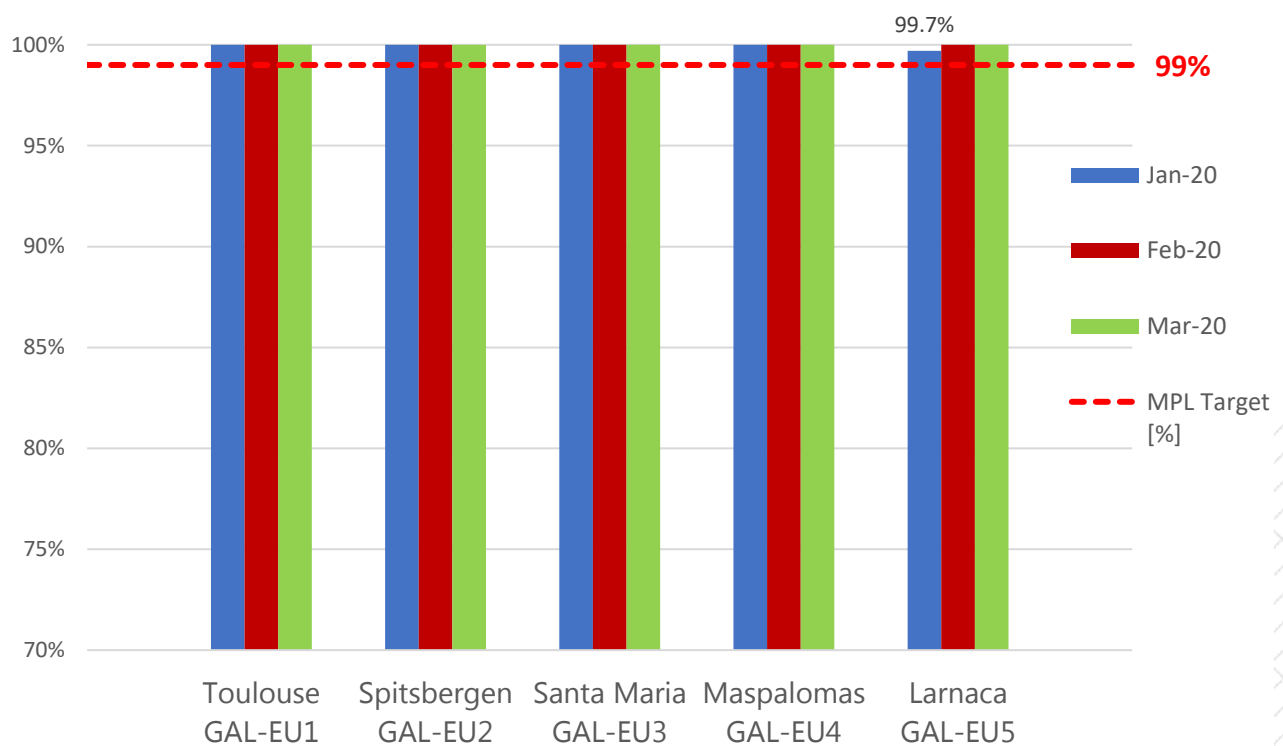


Figure 3: Per Reference Beacon Valid Message Detection Probability [%]

⁷ Ref.: [SAR-SDD], §5.1.3 (Table 11)

3.4 LOCATION PERFORMANCES

3.4.1 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] and the MPLs specified at 90%⁸ in single burst and 98% in multi-burst are valid when the SAR/Galileo MEOLUT Facilities are in Nominal Mode.

Figure 4 below shows the monthly single-burst location probability, which comfortably exceeds the defined MPL of 90% for each of the SAR/Galileo Reference Beacons, with a minimum value of **99.3%**, a best value of **100%** and an average over the reporting period of **99.87%**.

