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EUROPEAN GNSS (GALILEO) INITIAL SERVICES

SAR/GALILEO SERVICE DEFINITION DOCUMENT

TERMS AND CONDITIONS OF USE OF THE GALILEO INITIAL SEARCH AND RESCUE SERVICE

The Galileo SAR Service has been designed in order to support the Cospas – Sarsat International Satellite System for Search and Rescue in the context of the MEOSAR system (Medium Earth Orbit Search And Rescue). The users of this service are the national search and rescue administrations participating in the Cospas – Sarsat Programme. The use of the Galileo SAR Service to support Search and Rescue operations undertaken by the users remains solely under their own responsibility.

Scope of Galileo SAR Commitment

The main infrastructure providing the Galileo SAR Service conforms to the CospasSarsat standards applicable at the date of the start of the initial service provisioning for the MEOSAR Early Operational Capability. Although care has been taken in designing, implementing and operating the system, as well as in providing the SAR, the SAR is not meant to offer any service guarantee to the users.

The minimum performance levels against which the system has been validated and is operated, as well as data of actual performance of the SAR, are expressed in this document in statistical values that are valid under assumptions described in the Galileo SAR SDD. The Commission reserves the right to revise the Galileo Initial SAR SDD should these assumptions change or to reflect changes in performance during the deployment of the Galileo infrastructure. This commitment regarding the minimum level of performance shall be without prejudice to the disclaimer of liability below, measures potentially affecting service availability that may be taken either by the Security Accreditation Board, or according to the Council decision 2014/496/ CSFP, or in the interests of Member States' national security.

The European Union plans to take all necessary measures for the foreseeable future to maintain or exceed the minimum levels of the SAR performance described herein.

The minimum level of performance of the Galileo SAR, as specified in the Galileo SAR SDD, is obtained under the condition that the user equipment complies with the Cospas – Sarsat standard for 406MHz distress beacons defined in the Cospas – Sarsat C/S T.001 document.

Users are reminded that important service notices (Notice Advisory to Galileo Users – NAGUs, SART Status, SAR Service Status) are published by the Galileo service centre (GSC website) or distributed by the French Mission Control Centre (distribution of specific status messages) and shall be taken into account when planning to use the Galileo SAR.

User Responsibilities

The user retains his responsibility to exercise a level of care appropriate with respect to the use he intends to make of the Galileo SAR, taking into account the considerations outlined above.

Users are reminded that location probability and accuracy performance they will experience is also driven by other parameters outside the control of the Galileo SAR provider (e.g. interferer induced errors, outage of Search and Rescue transponders from other GNSS constellations), which have to be taken into account when deciding to use the Galileo SAR for a given purpose.

Before any use of the Galileo SAR, users should study this document in order to understand how they can use the service, as well as to familiarise themselves with the performance levels and other aspects of the service they can rely on, in particular section 5 and Annex C.

In case of doubt, the users and other parties should contact the appropriate helpdesk for the Galileo SAR Service (see Annex H for contact details).

Disclaimer of Liability

As the owner of the Galileo system, the European Union - including any of its institutions, offices or agencies, such as the European Commission, the European GNSS Agency (GSA), and other entities acting on the basis of a contract or agreement with the European Union involved in the Galileo SAR service provision - does not offer any warranties of any kind (whether expressed or implied) with respect to the Galileo SAR Service, including, but not limited to, the warranties regarding availability, continuity, accuracy, integrity, reliability and fitness for a particular purpose or meeting the users´ requirements. No advice or information, whether oral or written, obtained from the European Union - including any of its institutions, offices or agencies, such as the European Commission, the European GNSS Agency (GSA), and other entities acting on the basis of a contract or agreement with the European Union involved in the Galileo SAR service provision - shall create any such warranty.

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and Rescue Service, including, but not limited to, direct, indirect, special or consequential damages, including, but not limited to, damages for interruption of business, loss of profits, goodwill or other intangible losses, other than in accordance with Article 340 of the Treaty on the Functioning of the European Union.

