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SAR/GALILEO Initial Service

Quarterly Performance Report

July-August-September 2017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

This document is the *Galileo Initial Search and Rescue Service (SAR/GALILEO IS) Public Performance Report* for the period of July, August and September 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) 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 chapters.

Section 3: Provides the detailed performance for the SAR/Galileo Initial Service Detection and Location Performance and is organised in three subsections: "Detection Probability", "Location Probability" and "Location Accuracy".

Section 4: Provides the detailed performance for the SAR/Galileo Initial Service Infrastructure availability and is presented in three subsections: "Availability of the SAR/Galileo Ground Segment", "Availability of SAR/Galileo Space Segment" and "Availability of the SAR/Galileo Server".

Section 5: The cited reference documents are listed.

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-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

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.

** GSAT-0212 and GSAT-0213 were respectively officially available from 1st and 9th of August 2017 onwards (see NAGUs 2017029 and 2017033).

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	https://www.gsc-europa.eu/system-status/orbital-and-technical-

Orbital and Technical Parameters	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

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 third 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. The following dashboards summarise the compliance with MPLs, using the colour coding defined in the legend below Table 3.

The detection and location 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	Jul-17	Aug-17	Sep-17
Detection and Location Service	Probability	Valid Message Detection Probability after 1 burst	≥ 99%			
		Location Probability after 1 transmitted burst	≥ 75%			
		Location Probability after 12 transmitted bursts	≥ 98%			
	Accuracy	Location accuracy after 1 transmitted burst within 5 km	≥ 70%			
		Location accuracy after 12 transmitted bursts within 5km	≥ 95%			
		Location accuracy after 12 transmitted bursts within 2km	≥ 80%			
Infrastructure Availability	MEOLUT	Maspalomas/ EU MEOLUT Availability [over 12 months]	Nominal	≥ 95%			
			Nominal + Degraded	≥ 97.5%			
		Spitzbergen/EU MEOLUT Availability [over 12 months]	Nominal	≥ 95%			
			Nominal + Degraded	≥ 97.5%			
		Larnaca/EU MEOLUT Availability [over 12 months]	Nominal	≥ 95%			
			Nominal + Degraded	≥ 97.5%			
	Satellites	Average SAR Transponder Availability		≥ 90%			

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-0207	GSAT-0208	GSAT-0209	GSAT-0210
GSAT-0211	GSAT-0212	GSAT-0213	GSAT-0214

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 location 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 99.9%, where the MPL is 99%.

Performance of Location Probability is above expectations, with monthly average values higher than 98.6% for single burst location probability, where the MPL is 75%, and 100% for the multi-burst location probability, where the MPL is 98%.

The performance of Location Accuracy is also above expectations, with average monthly values higher than 97.4% and 97.9% 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 higher than 93.1%, 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 as an average over 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 indicator and the colours in Table 3 give an assessment of the monthly performance relative to the annual threshold level.

The MEOLUTs of Larnaca, Maspalomas and Spitzbergen have shown good availability during the period July 2017-September 2017 with an average availability of respectively 99.0%, 99.1% and 98.9% in "Nominal" mode where the MPL is 95% (over 12 months) and of 99.7%, 99.6% and 99.6% in "Nominal + Degraded" mode where the MPL is 97.5% (over 12 months). The monthly availabilities for each of the MEOLUTs were all well above the threshold.

Availability of the Search and Rescue Repeaters was significantly above expectations during the period July – September 2017, as the SAR repeaters measured availability was 100% while the MPL is 90%.

Four additional SAR Repeaters have been introduced in the configuration for the MEOSAR operations during July and August 2017. These satellites (GSAT-0207, 0212, 0213 and 0214) were launched on 17 November 2016.

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

◊ Location Probability in section 3.2

◊ Location Accuracy in section 3.3

3.1 DETECTION PROBABILITY

The detection probability performance is computed for each Reference Beacon as the valid message detection probability after 1 transmitted burst. The detailed computation process for this performance parameter is described in the [SAR-SDD].