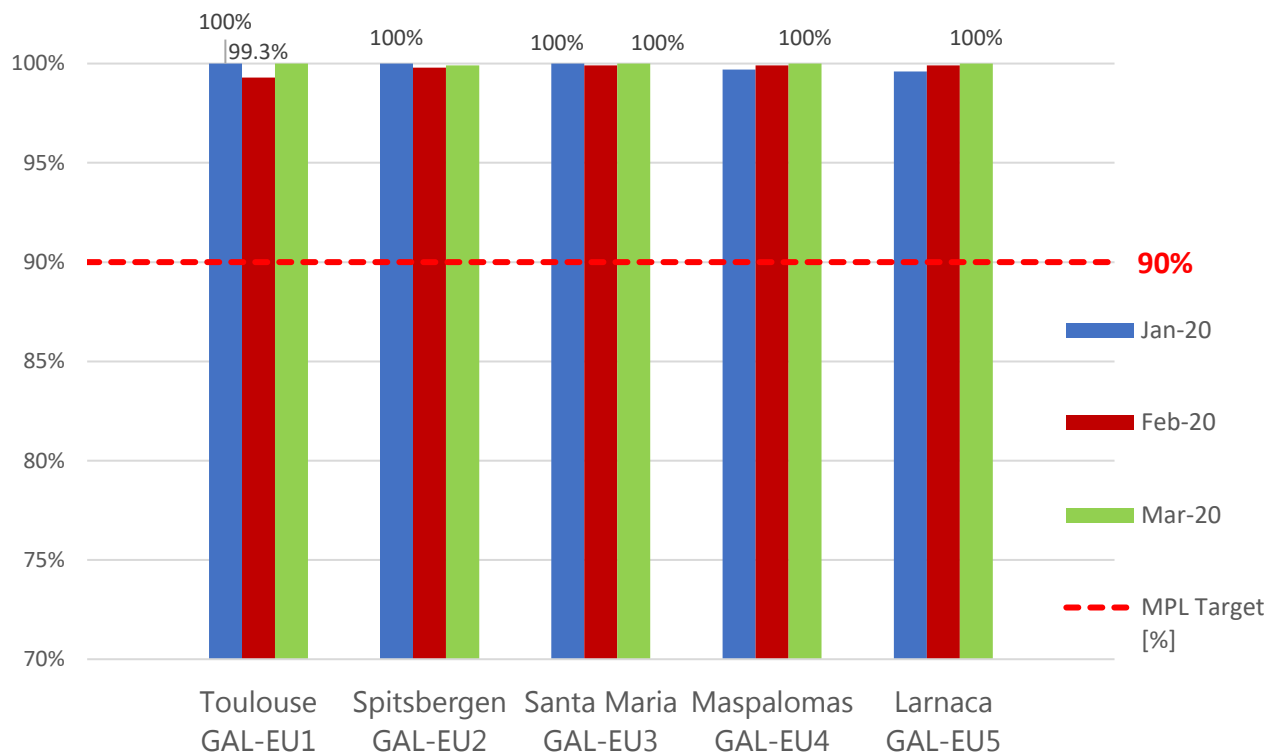


Figure 4: Per Reference Beacon Single Burst Location Probability [%]

⁸ Ref.: [SAR-SDD], §5.1.4 (Table 12)

The multi-burst location probability, displayed in Figure 5 below, is always **100%** for each of the REFBEs, except for the Larnaca REFBE in January when it was **99.7%**. and Toulouse REFBE in February being **99.9%**. However, performance is always exceeding the defined [SAR-SDD]⁶ MPL target of 98%.

