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EUROPEAN GNSS (GALILEO)

SAR SERVICE

QUARTERLY PERFORMANCE REPORT

OCTOBER – DECEMBER 2021



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1 INTRODUCTION

This document is the *Galileo Enhanced Service Search and Rescue Service (SAR/GALILEO) Public Performance Report* for the period of October, November, December 2021. Following the declaration of the SAR/Galileo Enhanced Services in January 2020, issue 2.0 of [SAR-SDD] was published and is the reference document for the present performance report.

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: is an introduction to this report. It includes the status of Galileo constellation for the Search and Rescue Service over the quarterly reported 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: Lists the reference documents.

Section 8: Defines the acronyms and abbreviations used in the document.

Table 1 provides the status of the relevant SAR/Galileo space constellation, for which the performance data has been derived for the reported period.

Satellite Code	SV ID (PRN)	Cospas-Sarsat ID	Orbital Slot	Status
GSAT-0103	19	419	C04	Available
GSAT-0104	20	420	C14	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	B14	Available 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

For the most up-to-date information, please refer to the European GNSS Service Centre (GSC) Web pages listed in Table 2 hereafter.

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 is operational and available for SAR/Galileo FLS only, since May 4th 2020.

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 collect relevant information on signal performance as observed by the users. Finally, GSC provides an important service which consists in the provision of detailed orbit data for the Galileo satellites on a server accessible to the SAR community. Access to this server 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.

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

SAR MPLs		Target Value	Element	Oct-21	Nov-21	Dec-21	
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			
L.Prob. [SB]	≥90%	GAL-EU1 - Toulouse					
		GAL-EU2 - Spitsbergen					
		GAL-EU3 - Santa Maria					
		GAL-EU4 - Maspalomas					
L.Prob. [1-12 B]	≥98%	GAL-EU1 - Toulouse					
		GAL-EU2 - Spitsbergen					
		GAL-EU3 - Santa Maria					
		GAL-EU4 - Maspalomas					
RLM Delivery	Latency ≤ 15 [min]	≥99%	Average among all REFBEs				
RLM Reception	Probability	≥99%	Average among all REFBEs				

Table 3a: MPL Fulfilment Status Dashboard

SAR MPLs			Target Value	Element	Oct-21	Nov-21	Dec-21
SAR Transponder Availability	Per Satellite	Monthly Percentage	>=95%	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-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			
				Spitsbergen			
	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)

Table 3c: Dashboards legend colour code

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** met the MPL target set to 99% during the reporting period with annually normalised value of **99.80%** in December.

The **Availability of the SAR/Galileo European MEOLUT Facilities** in “Nominal” and “Nominal + Degraded” modes during the reported period remains at excellent levels with annually normalised values in December better than **97.5%** and **98.7%** 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 of **100%** every month of the reported period, where the MPL target is 99%.

The **Performance of Location Probability** achieved excellent values with monthly values higher than **99.9%** for single burst, where the MPL target is 90%, 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 **99.6%** for single burst and **99.9%** 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 **99.33%** in November and **100%** in October and December with an MPL set to 95%.

The **RLM Delivery Latency within 15 min** was above **99.97%** and at **99.98%** in average over the reported period for an MPL set to 99%.

The **RLM Reception Probability** was **100%** each month of the reported period for an MPL set to 99%.

The **Availability of the SAR Transponders** achieved excellent levels of performance with satellite transponder long-term availability above the MPL of 95% for all the SAR transponders, except for GSAT-0104 and GSAT-0204 which underwent orbit reallocations in April and May 2021 and for which the long-term availability is 86.03% and 91.39% respectively.

3 SAR/GALILEO FORWARD LINK SERVICE PERFORMANCE

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 0;
- ◇ 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] ⁴. 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. Figure 1 below also report the short term (monthly) FLS availability to show the performance trend over time. During the reported period, the monthly FLS availability was **100%**.

The normalised value was **99.8%** every month compliant with the MPL target of 99% defined over 12 months.

