



EUROPEAN GNSS (GALILEO)

SAR SERVICE

QUARTERLY PERFORMANCE REPORT

OCTOBER - DECEMBER 2022

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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 and December 2022. 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.

GSAT_ID	SV-ID (PRN)	ORBIT SLOT	COSPAS- SARSAT ID	AVAILABILITY FOR SAR	
				FLS	RLS
GSAT-0101	11	B05	-	<input type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0102	12	B06	-	<input type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0103	19	C04	419	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0104	20	C14	420	<input checked="" type="checkbox"/>	<input type="checkbox"/>
GSAT-0201	18	Not-nominal ¹	418	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0202	14	Not-nominal ²	414	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0203	26	B08	426	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0204	22	B14	422	<input type="checkbox"/>	<input type="checkbox"/>
GSAT-0205	24	A08	424	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0206	30	A05	430	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0207	7	C06	407	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0208	8	C07	408	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0209	9	C02	409	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0210	1	A02	401	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0211	2	A06	402	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0212	3	C08	403	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0213	4	C03	404	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0214	5	C01	405	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0215	21	A03	421	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0216	25	A07	425	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0217	27	A04	427	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0218	31	A01	431	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

¹ Although Galileo satellite GSAT-0201 is located in an eccentric orbit, it has been declared operational for the SAR/Galileo Services.

² Although Galileo satellite GSA-0202 is located in an eccentric orbit, it has been declared operational for the SAR/Galileo Services

GSAT_ID	SV-ID (PRN)	ORBIT SLOT	COSPAS- SARSAT ID	AVAILABILITY FOR SAR	
				FLS	RLS
GSAT-0219	36	B04	436	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0220	13	B01	413	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0221	15	B02	415	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0222	33	B07	433	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0223	34	B03	434	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
GSAT-0224	10	B15	410	<input type="checkbox"/>	<input type="checkbox"/>

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.

GNSS Service Centre Web Resources	
SAR Galileo Constellation Information	https://www.gsc-europa.eu/system-service-status/sar-information/sargalileo-satellites-information https://www.gsc-europa.eu/system-service-status/sar-information
Reference and Calibration Beacon Information	https://www.gsc-europa.eu/system-service-status/sar-information/sargalileo-reference-calibration-beacons
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)
Operational Notifications	https://www.gsc-europa.eu/system-service-status/sar-information/sargalileo-operational-notifications

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 except for the SART availability of GSAT-0210 and GSAT-0204 due to events occurred before the reporting period which affect the long-term availability.

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-22	nov-22	déc-22	
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%	Average among all REFBEs				
RLM Reception	Probability	>=99%	Average among all REFBEs				

Table 3a: MPL Fulfilment Status Dashboard


SAR MPLs			Target Value	Element	oct-22	nov-22	déc-22
SAR Transponder Availability	Per Satellite	Monthly Percentage	>=95%	GSAT0103			
				GSAT0104			
				GSAT0201			
				GSAT0202			
				GSAT0203			
				GSAT0204			
				GSAT0205			
				GSAT0206			
				GSAT0207			
				GSAT0208			
				GSAT0209			
				GSAT0210			
				GSAT2011			
				GSAT0212			
				GSAT0213			
				GSAT0214			
				GSAT0215			
				GSAT0216			
				GSAT0217			
				GSAT0218			
				GSAT0219			
				GSAT0220			
				GSAT0221			
				GSAT0222			
GSAT0223							
GSAT0224							
SAR Ground Segment Availability	MEOLUT Status	Nominal	>=95%	Larnaca			
				Maspalomas			
				Spitsbergen			
		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].

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 **99.95%** 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 **95.5%** and **99.7%** 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 above **99.9%** every month of the reported period, where the MPL target is 99%.

The **Performance of Location Probability** achieved excellent values with monthly values above **99.9%** for single burst, where the MPL target is 90%, and above **99.9%** 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 **98.5%** for single burst and **99.6%** 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 above **98.39%** every month of the reported period for an MPL set to 95%.

The **RLM Delivery Latency within 15 min** was above **99.98%** every month of the reported period for an MPL set to 99%.

The **RLM Reception Probability** was **100%** every 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-0210 (due to the unplanned anomaly in May 2022 that affected the long-term availability over the reporting period) and for GSAT-0204 (which is not operational for SAR since September 2022 and for which the long term availability is decreasing over the reporting period).

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 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]³. 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 **99.95%** every month, compliant with the MPL target of 99% defined over 12 months.