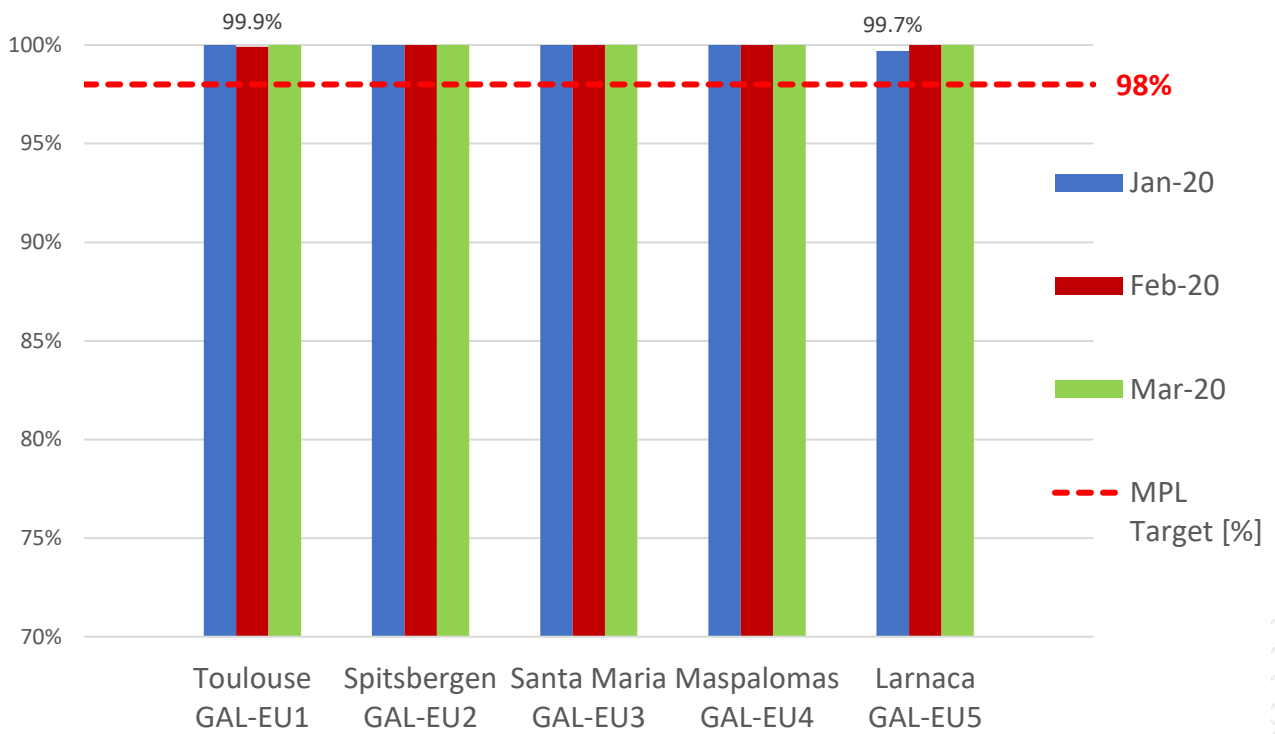


Figure 5: Per Reference Beacon Multi-Burst Location Probability [%]

3.4.2 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]⁹ are valid when the MEOLUT is in Nominal mode and the results are presented per Reference Beacon in Figure 6, Figure 7 for the 5km error in single-burst and multi-burst and in Figure 8 for the 2km threshold in multi-burst only (reported only as metric).

The single-burst 5km location accuracy depicted in Figure 6 shows compliance by all REFBE to the [SAR-SDD] MPL target of 90%, with average value of **99.3%**, the worst performing REFBE achieving **98.6%** and the best performing **99.9%**.