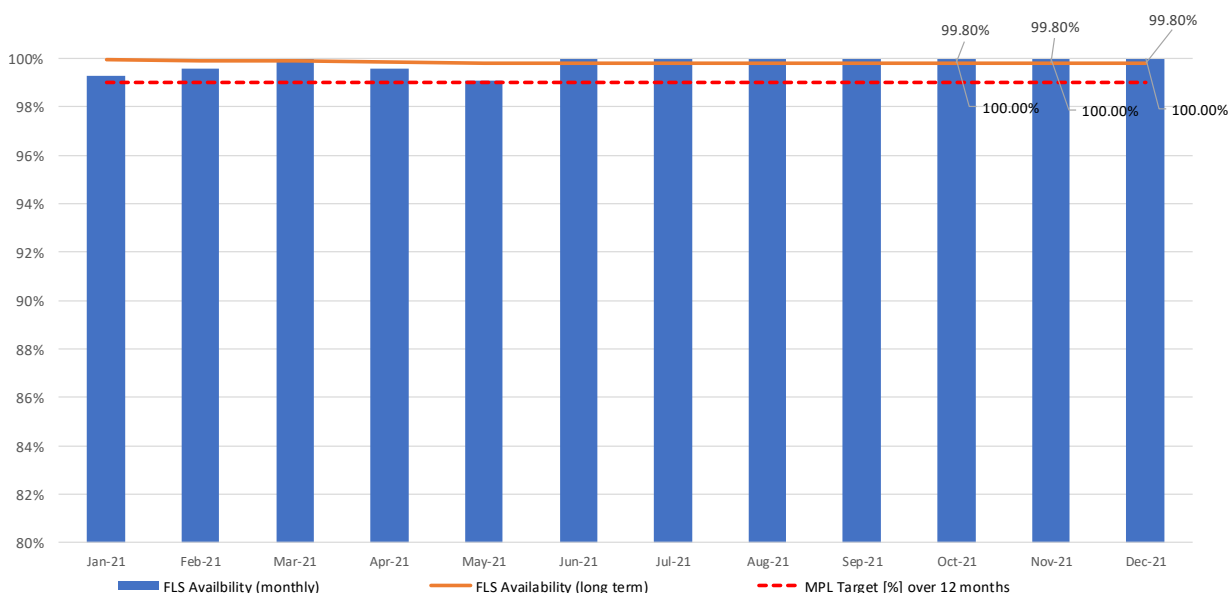


Figure 1: Forward Link Service Availability - monthly and long-term trend

⁴ Ref.: [SAR-SDD], §5.1.1 (Table 9)

3.2 EUROPEAN MEOLUT FACILITY AVAILABILITY

The MPLs for the availability of the SAR/Galileo European MEOLUT Facility are defined in the [SAR-SDD]⁵ over a period of twelve months (long-term), with a sliding window moving one month ahead every month. Figure 2 and Figure 3, below, also report the short term (monthly) EU MEOLUT Local Facility availability to show the performance trend over time.

During the reported 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 December 2021 values of **99.1%**, **99.2%** and **97.5%** for respectively Larnaca, Maspalomas and Spitsbergen EU MEOLUT Facilities long term availability.

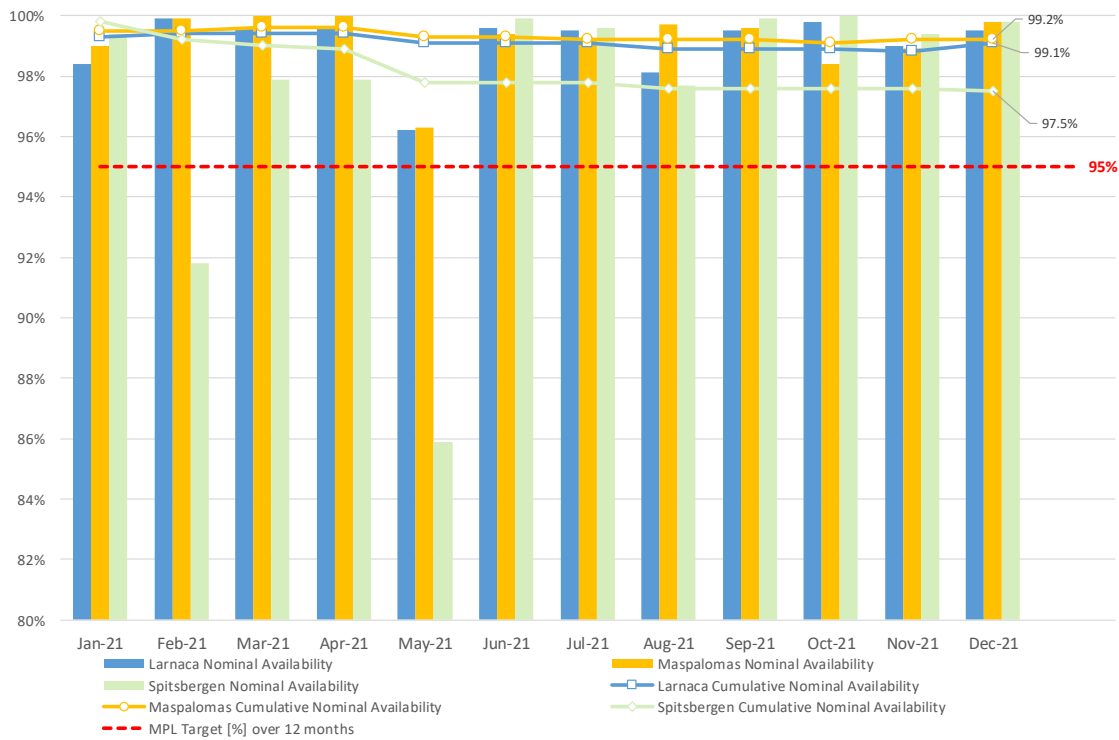


Figure 2: Per MEOLUT Facility Monthly Availability of Nominal Mode [%]

⁵ Ref.: [SAR-SDD], §5.1.2 (Table 10)

The "Nominal + Degraded" mode availability is reported in Figure 3 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 reported period achieving in December 2021 values of **99.3%**, **99.6%** and **98.7%** for respectively Larnaca, Maspalomas and Spitsbergen EU MEOLUT Facilities long term availability.