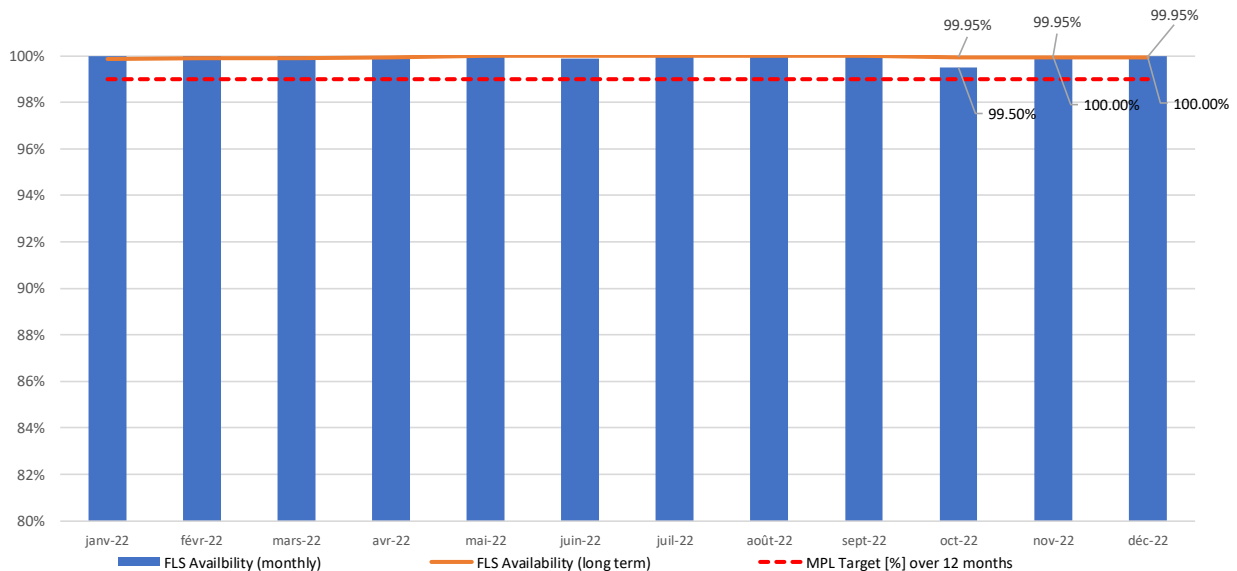


Figure 1: Forward Link Service Availability - monthly and long-term trend

³ 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] ⁴ 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 2022 values of **98.1%**, **95.5%** and **99.1%** for respectively Larnaca, Maspalomas and Spitsbergen EU MEOLUT Facilities long term availability.

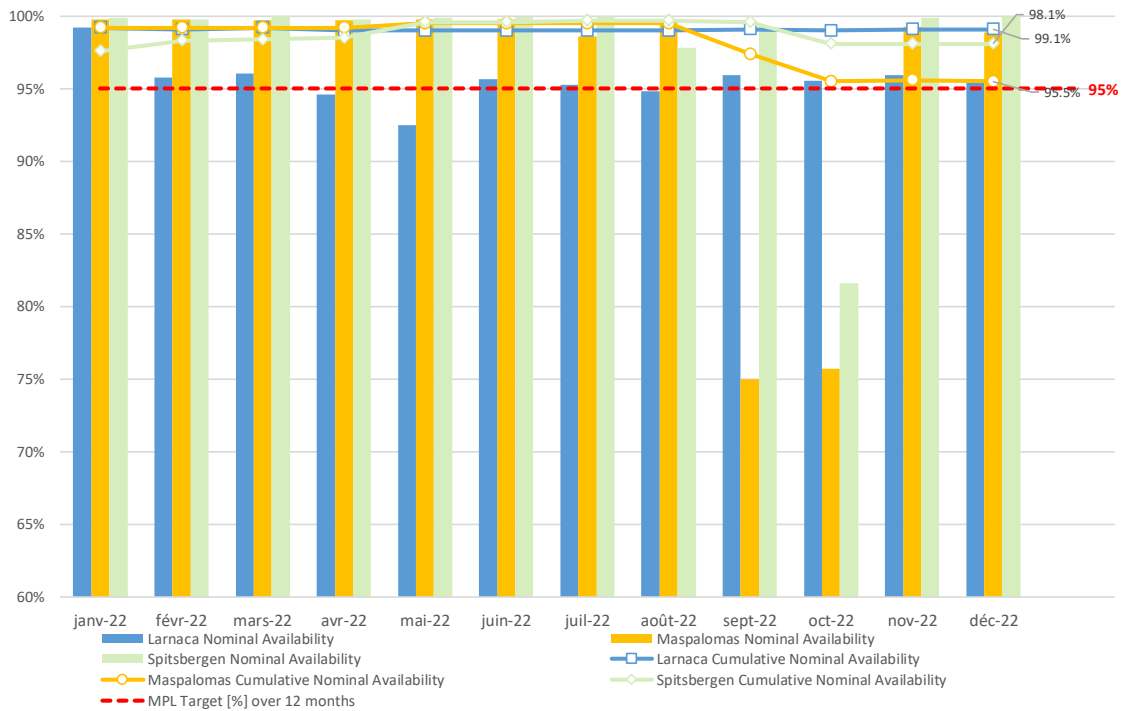


Figure 2: Per MEOLUT Facility Monthly Availability of Nominal Mode [%]

⁴ 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 2022 values of **99.7%**, **99.8%** and **99.8%** for respectively Larnaca, Maspalomas and Spitsbergen EU MEOLUT Facilities long term availability.