Figure 1 below shows the monthly single burst detection probability for each of the SAR/Galileo Reference Beacons (REFBE).
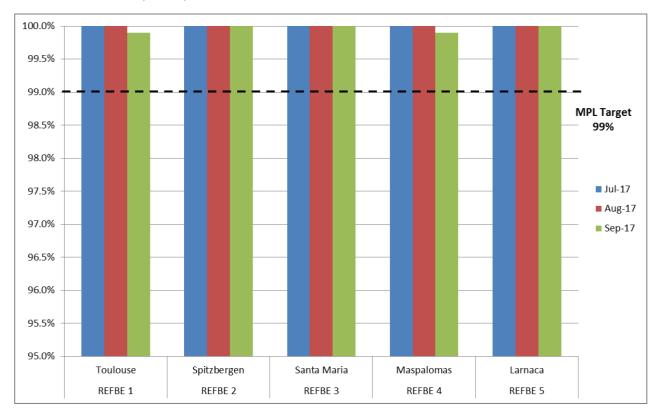

Figure 1: Per Reference Beacon Single Burst Detection Probability

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.

Figure 2 below shows the monthly single burst location probability for each of the SAR/Galileo Reference Beacons (REFBE). 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] .
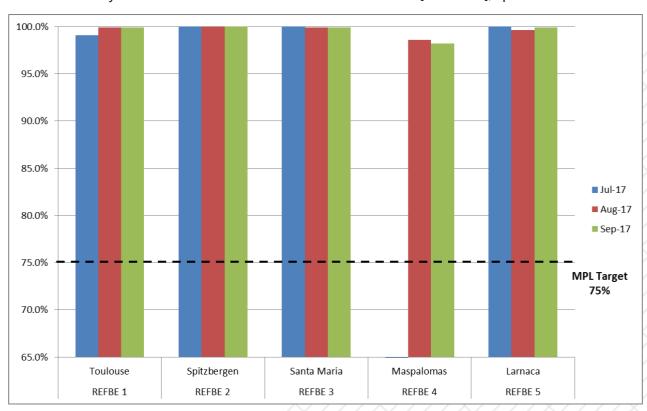

Figure 2: Per Reference Beacon Single Burst Location Probability

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[1] Ref.: [SAR-SDD] , §5.1.1 (Table 9)

[2] Ref.: [SAR-SDD] , §5.1.1 (Table 10)

Figure 3 below shows the monthly multi-burst (12 bursts – 10 minutes) location probability for each of the SAR/Galileo Reference Beacons (REFBE). The multi-burst location probability for each of the Reference Beacons is in all cases 100%, well above the Minimum Performance Level from [SAR-SDD], specified as 98% [3] .

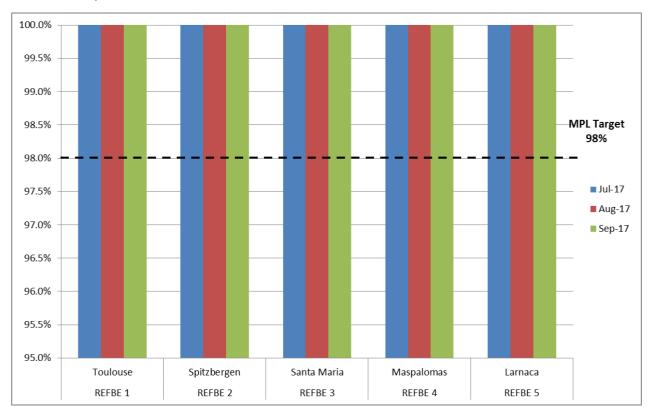
Figure 3: Per Reference Beacon Multi-Burst Location Probability (10 min).

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.

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[3] Ref.: [SAR-SDD] , §5.1.1 (Table 10)

Figure 4 below shows the monthly probability of achieving a location with 5 km accuracy with a single burst from each of the SAR/Galileo Reference Beacons. The probability of achieving 5km accuracy in single burst location for each of the Reference Beacons is always above the Minimum Performance Level from [SAR-SDD], specified as 70% [4].
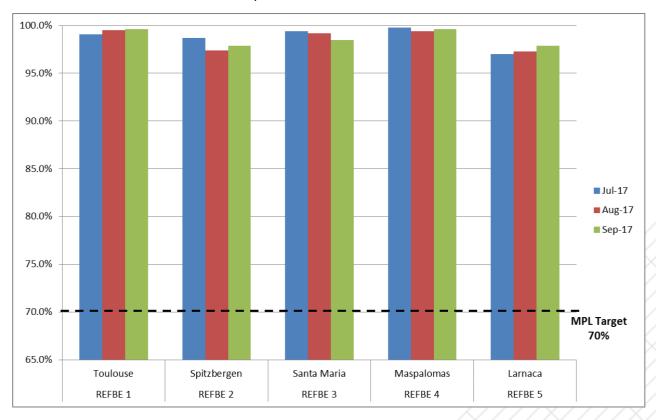