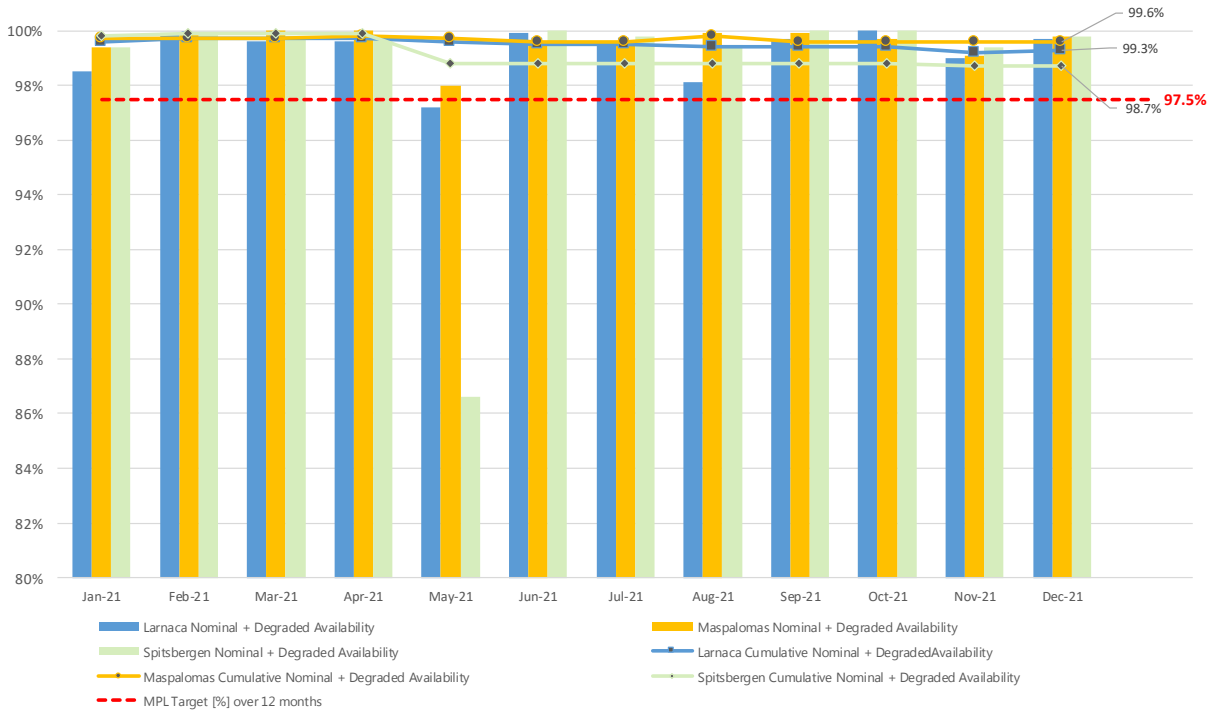


Figure 3: Per MEOLUT Facility Monthly Availability of "Nominal + Degraded" Mode [%]

3.3 DETECTION PERFORMANCE

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 MPL specified at 99%⁶ is valid whether the SAR/Galileo MEOLUT Facilities are in Nominal or Degraded mode.

Figure 4 below shows the monthly valid message detection probability for each Reference Beacon which achieved **100%** every month during the reported period.