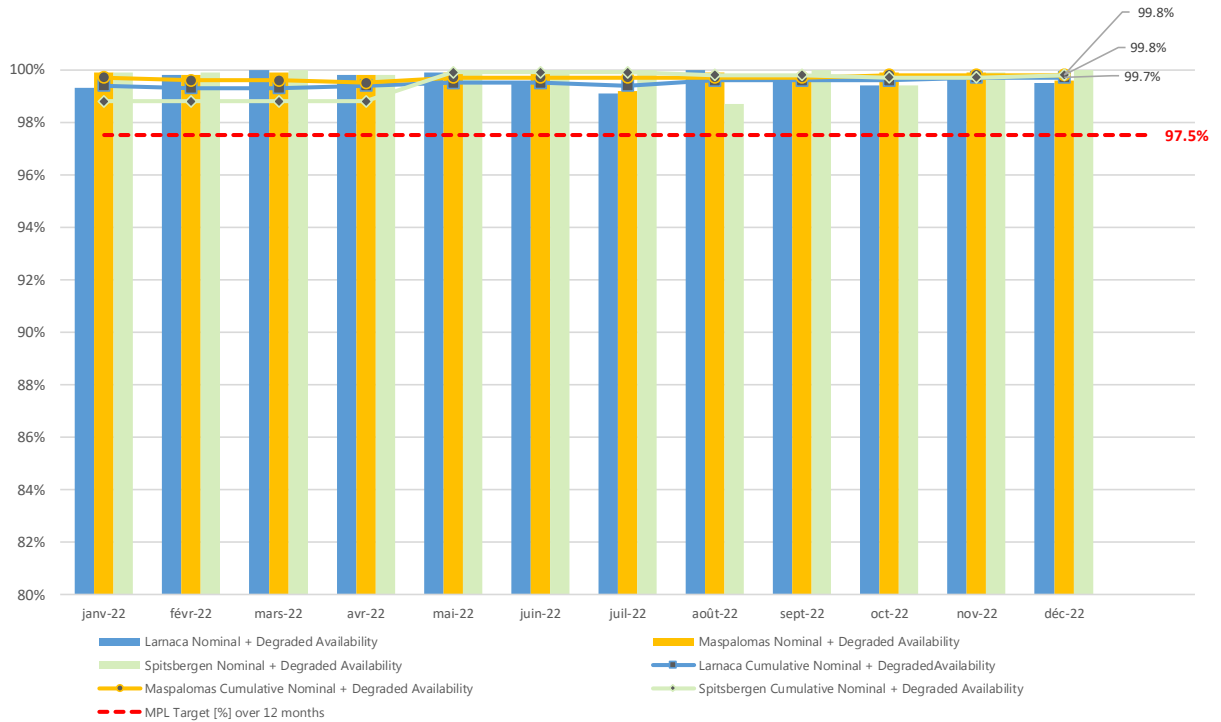


Figure 3: Per MEOLUT Facility Monthly Availability of "Nominal + Degraded" Mode [%]

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%⁵ 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 performance above **99.9%** every month during the reported period.