Figure 4: Per Reference Beacon Probability of 5km Accuracy in Single Burst

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[4] Ref.: [SAR-SDD] , §5.1.1 (Table 10)

Figure 5 below 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. 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].
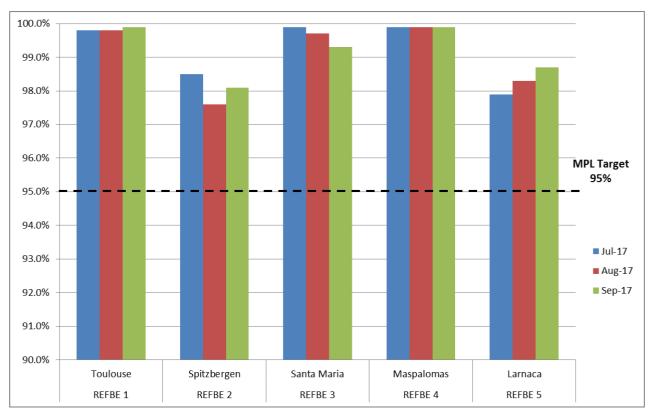

Figure 5: Per Reference Beacon Probability of 5km Accuracy in Multi-Burst

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[5] Ref.: [SAR-SDD] , §5.1.1 (Table 10)

Figure 6 below 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. 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].
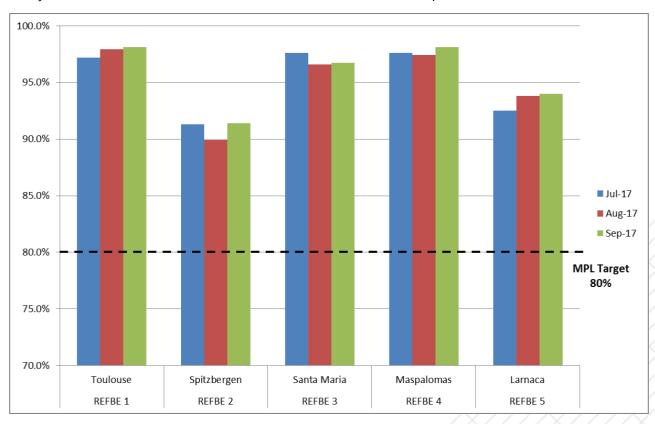

Figure 6: Per Reference Beacon Probability of 2km Accuracy in Multi-Burst

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[6] Ref.: [SAR-SDD] , §5.1.1 (Table 10)

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 nine months. However, 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, which suffered significant degradation due to uplink interference during the months of February 2017 – March 2017, has gradually recovered a more nominal status over the month of April 2017. The availability performance has been fully recovered since May 2017.

Figure 7 below presents the availability of each of the MEOLUT Local Facilities in nominal mode during the months January – September 2017. The Maspalomas and Spitzbergen MEOLUT Local Facilities show monthly availability in nominal mode close to or above the annual average Minimum Performance Level, which is specified as 95%. The cumulative average availabilities over the first nine months of service delivery reaches 95.8% and 98.5% respectively in September 2017. The cumulative availability of the Larnaca MEOLUT in nominal mode is recovering due to good performance over the period April – September 2017 to achieve 90.4%, averaged over the first nine months of service delivery.