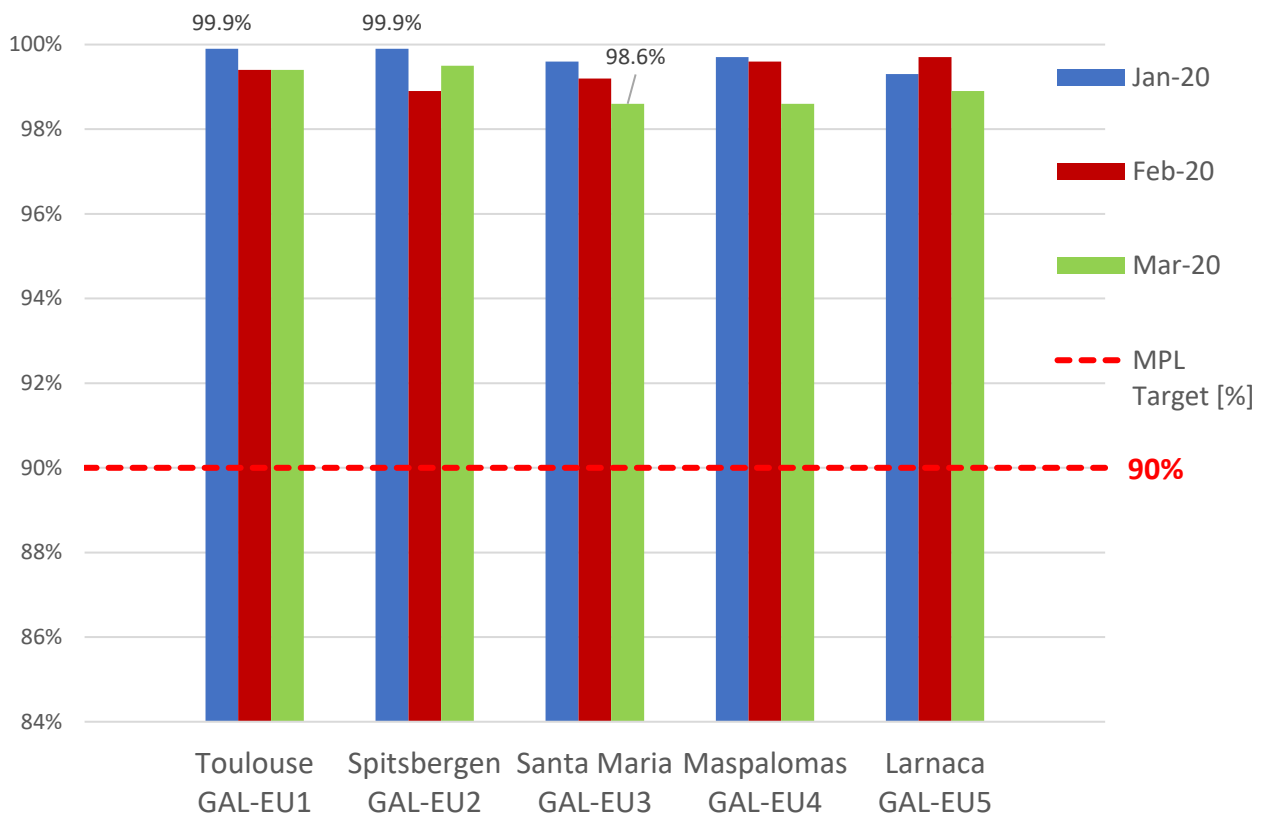


Figure 6: Per Reference Beacon Probability of 5km Accuracy in Single Burst [%]

⁹ Ref.: [SAR-SDD], §5.1.4 (Table 12)

The multi-burst location accuracy with 5km error, presented in Figure 7, achieved excellent levels of performance with average value for all REFBE of **99.8%** comfortably exceeding the [SAR-SDD] MPL specified as 95%. The worst performing REFBE achieved **99.1%** and the best **100%**.