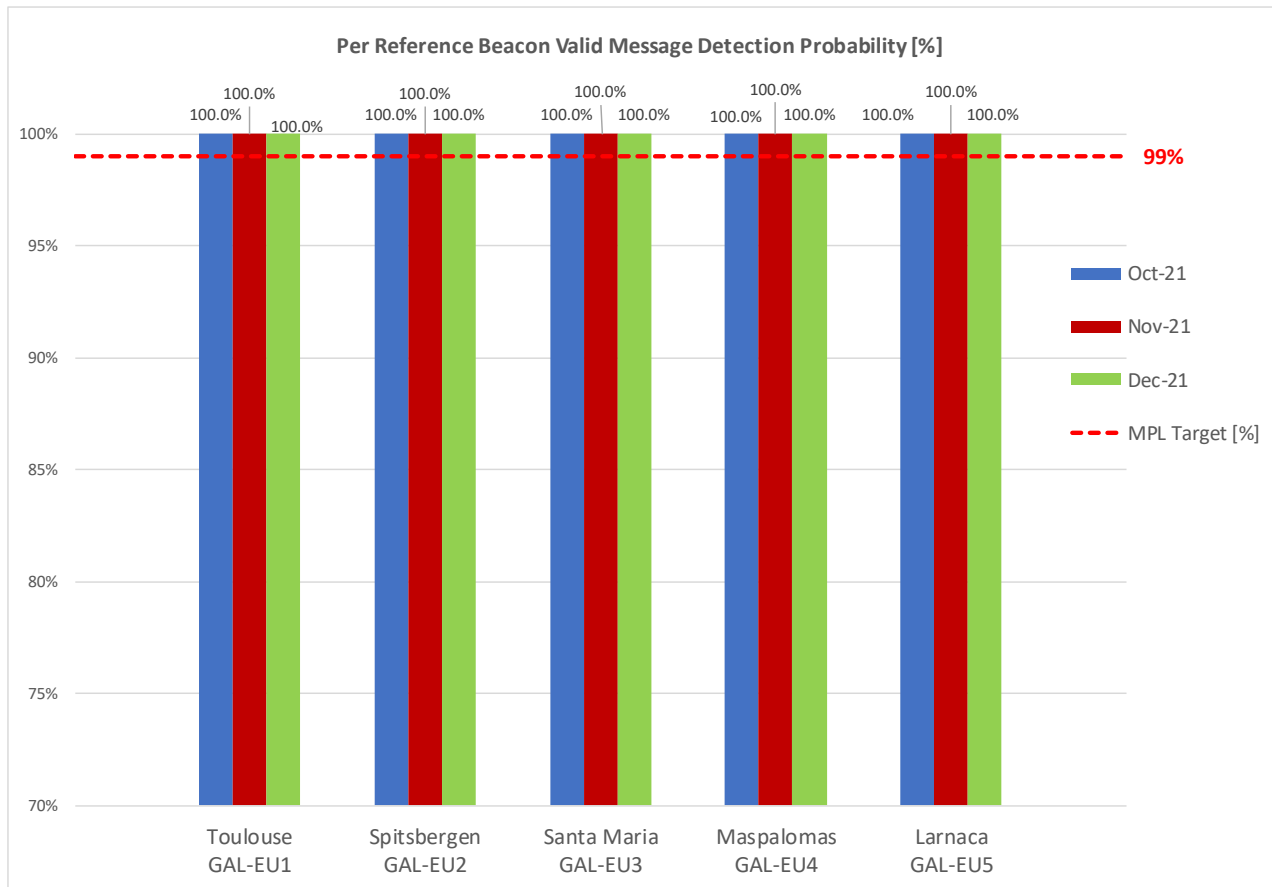


Figure 4: Per Reference Beacon Valid Message Detection Probability [%]

⁶ Ref.: [SAR-SDD], §5.1.3 (Table 11)

3.4 LOCATION PERFORMANCE

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%⁷ in single burst and 98% in multi-burst are valid when the SAR/Galileo MEOLUT Facilities are in Nominal Mode.

Figure 5 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 **96.7%**, a best value of **100%** and an average over the reported period of **99.4%**.

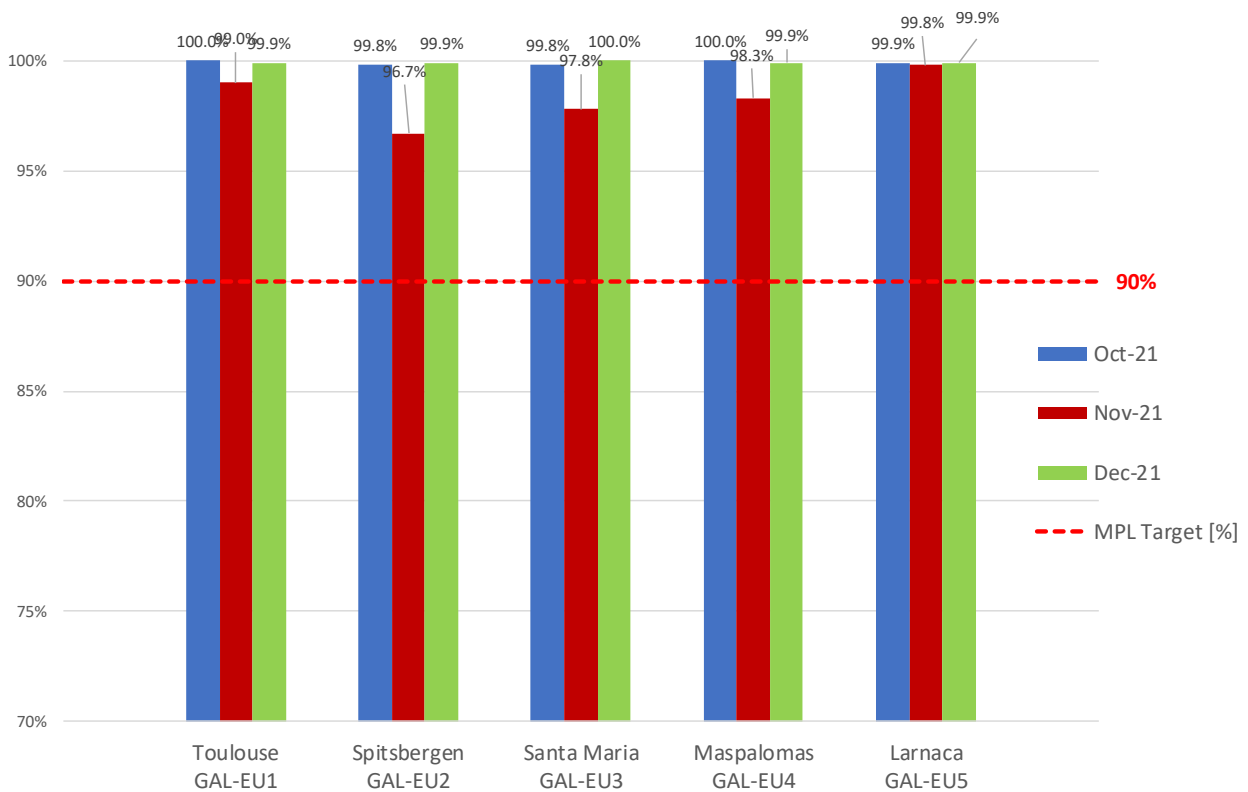


Figure 5: Per Reference Beacon Single Burst Location Probability [%]

⁷ Ref.: [SAR-SDD], §5.1.4 (Table 12)

Figure 6 below shows the monthly multi-burst location probability which meets the defined MPL of 98% for each of the SAR/Galileo Reference Beacons, with a minimum value of **99.5%**, a best value of **100%** and an average over the reported period of **99.96%**.