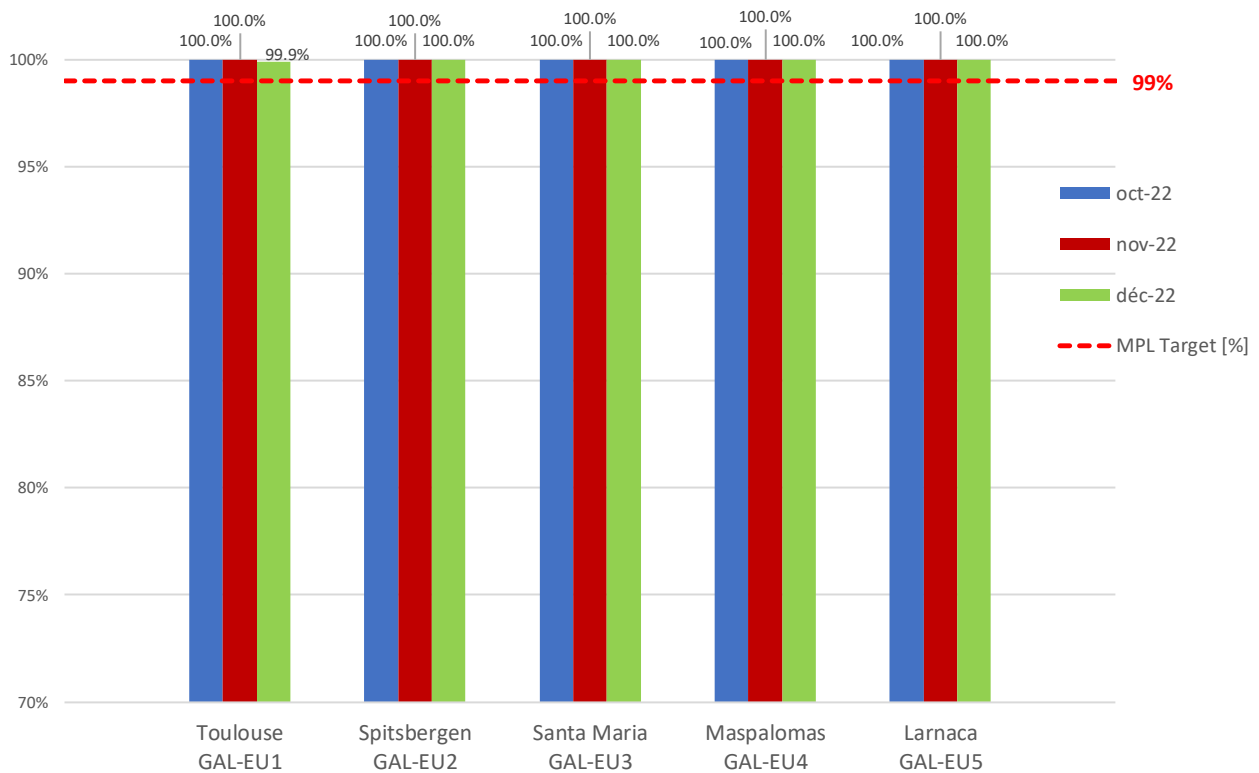


Figure 4: Per Reference Beacon Valid Message Detection Probability [%]

⁵ 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%⁶ 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 achieved performance above **99.9%** every month during the reported period.