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TABLE OF CONTENTS

TERMS AND CONDITIONS OF USE OF THE GALILEO INITIAL SEARCH AND RESCUE SERVICE i

SECTION 1:
INTRODUCTION 1

1.1 PURPOSE AND SCOPE OF THE DOCUMENT 1

SECTION 2:
COSPAS – SARSAT SYSTEM 2

2.1 OVERVIEW 3
2.2 DISTRESS BEACONS 3
2.3 LEOSAR AND GEOSAR 3
2.4 MEOSAR SYSTEM 4
2.4.1 MEOSAR SATELLITES 5
2.4.2 MEOLUT GROUND STATIONS 5

SECTION 3:
SAR/GALILEO INITIAL SERVICE 8

3.1 SERVICE DEFINITION 9
3.2 SAR/GALILEO INFRASTRUCTURE 10
3.2.1 SAR/GALILEO SPACE SEGMENT 10
3.2.2 SAR/GALILEO GROUND SEGMENT 11
3.2.2.1. OVERVIEW 11
3.2.2.2. SAR/GALILEO MEOLUT 13
3.2.2.3. MTCF 14
3.2.2.4. SAR/GALILEO NETWORK 14
3.2.2.5. SAR/GALILEO REFERENCE BEACONS 15
3.2.2.6. SAR SERVER 16

SECTION 4:
SAR/GALILEO SERVICE OPERATIONS CONCEPT 18

4.1 SAR/GALILEO SERVICE CENTRE 19
4.2 SAR/GALILEO DATA SERVICE PROVIDER 19
4.3 SAR/GALILEO GROUND SEGMENT HOSTING SITE ENTITIES 19
4.4 SAR/GALILEO GROUND SEGMENT MAINTENANCE 19
4.5 SGDSP INTERFACES 20
4.6 OPERATIONAL SCENARIOS RELEVANT TO COSPAS – SARSAT OPERATIONS 21
4.7 INTERFACE FOR AN EXTERNAL MEOLUT 21

SECTION 5:
SAR/GALILEO INITIAL SERVICE PERFORMANCE 24

5.1 DETECTION AND LOCATION PERFORMANCE 25
5.1.1 DETECTION PERFORMANCE 25
5.1.2 LOCATION PERFORMANCE 25
5.1.3 PERFORMANCE OVER SERVICE COVERAGE AREA 26
5.2 SEGMENTS AVAILABILITY 26
5.2.1 AVAILABILITY OF THE SAR/GALILEO SPACE SEGMENT 26
5.2.2 AVAILABILITY OF THE SAR GROUND SEGMENT AND SAR/GALILEO SERVICE STATUS MODES 27
5.3 SAR/GALILEO INITIAL SERVICE LIMITATIONS 29
5.3.1 SERVICE LIMITATION CASES 29

SECTION 6:
SAR/GALILEO INITIAL SERVICE PERFORMANCE MONITORING 30

6.1 KEY PERFORMANCE INDICATORS COLLECTION 31
6.2 KPI COLLECTION PLATFORM (KCP) DESCRIPTION 31

SECTION 7:
SAR/GALILEO SERVICE EVOLUTION 32

7.1 SAR/GALILEO SERVICE ROADMAP 33
7.2 RETURN LINK SERVICE 33
7.3 SATELLITE COVERAGE WITH INCREASED NUMBER OF SAR/GALILEO REPEATERS 33