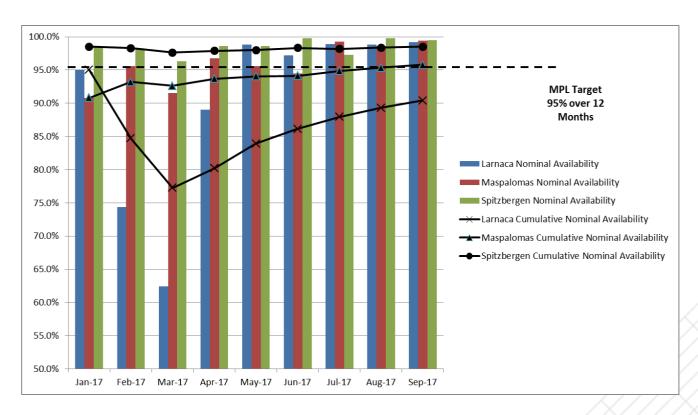[7] Ref.: [SAR-SDD] , §5.2.2 (Table 13, Table 14 and Table 15)

Figure 7: Per MEOLUT Monthly Availability of Nominal Mode

Figure 8 below presents the availability of each of the MEOLUT Local Facilities in "Nominal+ Degraded" mode during the months January – September 2017. The Maspalomas and Spitzbergen MEOLUT Local Facilities show monthly availability in "Nominal + Degraded" Mode above the Minimum Performance Level, which is specified as 97.5%. The cumulative average availabilities over the first nine months of service delivery are 99.1% and 99.0% respectively. The cumulative availability of the Larnaca MEOLUT in "Nominal + Degraded" Mode is recovering due to good performance over the period April – September 2017 to achieve 92.6%, averaged over the first nine months of service delivery.
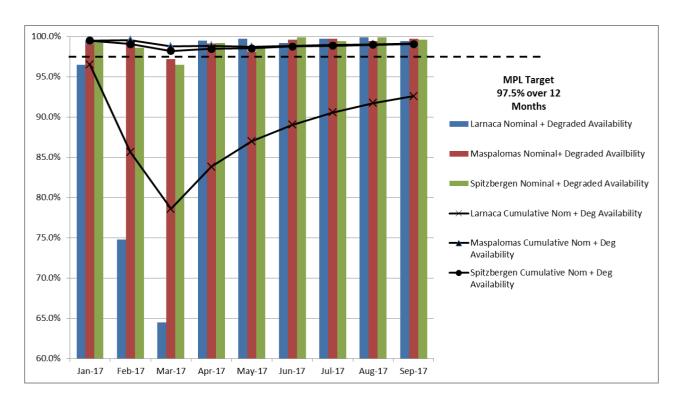
Figure 8: Per MEOLUT Monthly Availability of "Nominal + Degraded" Mode

The MEOLUT Tracking Coordination Facility (MTCF) and SAR Network (SARN) availability during the period July – September 2017 is provided in **Table 4** below. 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. However, at this point in time, key performance indicators can only be averaged over the first 9 months, since the Initial Services declaration. 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 9 months are:

- 99.04% for the MTCF availability which is slightly below the MPL of 99.9%

- 99.84% for the SARN availability which is above the MPL of 99.4%

Other SAR Ground Segment Components	Target Value	July-17	August-17	September-17
MTCF Availability [12 months]	≥ 99.9%	100%	100%	100%
SARN Availability [12 months] Worst Case Connection	≥ 99.4%	100%	≥ 99.97%	≥ 99.97%

Table 4: MTCF and SARN Monthly Availability, July – September 2017

4.2 AVAILABILITY OF THE SAR/GALILEO SPACE SEGMENT

During the period of July – September 2017, all SAR Transponders achieved an availability of 100% each month.

4.3 AVAILABILITY OF THE SAR/GALILEO SERVER

During the period of July – September 2017, the SAR/Galileo Server located in the GSA headquarters has provided SAR satellites orbit data. 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 – September 2017 of 98.1%. Monthly availabilities over July – September 2017 for this server are shown in the Table below for information.

	Target Value	July-17	August-17	September-17
SAR/Galileo Orbit Data Server Availability	N/A	100%	100%	100%

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

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

6 LIST OF ACRONYMS

Acronym	Definition
C/S	Cospas-Sarsat
FOA	Frequency of Arrival
FOC	Full Operational Capability
GPS	Global Positioning System
GSC	European GNSS Service Centre
ICD	Interface Control Document
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
RMS	Root Mean Square
SARN	SAR Network
SDD	Service Definition Document
SGC	SAR/Galileo Coverage
SIS	Signal in Space
TOA	Time of Arrival

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