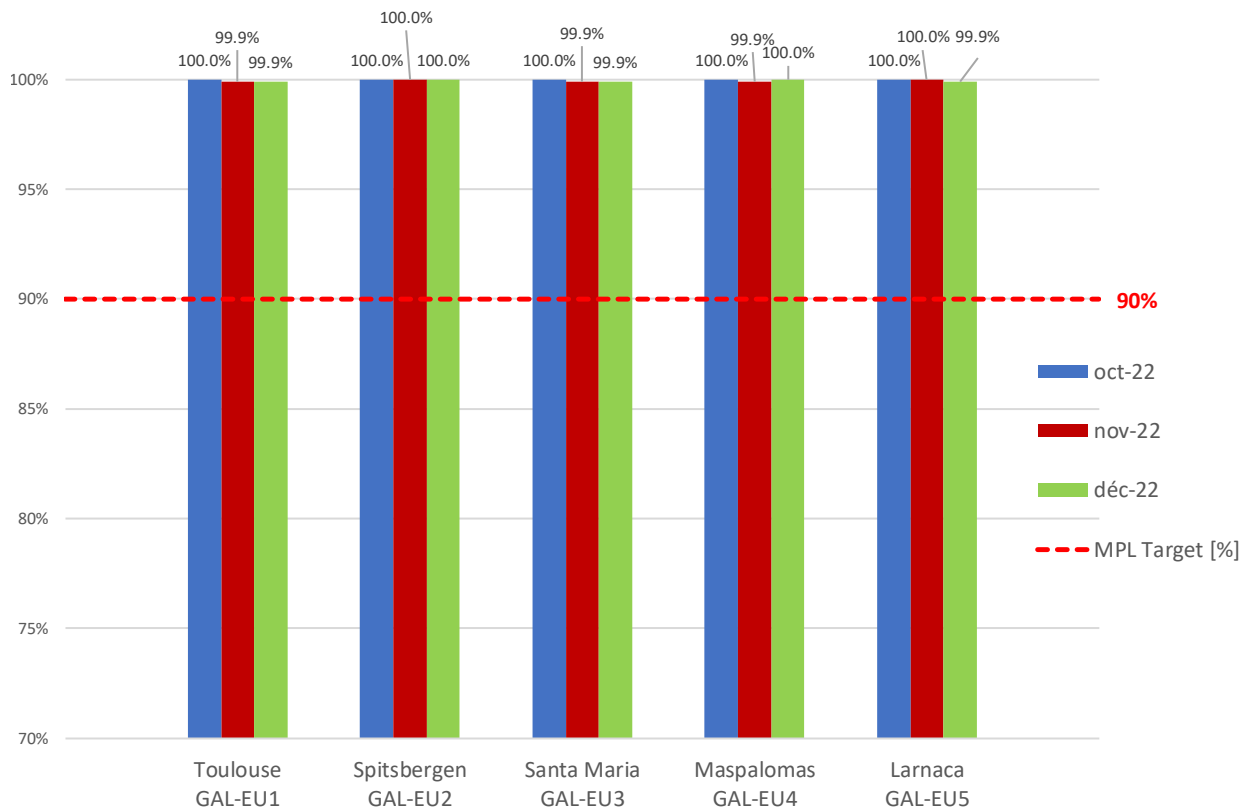


Figure 5: Per Reference Beacon Single Burst Location Probability [%]

⁶ 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 performance above **99.9%** for each beacon and each month of the reported period.

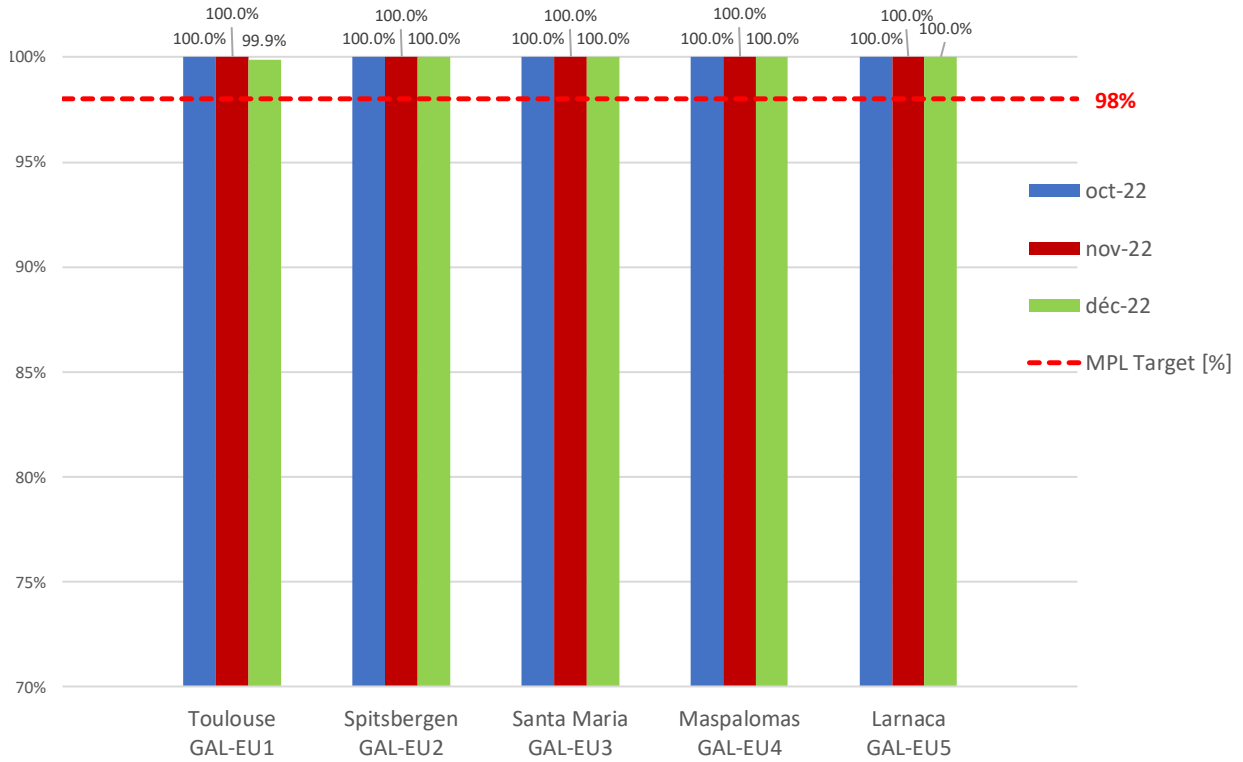


Figure 6: Per Reference Beacon Multi-Burst Location Probability [%]

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] ⁷ 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.

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 **98.5%**, a best value of **100%** and an average over the reported period of **99.5%**.