ANNEX A:
REFERENCE DOCUMENTS.....36

ANNEX B:
ACRONYMS.....38

ANNEX C:
OBSERVED SAR/GALILEO INITIAL SERVICE PERFORMANCE.....40

C.1. OBSERVED SERVICE AVAILABILITY.....41

C.2. OBSERVED LOCATION PROBABILITY ACCURACY.....41

C.3. OBSERVED MEOLUT AVAILABILITY.....41

ANNEX D:
COVERAGE SIMULATIONS.....44

D.1. CURRENT SPACE SEGMENT COVERAGE.....45

D.2. EXPECTED COVERAGE OF SPACE SEGMENT IN MID 2017.....46

D.3. EXPECTED COVERAGE OF SPACE SEGMENT AT END OF YEAR 2017.....46

D.4. FULL SAR/GALILEO SPACE SEGMENT COVERAGE.....46

ANNEX E:
EXTERNAL DATA EXCHANGE.....48

E.1. TOA/FOA EXCHANGE AND MTCF TRACKING PLAN FILES.....49

E.2. EXTERNAL MEOLUT CONNECTION.....50

ANNEX F:
SAMPLE NARRATIVE MESSAGE SIT 605.....52

ANNEX G:
SAR/GALLEO SERVER USER MANUAL AND INTERFACES.....54

G.1. GSC – SAR SERVER OVERVIEW.....55

G.1.1 GSC – SAR SERVER CONTENT.....55

G.1.1.1. GALILEO ORBITAL PRODUCTS.....55

G.1.1.2. HASH FILES.....56

G.1.1.3. WELCOME MESSAGE AND VALIDITY LOG FILE.....56

G.1.2 SERVER FOLDERS STRUCTURE.....57

G.1.3 SERVER STORAGE RULES.....58

G.1.4 SERVER USER COMMANDS.....58

G.2. GSC – SAR SERVER FILES FORMAT.....58

G.2.1 GALILEO ORBITAL PRODUCTS.....58

G.2.1.1. RINEX NAVIGATION MESSAGE (NAVRE).....58

G.2.1.2. PREDICTED SATELLITE ORBITS (PRDOB).....58

G.2.1.3. PREDICTED SATELLITE CLOCK (PSATC).....58

G.2.1.4. ALMANAC (INF_ALMANACDATA).....58

G.2.1.5. EPHEMERIS DATA (NAV_EPHEMTORLSP).....59

G.2.2 HASH FILES.....59

G.2.3 VALIDITY LOG FILE.....59

G.3. USER INTERFACES.....59

G.3.1 USER ACCESS REQUEST.....59

G.3.2 SERVICE INVESTIGATION REQUEST FROM SAR USERS.....61

G.3.3 SERVICE NOTIFICATION.....61

G.4. SAR COMMUNITY INVESTIGATION REQUEST CONTENT.....61

ANNEX H:
FURTHER INFORMATION REQUEST ON THE SAR/GALILEO SERVICE.....64

LIST OF FIGURES

FIGURE 1. SAR EVENTS DISTRIBUTION. 3

FIGURE 2. A SELECTION OF AVAILABLE DISTRESS BEACONS 3

FIGURE 3. DESCRIPTION OF LEOSAR AND GEOSAR SYSTEM. 4

FIGURE 4. COSPAS – SARSAT MEOSAR SYSTEM USING L BAND SATELLITES. 5

FIGURE 5. SAR REPEATER. 5

FIGURE 6. SAR/GALILEO ARCHITECTURE. 9

FIGURE 7. SAR/GALILEO SERVICE COVERAGE AND SAR/GALILEO SITES. 9

FIGURE 8. FULL GALILEO CONSTELLATION AND SATELLITE OVERVIEW 11

FIGURE 9. SAR/GALILEO GROUND SEGMENT OVERALL ARCHITECTURE. 12

FIGURE 10. MASPALOMAS EU/MEOLUT LOCAL FACILITY. 14

FIGURE 11. SPITSBERGEN EU/MEOLUT LOCAL FACILITY. 14

FIGURE 12. LARNACA EU/MEOLUT LOCAL FACILITY. 14

FIGURE 13. SARN SYNOPTIC. 15