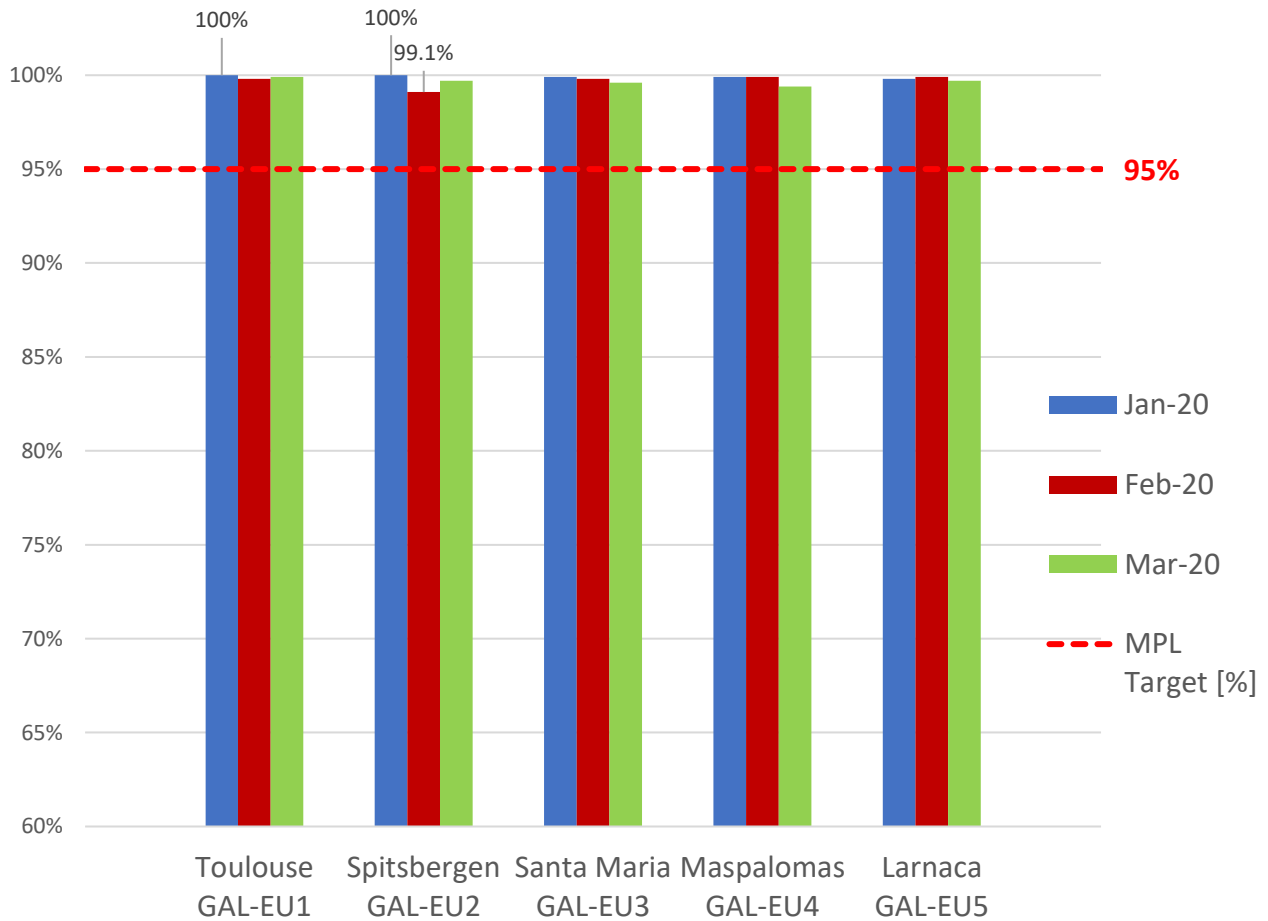


Figure 7: Per Reference Beacon Probability of 5km Accuracy in Multi-Burst [%]

4 RETURN LINK SERVICE PERFORMANCES

4.1 RETURN LINK SERVICE AVAILABILITY

The MPL for the Return Link Service availability is defined in the [SAR-SDD] ¹⁰.

The Return Link Service availability MPL is defined over a period of twelve months (long-term), with a sliding window moving one month ahead every month. As there are not yet 12 months of data available, the value is normalized over the period for which data are available, i.e. January MPL value reports January availability, February MPL value reports the average value for January and February and so on.

During the reported period, the monthly RLS availability was **100%** every month, and then the normalized values were 100% as well which would be compliant with the MPL defined over 12 months.

SAR/Galileo RLS Availability [%]	January 2020	February 2020	March 2020
MPL Target [99%]	100%	100%	100%

Table 5: Return Link Service Monthly Availability, January – March 2020

4.2 RLM DELIVERY LATENCY AND RECEPTION PROBABILITY

The Galileo System delivery latency and RLM Reception Probability MPLs always refer to the percentage of time that the RLS is available and are bounded by transmission of the Galileo Navigation Message in the SIS and the probability of an error free decoding of the RLM fields of the Galileo Navigation Message retrieved from the SIS at the GNSS receiver in, or connected to, the originating alert beacon.