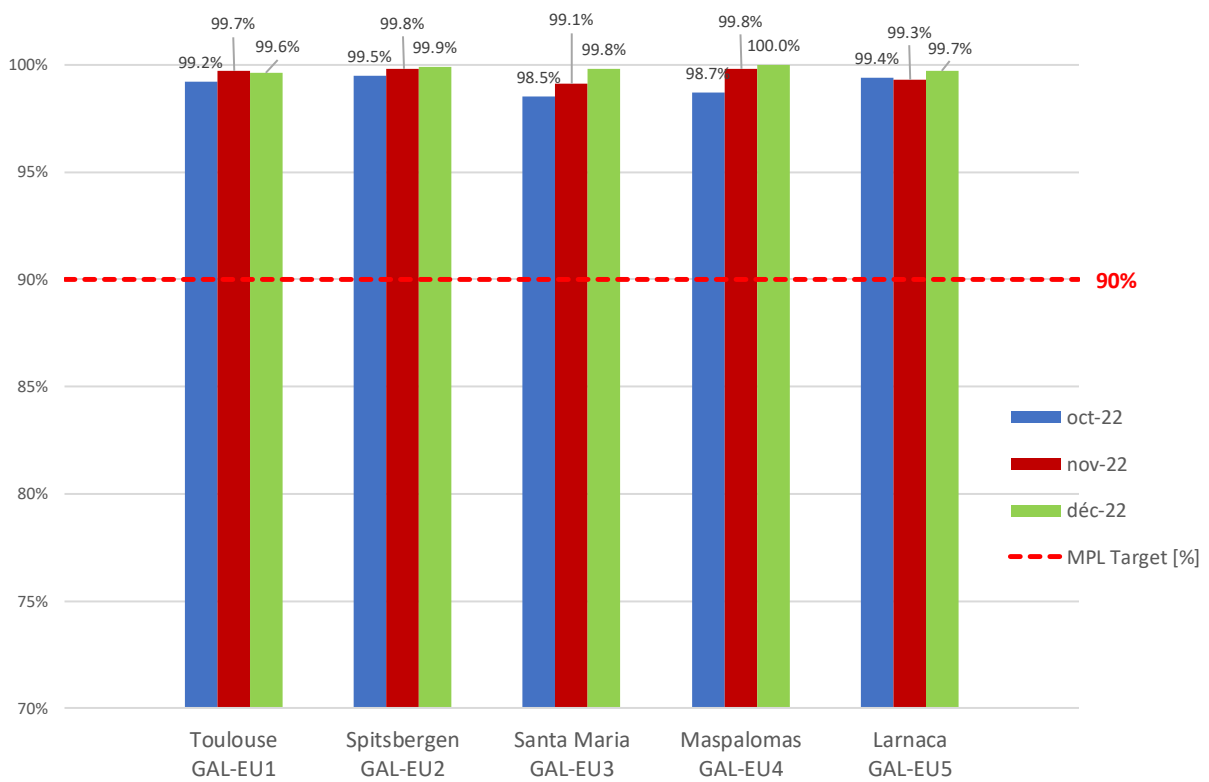


Figure 7: Per Reference Beacon Probability of 5km Accuracy in Single Burst [%]

⁷ 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 **99.6%**, a best value of **100%** and an average over the reported period of **99.9%**.