FIGURE 14. REFERENCE BEACONS TRANSMISSION SCHEDULE WITHIN 1 HOUR. 16

FIGURE 15. INTERFACES OF THE SAR/GALILEO OPERATIONS. 20

FIGURE 16. SINGLE-BURST DETECTION PROBABILITY (SPACE SEGMENT OF OCTOBER 2016). 26

FIGURE 17. SIMULATED LOCATION PROBABILITY AFTER 10 MINUTES (SPACE SEGMENT OF OCTOBER 2016). 26

FIGURE 18. SIMULATED PROBABILITY OF LOCATION ACCURACY WITHIN 5 KM AFTER 10 MINUTES (SPACE SEGMENT OF OCTOBER 2016). 26

FIGURE 19. EU/MEOLUT SATELLITE ORBIT DATA RECOVERY PROCESS. 27

FIGURE 20. SGDSP KPI SERVICE. 31

FIGURE 21. DECEMBER 2016 - SPACE SEGMENT CO-VISIBILITY (AT LEAST 3 SATELLITES). 45

FIGURE 22. DECEMBER 2016 - SPACE SEGMENT CO-VISIBILITY (AT LEAST 4 SATELLITES). 45

FIGURE 23. MID 2017 EXPECTED SPACE SEGMENT CO-VISIBILITY (AT LEAST 3 SATELLITES). 46

FIGURE 24. MID 2017 EXPECTED SPACE SEGMENT CO-VISIBILITY (AT LEAST 4 SATELLITES). 46

FIGURE 25. EXPECTED WORST CASE MINIMUM NUMBER OF VISIBLE SATELLITES FOR END OF YEAR2017 SPACE SEGMENT. 46

FIGURE 26. MINIMUM NUMBER OF VISIBLE SATELLITES FOR FULL SAR/GALILEO CONSTELLATION. 47

FIGURE 27. GSC – SAR SERVER WELCOME MESSAGE 56

FIGURE 28. GSC – SAR SERVER FOLDERS STRUCTURE 57

FIGURE 29. MD5 HASH EXAMPLE FILE 59

FIGURE 30. VALIDITY LOG FILE EXAMPLE. 59

FIGURE 31. SAR SERVER – USER ACCESS REQUEST. 60

LIST OF TABLES

TABLE 1. LIST OF LEOSAR SATELLITES. 4

TABLE 2. LIST OF GEOSAR SATELLITES. 4

TABLE 3. DESCRIPTION OF MEOSAR CONSTELLATIONS. 5

TABLE 4. SAR/GALILEO PAYLOAD CHARACTERISTICS. 10

TABLE 5. SPECIFIC SAR/GALILEO TRANSPONDER CHARACTERISTICS IN NORMAL AND NARROWBAND MODES. 11

TABLE 6. LIST OF SAR/GALILEO SATELLITES. 11

TABLE 7. SAR/GALILEO GROUND SEGMENT LOCATIONS. 13

TABLE 8. REFERENCE BEACON CHARACTERISTICS. 15

TABLE 9. SAR/GALILEO INITIAL SERVICE DETECTION PERFORMANCE EXPECTATIONS. 25

TABLE 10. SAR/GALILEO INITIAL SERVICE LOCATION PERFORMANCE EXPECTATIONS. 25

TABLE 11. SAR/GALILEO TRANPONDER MINIMUM EXPECTED AVAILABILITY. 26

TABLE 12. SAR/GALILEO SERVICE GLOBAL STATUS. 28

TABLE 13. MEOLUT STATUS REQUIREMENTS OVER A PERIOD OF 1 YEAR. 28

TABLE 14. SARN STATUS OVER A PERIOD OF 1 YEAR. 28

TABLE 15. MTCF STATUS OVER A PERIOD OF 1 YEAR. 28

TABLE 16. SAR/GALILEO INITIAL SERVICE LIMITATIONS. 29

TABLE 17. SAR/GALILEO SERVICE ROADMAP. 33

TABLE 18. SIMULATION OF 3 AND 4 SATELLITES COVERAGE AVAILABILITY THOUGH TIME FROM SGC. 34

TABLE 19. SATELLITE SLOTS CONSIDERED IN THE EVALUATION. 34