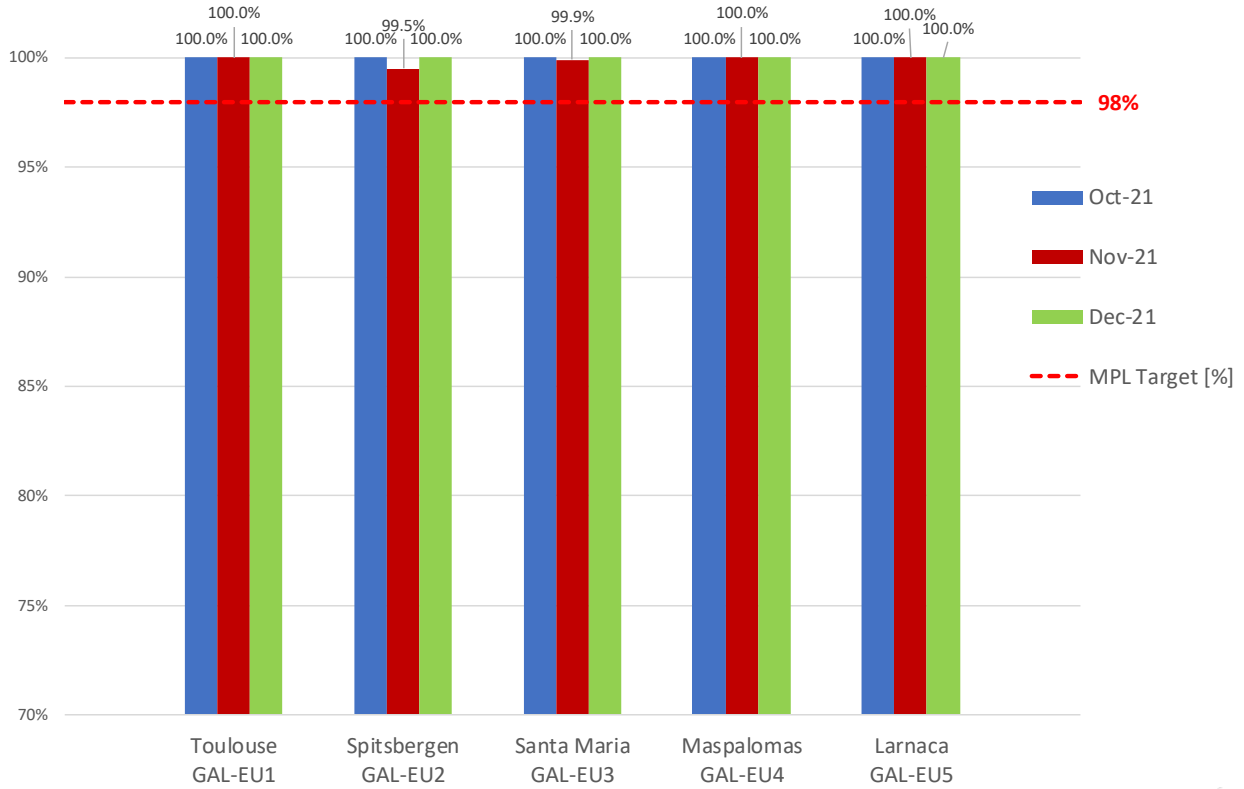


Figure 6: Per Reference Beacon Multi-Burst Location Probability [%]

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]⁸ are valid when the MEOLUT is in Nominal mode and the results are presented per Reference Beacon in Figure 7 and Figure 8 for the 5km error in single-burst and multi-burst and in Figure 10 for the 2km threshold in multi-burst only (reported only as metric).

Figure 7 below shows the monthly single-burst 5km location accuracy which meets the defined MPL of 90% for each of the SAR/Galileo Reference Beacons, with a minimum value of **99.1%**, a best value of **100%** and an average over the reported period of **99.6%**.