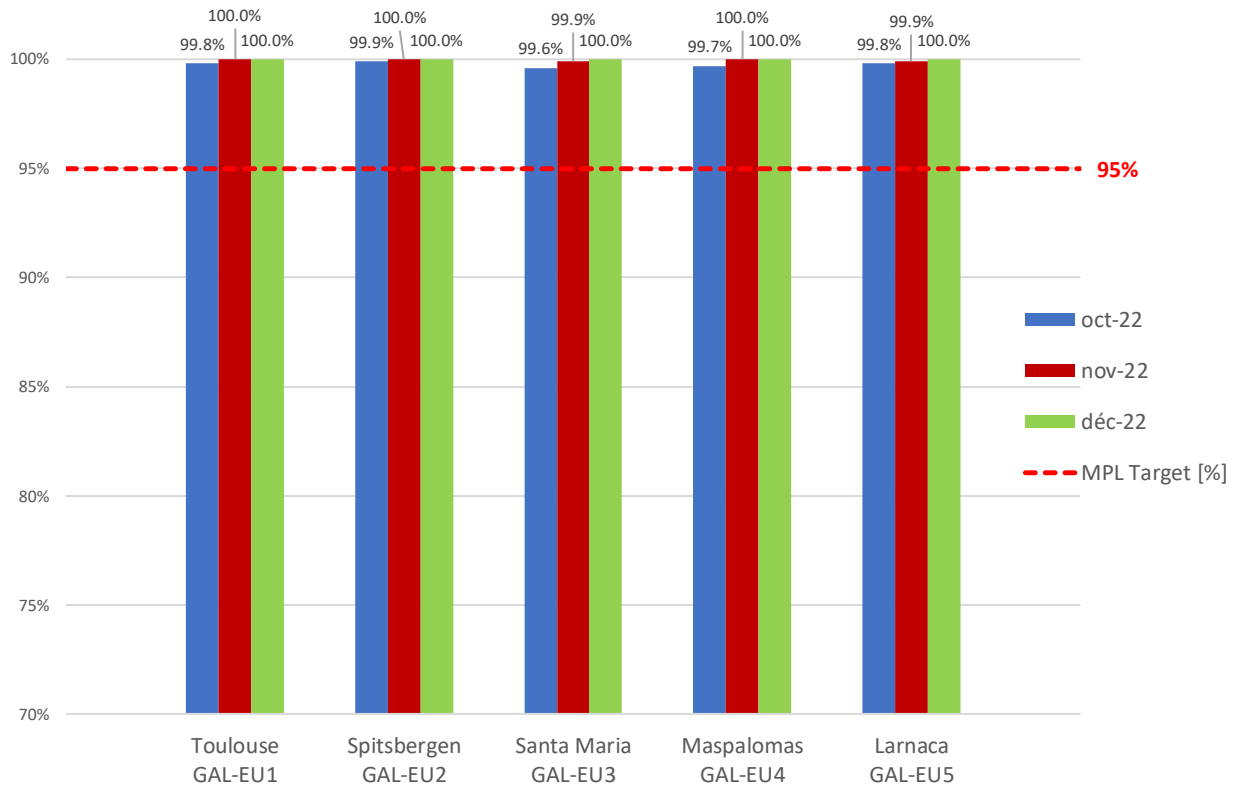


Figure 8: Per Reference Beacon Probability of 5km Accuracy in Multi-Burst [%]

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] ⁸.

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 above **98.39%** every month of the reported period. The normalized value was above **99.84%** every month, compliant with the MPL target of 95% defined over 12 months.

Note that since RLS service declaration, the MPL target was wrongly reported as 99% in the Quarterly Reports, this value is corrected in this version and set to the correct target defined in the SDD: 95%.

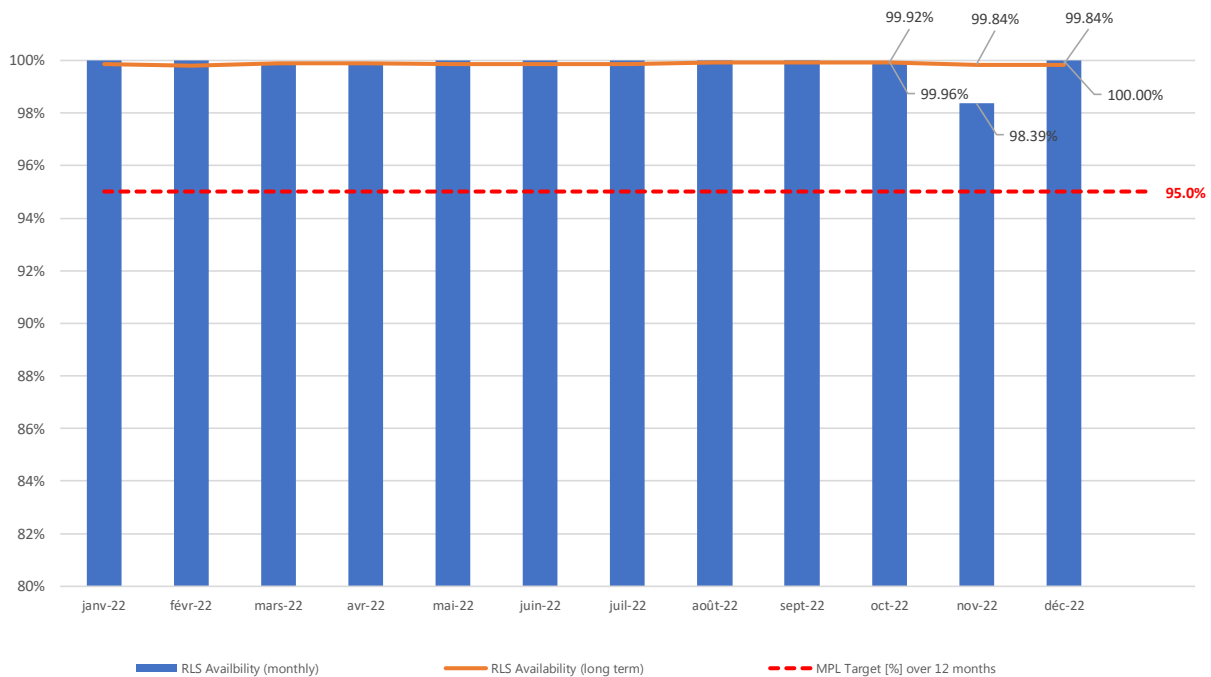


Figure 9: Return Link Service Availability - monthly and long-term trend

⁸ 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%⁹.