TABLE 20. KPI COLLECTION PERIOD (AUGUST 2016) DETECTION SERVICE PERFORMANCE. 41

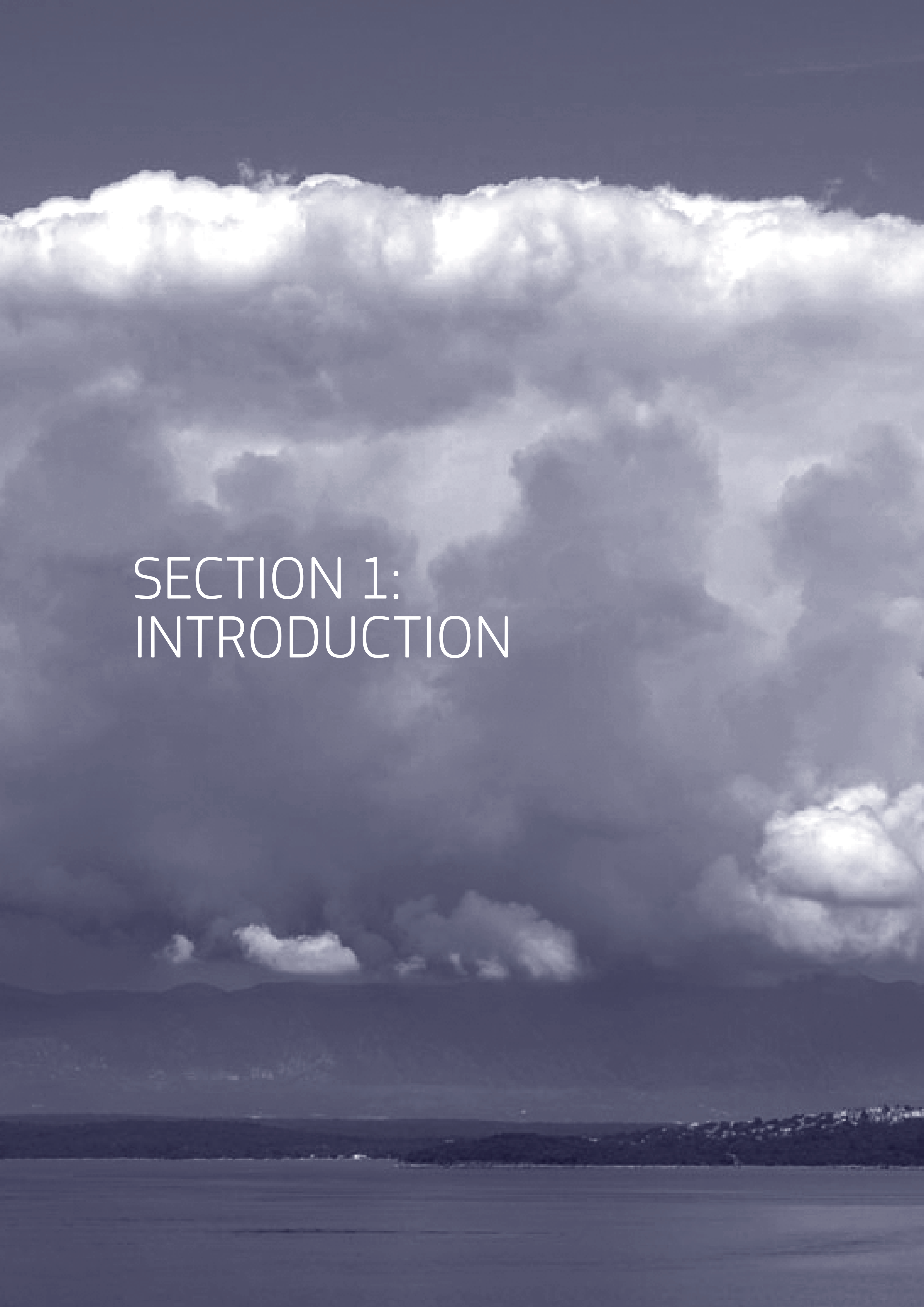
TABLE 21. KPI COLLECTION PERIOD (AUGUST 2016) LOCATION SERVICE PERFORMANCE. 41

TABLE 22. MEOLUT AVAILABILITY STATUS OVER THE KPI COLLECTION PERIOD IN AUGUST 2016. 42

TABLE 23. GSC – SAR SERVER ORBITAL PRODUCTS. 55

TABLE 24. SAR SERVER USER REGISTRATION FORM CONTENT. 60

TABLE 25. SAR COMMUNITY INVESTIGATION REQUEST. 62



SECTION 1: INTRODUCTION

1.1 PURPOSE AND SCOPE OF THE DOCUMENT

This SAR/Galileo Initial Service Definition Document provides SAR/Galileo Service users with a detailed overview of the SAR/Galileo Service provided by the European Commission. The SAR/Galileo Service is offered to the Search and Rescue community taking benefit of the MEOSAR program established by Cospas – Sarsat. This Service Definition Document describes the deployed infrastructure of the service, its operational concept as well as the expected service performance at the time of issue of this document. The expected evolution of the service performance as the Galileo system is deployed is also provided in the document. It includes the following sections:

- Section 1 “Introduction”.
- Section 2 “Cospas – Sarsat System” describes the context of the Cospas – Sarsat program in which the SAR/Galileo Service is provided. The general Cospas – Sarsat architecture is presented with its currently operational LEOSAR and GEOSAR systems and the transition to the MEOSAR system. The function of different technical components (beacons, satellites, ground stations and Mission and Control Centres, SAR Rescue Centres and entities) is recalled.
- Section 3 “SAR/Galileo Initial Service” defines the SAR/Galileo Initial Service and the coverage area. This section also presents the different entities involved, describing SAR/Galileo infrastructures including Galileo SAR Payloads, the SAR/Galileo Service Centre in Toulouse and the three European ground stations spread over Europe. It describes the function of all components and the interfaces between them.
- Section 4 “SAR/Galileo Service Operations concept”. This section describes how operations are conducted in the frame of the SAR/Galileo Ground Segment and SAR/Galileo Space Segment, and the operational external interfaces available to any external MEOLUT.