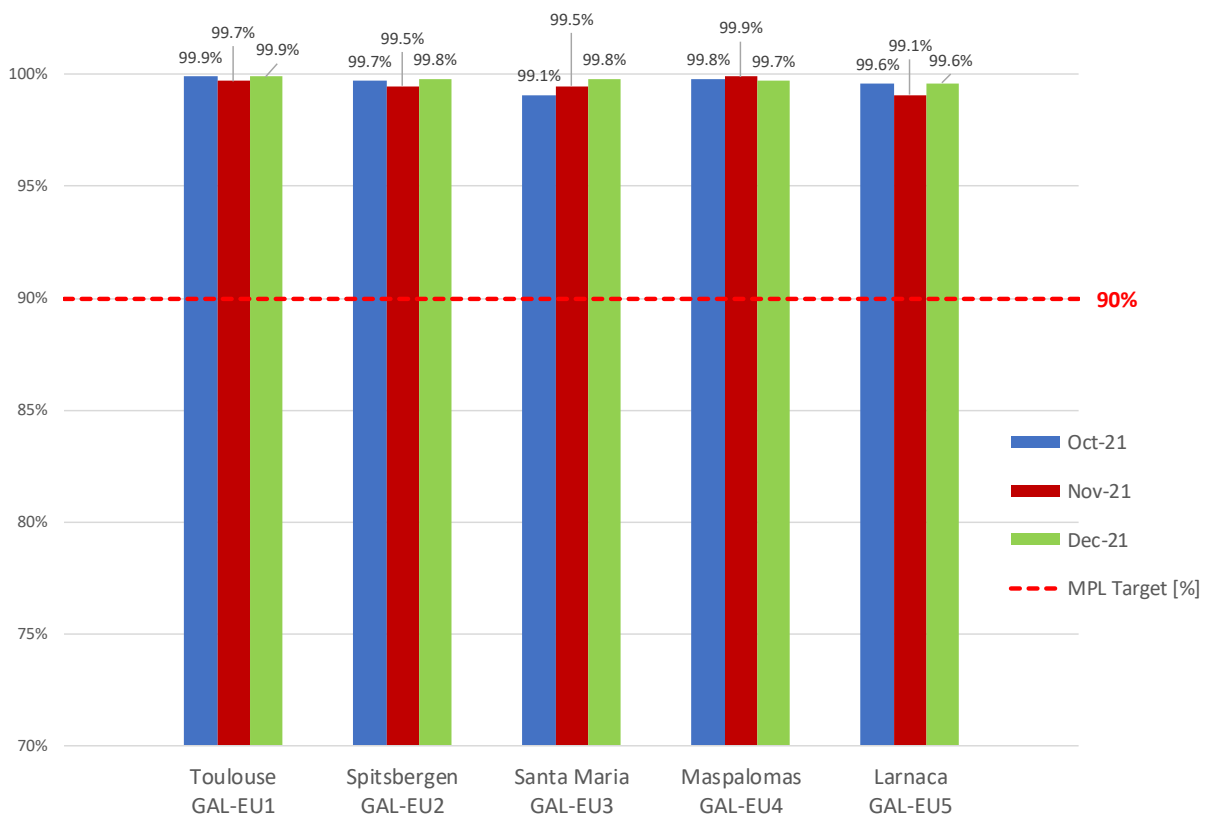


Figure 7: Per Reference Beacon Probability of 5km Accuracy in Single Burst [%]

⁸ Ref.: [SAR-SDD], §5.1.4 (Table 12)

Figure 8 below shows the monthly multi-burst 5km location accuracy which meets the defined MPL of 95% for each of the SAR/Galileo Reference Beacons, with a minimum value of **99.8%**, a best value of **100%** and an average over the reported period of **99.9%**.

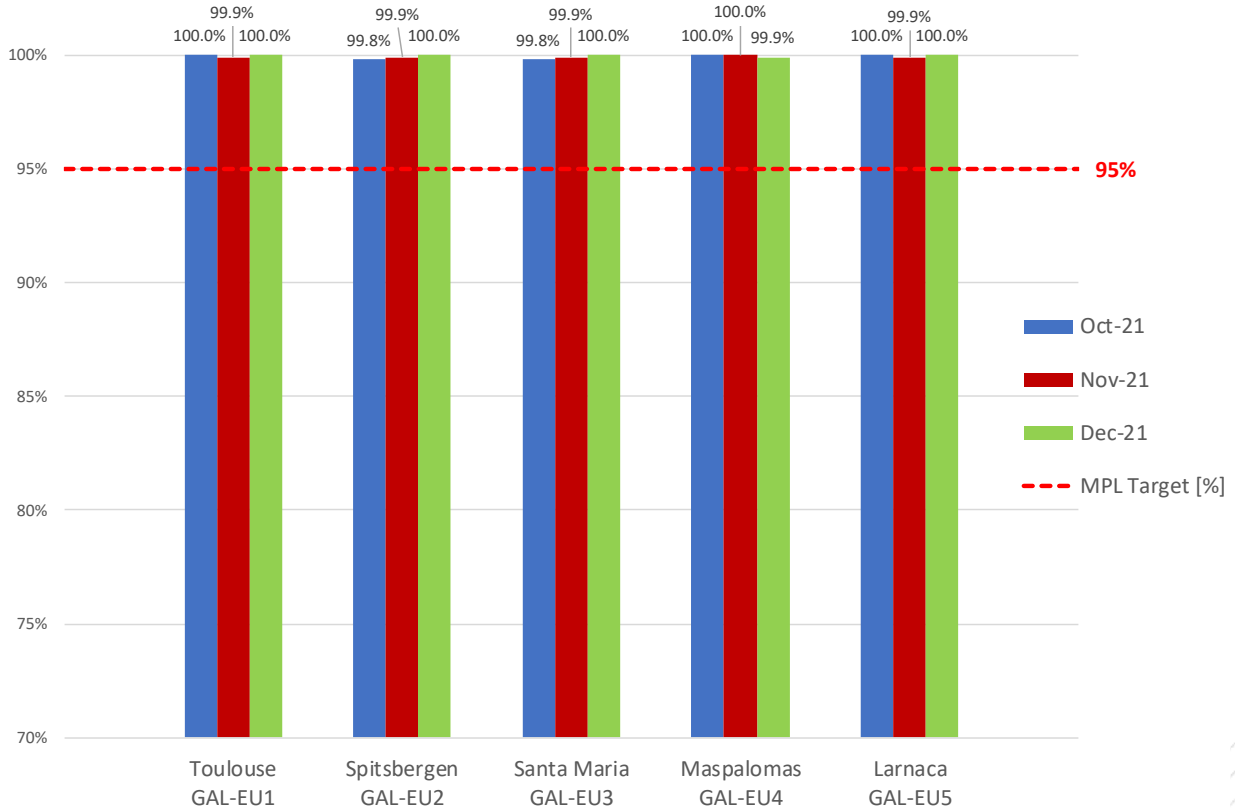


Figure 8: Per Reference Beacon Probability of 5km Accuracy in Multi-Burst [%]

4 RETURN LINK SERVICE PERFORMANCE

4.1 RETURN LINK SERVICE AVAILABILITY

The MPL for the Return Link Service availability is defined in the [SAR-SDD] ⁹.