4.2.1 DELIVERY LATENCY

The RLS delivery latency within 15 [min] performance is computed over a calendar month. The boundaries of the monitored loop are defined in the [SAR-SDD] and the MPLs specified at 90% ¹¹.

During the reported period, the monthly delivery latency was above the MPL with an average value of **99.94%**.

¹⁰ Ref.: [SAR-SDD], §5.2.1 (Table 14)

¹¹ Ref.: [SAR-SDD], §4.4 and §5.2.2 (Table 16)

SAR/Galileo RLS Delivery Latency within 15 min [%]	January 2020	February 2020	March 2020
MPL Target [99%]	99.84%	99.97%	99.70%

Table 6: Return Link Service Monthly Delivery Latency within 15 min, January – March 2020

4.2.2 RECEPTION PROBABILITY

The RLS reception probability performance is computed over a calendar month. The MLP defined in the [SAR-SDD] is set to 99% ¹¹.

During the reported period, the monthly reception probability was above the MPL with an average value of **99.76%**.

SAR/Galileo RLS Reception probability [%]	January 2020	February 2020	March 2020
MPL Target [99%]	99.42%	99.86%	100%

Table 7: Return Link Service Monthly Reception Probability, January – March 2020



5 SAR/GALILEO SPACE SEGMENT AVAILABILITY

The MPL defined in the [SAR-SDD] is set to 95% ¹² for every single SAR transponder (SART), to be annually normalised. All Galileo SARTs obtained an excellent availability performance of **100%** every month, exception made for two specific events:

- GSAT-0214 SAR Transponder availability was 88.07% in February 2020, due to an unexpected and autonomous change of on-board payload configuration;
- GSAT-0103 SAR Transponder availability was 52.35% in March 2020, due to an on-board anomaly, followed by maintenance.

¹² Ref.: [SAR-SDD], §5.3 (Table 18)

6 SUPPLEMENTARY METRICS

This section reports availability performance of elements of the SAR/Galileo Ground Segment that are not MPLs.

6.1 LOCATION ACCURACY PERFORMANCE WITHIN 2KM

Multi-burst location accuracy within 2km is no longer an MPL but an Expected value defined in the [SAR-SDD] at 90%¹³.

The expected value is met during the reporting period as displayed in Figure 8. The performance achieved is always better than the target value, with an average of **96.1%**, the best performing REFBE reaching **97.8%** and the worst one attaining **93.2%**.