- Section 5 “SAR/Galileo Initial Service Performance”. This section defines the service and the associated level of performance that can be expected in terms of availability of detection and location, accuracy of location and availability of ground segment components.
- Section 6 “SAR/Galileo Initial Service Performance Monitoring” explains how the service performance is monitored in order to guarantee the service quality.
- Section 7 “SAR/Galileo Service Evolution” gives a perspective view of the SAR/Galileo Service consolidation in the future.
- Annex A "Reference Documents".
- Annex B "Acronyms".
- Annex C “Observed SAR/Galileo Initial Service Performance” presents the current system real performance indicator values over a given observation period.
- Annex D “Coverage Simulation” shows different maps of the output from the geometrical coverage simulation with different space segment configurations.
- Annex E “External Data Exchange” gives some examples of the file formats used within the SGS that can be exchanged with external facilities such as a MEOLUT.
- Annex F "Sample Narrative Message SIT 605" gives an example of the SIT605 message that will be distributed to inform the Cospas – Sarsat MCC about SAR/Galileo Service Status.
- Annex G "SAR/Galileo Server User Manual and Interfaces" provides all the elements for external MEOLUT operators to access to the Galileo satellites Orbit Data Server and retrieve ephemeris, almanacs, etc..
- Annex H lists the contact points for additional information or support on the SAR/Galileo Service.

SECTION 2: COSPAS – SARSAT SYSTEM[1]

2.1 OVERVIEW

Cospas – Sarsat is an international satellite system for Search And Rescue (SAR) distress alerting that was established in 1979 by Canada, France, the USA and the former USSR. Since its inception the Cospas – Sarsat Program has continually progressed at the technical level, but also by expanding to other countries wishing to participate. Currently the organization gathers 43 countries. Cospas – Sarsat cooperates actively with the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO) and the International Telecommunication Union (ITU).

Since regulations have been adopted requiring the installation of beacons on aircraft or on merchant vessels and fishing boats, more than 1.4 million beacons are in service around the world, which permitted rescuing more than 37,000 people in 31 years and more than 2000 per year currently.

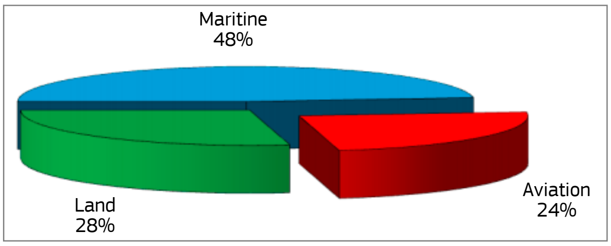


Figure 1. SAR events distribution.