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.

During the reported period, the monthly RLS availability was **100%** in October and December, and 99.33% in November. The normalized value was above **99.87%** every month compliant with the MPL target of 99% defined over 12 months.

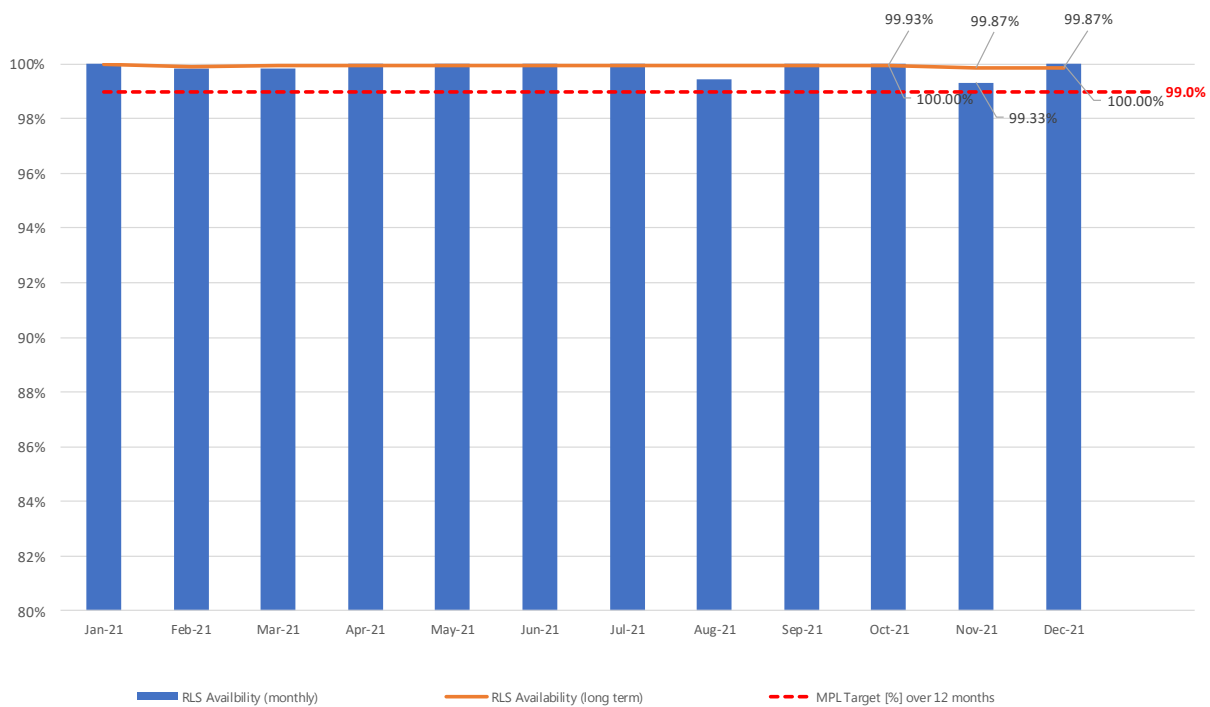


Figure 9: Return Link Service Availability - monthly and long-term trend

⁹ Ref.: [SAR-SDD], §5.2.1 (Table 14)

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 MPL is specified at 99%¹⁰.

During the reported period, the monthly delivery latency was above the MPL with an average value of **99.99%**.

SAR/Galileo RLS Delivery Latency within 15 min [%]	October 2021	November 2021	December 2021
MPL Target [99%]	99.97%	99.97%	100%

Table 4: Return Link Service Monthly Delivery Latency within 15 min, October – December 2021

4.2.2 RECEPTION PROBABILITY

The RLS reception probability performance is computed over a calendar month. The MPL defined in the [SAR-SDD] is set to 99%¹⁰.

During the reported period, the monthly reception probability was above the MPL with a monthly and an average value of **100%**.

SAR/Galileo RLS Reception probability [%]	October 2021	November 2021	December 2021
MPL Target [99%]	100%	100%	100%

Table 5: Return Link Service Monthly Reception Probability, October – December 2021

¹⁰ Ref.: [SAR-SDD], §4.4 and §5.2.2 (Table 16)

5 SAR/GALILEO SPACE SEGMENT AVAILABILITY

The MPL defined in the [SAR-SDD] is set to 95% ¹¹ for every single SAR transponder (SART), to be normalised annually. All the Galileo SARTs obtained an availability performance of **100%** every month of the reported period except for GSAT-203 and GSAT-206 in November 2021 which respectively achieved 72.48% and 91.44% of monthly availability. The outages of the two satellites were due to planned manoeuvres.

All the satellites met the SAR Transponder availability MPL for the reporting period with values above **96.9%** except for GSAT 0104 and GSAT 0204 which respectively achieved minimum values of 86.03% and 91.39% in December. These satellites had a monthly availability of 100% during the reported period but the normalised value (over 12 consecutive months) is still affected by the orbit reallocation operations in April and May.

¹¹ Ref.: [SAR-SDD], §5.3 (Table 18)

6 SUPPLEMENTARY METRICS

This section reports relevant performance metrics of the SAR/Galileo Service that are not MPLs.

6.1 LOCATION ACCURACY PERFORMANCE WITHIN 2KM

Multi-burst location accuracy within 2km is an expected value defined in the [SAR-SDD] at 90%¹².