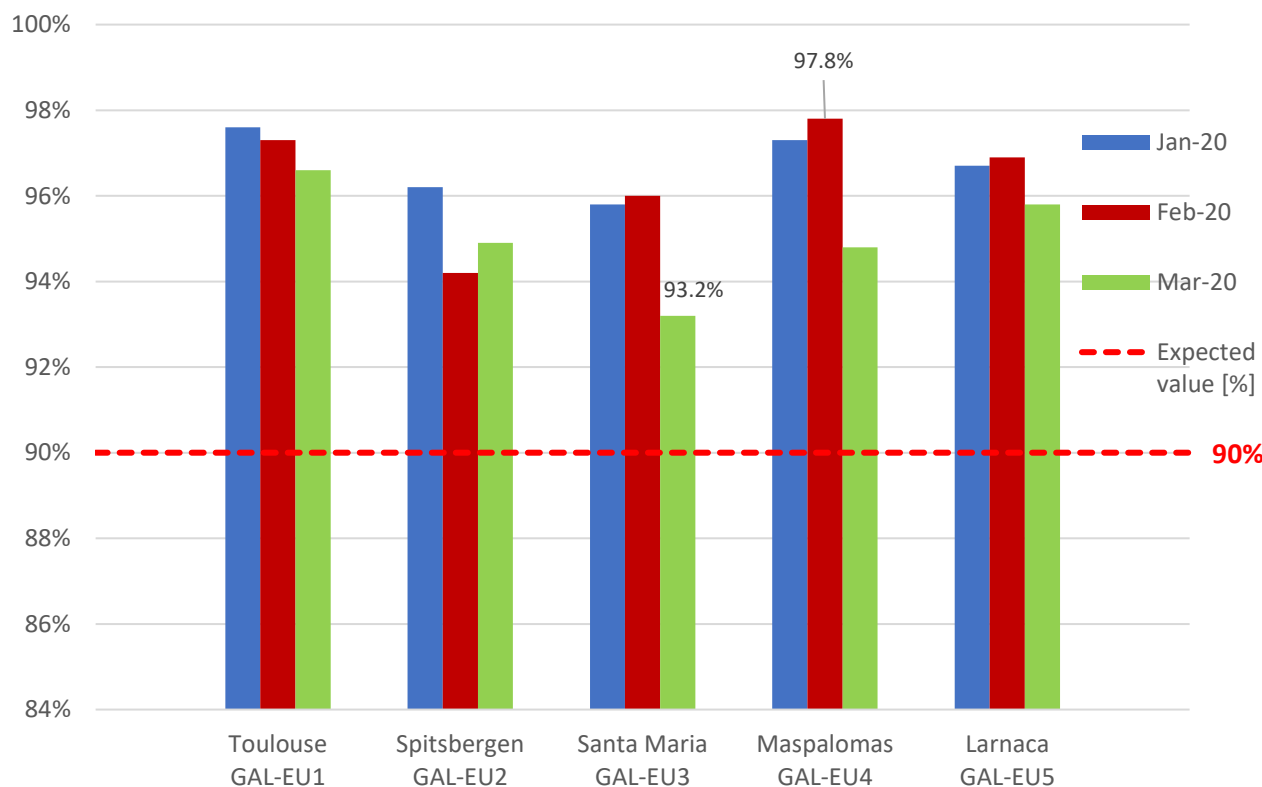


Figure 8: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst [%]

¹³ Ref.: [SAR-SDD], §5.1.4 (Table 13)

6.2 SAR/GALILEO SERVER AVAILABILITY

The [SAR-SDD] does not define specific MPLs for the SAR/Galileo Orbit Data Server availability, nevertheless the service achieved an average availability of 94.98% 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 8 below for information.

Other SAR/Galileo Ground Segment Elements	January 2020	February 2020	March 2020
SAR/Galileo Orbit Data Server Availability [%]	88.04%	99.28%	97.62%

Table 8: SAR/Galileo Orbit Data Server Monthly Availability, January – March 2020

7 REFERENCES

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

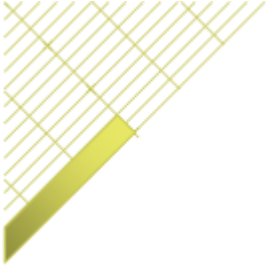
[SAR-SDD] *European GNSS (Galileo) SAR/GALILEO Service Definition Document (SAR-SDD), Issue 2.0, European Union, January 2020.*

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

8 LIST OF ACRONYMS

Acronym	Definition
<i>Cospas-Sarsat</i>	Cosmicheskaya Sistyema Poiska Avariynich Sudow-Search and Rescue Satellite-Aided Tracking
<i>EU</i>	European Union
<i>FLS</i>	Forward Link Service
<i>GSA</i>	European GNSS Agency
<i>GSAT</i>	Galileo Satellite
<i>GNSS</i>	Global Navigation Satellite System
<i>GSC</i>	European GNSS Service Centre
<i>MEOLUT</i>	Medium Earth Orbit Local User Terminal
<i>MPL</i>	Minimum Performance Level
<i>MTCF</i>	MEOLUT Tracking Coordination Facility
<i>PRN</i>	Pseudo-Random Noise
<i>REFBE</i>	SAR/Galileo Reference Beacon
<i>RLM</i>	Return Link message
<i>RLS</i>	Return Link Service
<i>SAR</i>	Search and Rescue
<i>SARN</i>	Search and Rescue Network
<i>SART</i>	Search and Rescue Transponder
<i>SDD</i>	Service Definition Document
<i>SGC</i>	SAR/Galileo Coverage

Acronym	Definition
<i>SIS</i>	Signal In Space
<i>SV</i>	Space Vehicle



End of Document



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