During the reported period, the monthly delivery latency was above the MPL with a minimal value of **99.98%** and an average value of **99.99%**.

SAR/Galileo RLS Delivery Latency within 15 min [%]	October 2022	November 2022	December 2022
MPL Target [99%]	99.98%	100%	100%

Table 4: Return Link Service Monthly Delivery Latency within 15 min, October - December 2022

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%⁹.

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 2022	November 2022	December 2022
MPL Target [99%]	100%	100%	100%

Table 5: Return Link Service Monthly Reception Probability, October - December 2022

⁹ 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%¹⁰ for every single SAR transponder (SART), to be normalised annually.

All the satellites met the SAR Transponder availability MPL for the reporting period with values above **95.37%** except for GSAT-0210 and GSAT-0204.

Satellite GSAT-0210 SAR Transponder normalised availability (over 12 consecutive months) is 91.98% every month of the reported period due to the unplanned anomaly of May 2022.

Satellite GSAT-0204 is not providing any SAR service since September 2022. This led to a decreasing normalised availability that reached 66% in December 2022.

¹⁰ 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%¹¹.

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 **96.6%**, a best value of **98.6%** and an average over the reported period of **98%**.

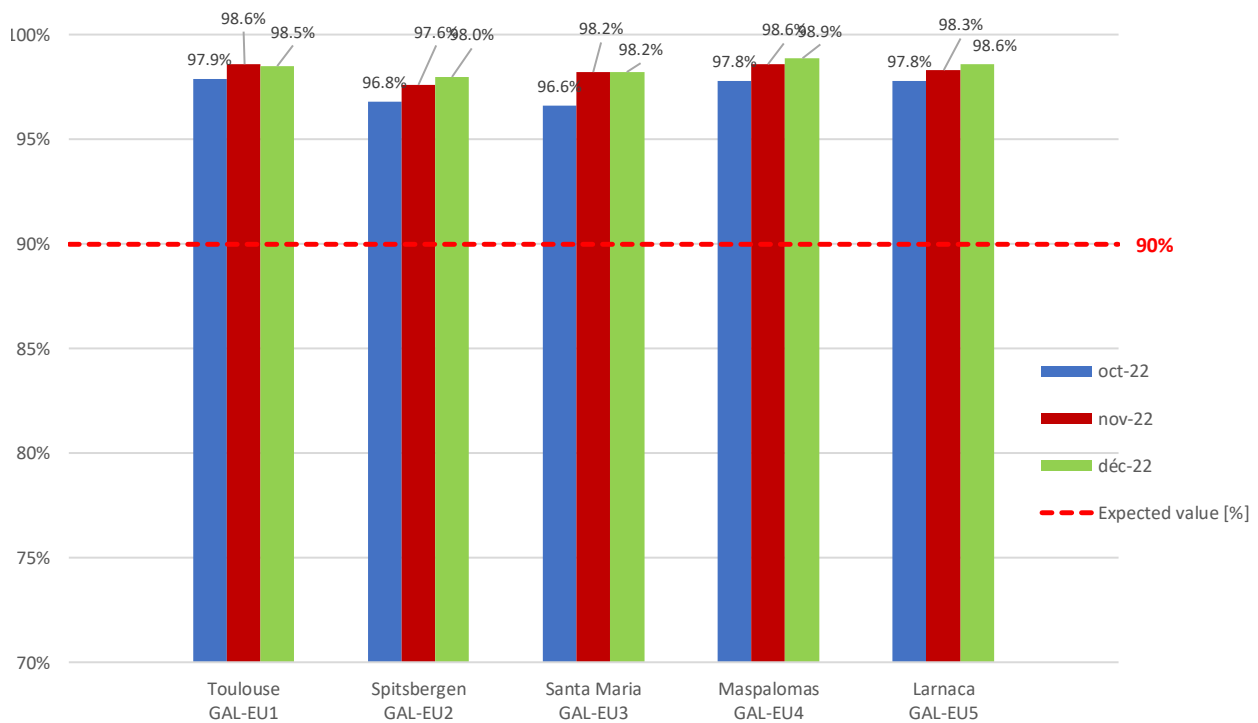


Figure 10: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst [%]

¹¹ 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 **92.99%** 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 2022	November 2022	December 2022
SAR/Galileo Orbit Data Server Availability [%]	95.23%	97.65%	86.08%

Table 6: SAR/Galileo Orbit Data Server Monthly Availability, October - December 2022



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>SART</i>	Search and Rescue Transponder
<i>SDD</i>	Service Definition Document
<i>SGC</i>	SAR/Galileo Coverage
<i>SIS</i>	Signal In Space



Acronym

Definition

SV

Space Vehicle

End of Document



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