The expected value is met during the reported period for all the reference beacons as displayed in Figure 10.

Figure 10 below shows the monthly multi-burst 2km location accuracy which comfortably exceeds the expected value of 90% for each of the SAR/Galileo Reference Beacons, with a minimum value of **96.1%**, a best value of **98.7%** and an average over the reported period of **97.8%**.

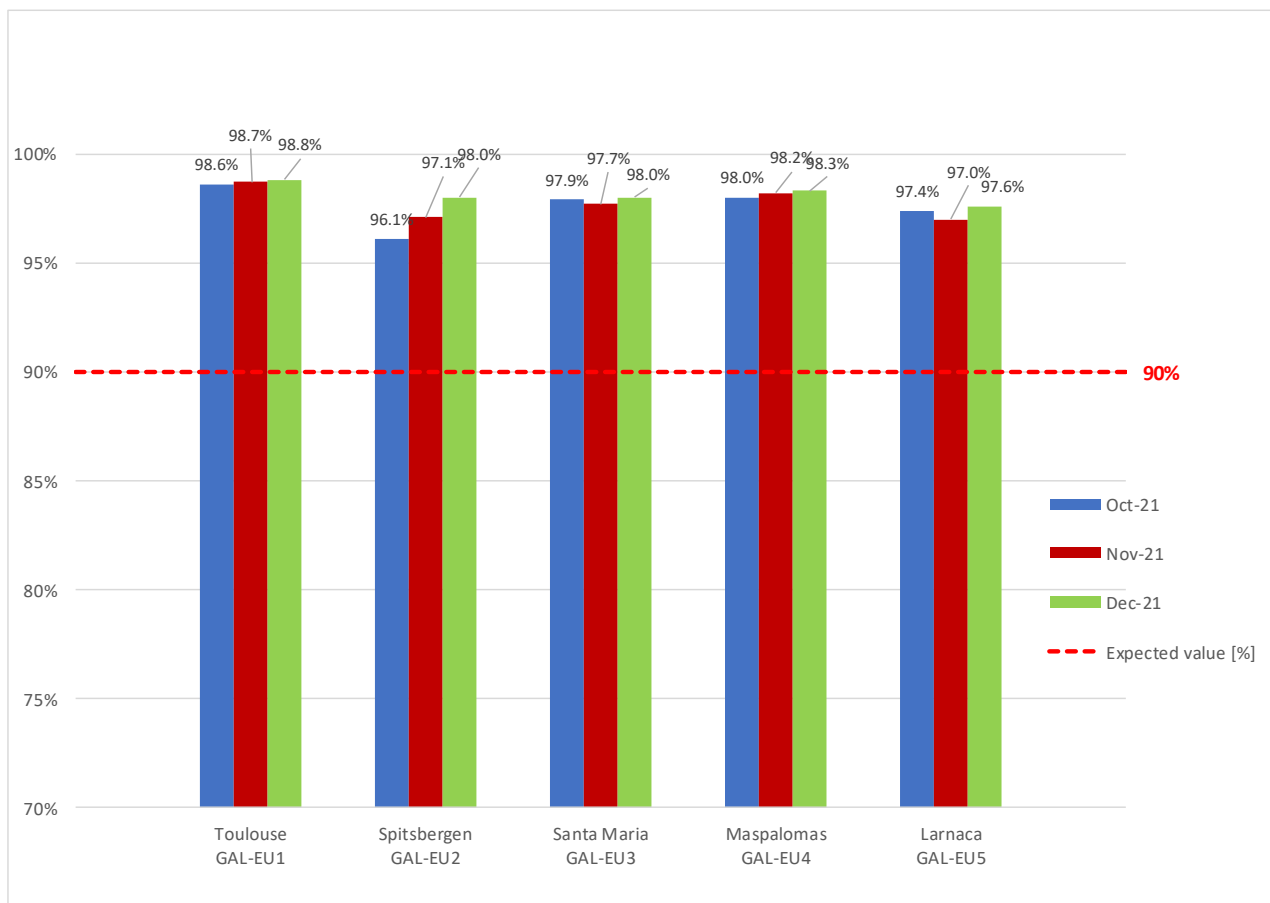


Figure 10: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst [%]

¹² Ref.: [SAR-SDD], §5.1.4 (Table 13)

6.2 SAR/GALILEO SERVER AVAILABILITY

The [SAR-SDD] does not define a specific target for the SAR/Galileo Orbit Data Server availability, nevertheless it achieved an average value of **97.97%** during the reported 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 for information.

Other SAR/Galileo Ground Segment Elements	October 2021	November 2021	December 2021
SAR/Galileo Orbit Data Server Availability [%]	97.86%	96.66%	99.38%

Table 6: SAR/Galileo Orbit Data Server Monthly Availability, October – December 2021

7 REFERENCES

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

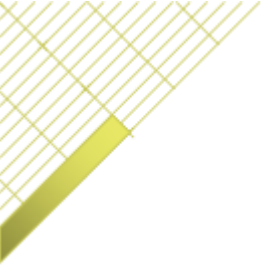
[SAR-SDD] *European GNSS (Galileo) SAR/GALILEO Service Definition Document (SAR-SDD), Issue 2.0, European Union, January 2020.*

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>EUSPA</i>	European Union Agency for the Space Programme
<i>FLS</i>	Forward Link Service
<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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