2.2 DISTRESS BEACONS

The first generation of Cospas – Sarsat 406 MHz beacons has been specifically designed for use with the LEOSAR system. These beacons have specific requirements on the stability of the transmitted frequency, and the inclusion of a digital message which allows the transmission of encoded data such as unique beacon identification. Specifications of C/S beacons are provided in Annex A[4]. The evolutions of the Cospas – Sarsat System, as MEOSAR, will ensure backwards compatibility with the beacons developed in the context of the LEOSAR system.

2.3 LEOSAR AND GEOSAR

The Cospas – Sarsat System provides distress alert and location information to Search And Rescue (SAR) services throughout the world for maritime, aviation and land users in distress. The current operational system is composed of:

EPIRB (Maritime)	ELT (Aviation)	PLB (Personal)

Figure 2. A selection of available distress beacons

1....... *Information based on C/S Documents and presentations available on the C/S web site (http://www.cospas-sarsat.int).*

- Satellites in Low-altitude Earth Orbit (LEOSAR) and Geostationary Orbit (GEOSAR) that process and/or relay signals transmitted by distress beacons;
- Ground receiving stations called Local User Terminals (LUT) which process the satellite signals to locate the beacon;
- Mission Control Centres (MCC) that provide the distress alert information to SAR authorities, Rescue Co-ordination Centre (RCC).

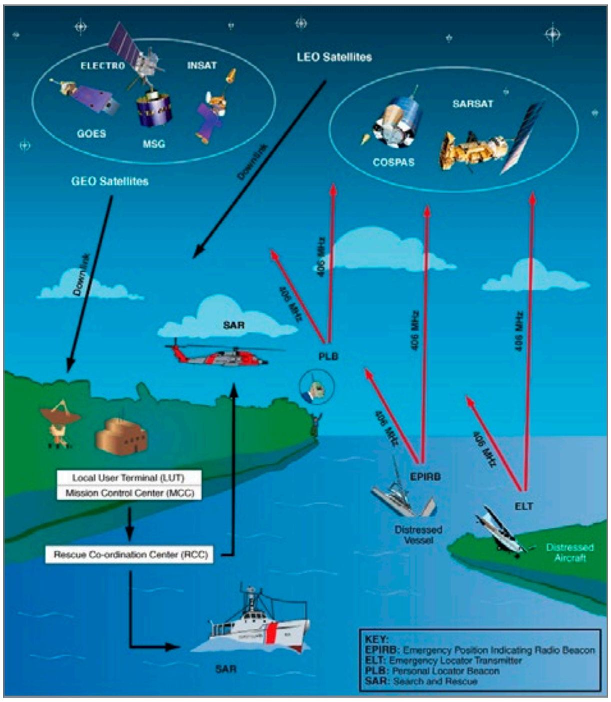


Figure 3. Description of LEOSAR and GEOSAR system.

Currently five satellites in Low-altitude Earth Orbit are operational, which provide a typical waiting time to locate between half an hour and two hours at mid-latitudes. The service availability is around 20% of the time.

LEOSAR CONSTELLATION	C/S ID	LAUNCH DATE	STATUS
SARSAT - 7	007	May 1998	operational
SARSAT - 10	010	May 2005	operational
SARSAT - 11	011	October 2006	operational
SARSAT - 12	012	February 2009	operational
SARSAT - 13	013	September 2012	operational

Table 1. List of LEOSAR satellites (Status CSC-57 December 2016).

In addition, there are currently eight satellites in the Geostationary Earth Orbit equipped with SAR repeater and declared operational. Four satellites are under test.

GEOSAR CONSTELLATION	C/S ID	LAUNCH DATE	STATUS
GOES - 13	213	May 2006	operational
GOES - 14	214	June 2009	spare
GOES - 15	215	March 2010	operational
INSAT - 3D	244	July 2013	operational
INSAT – 3DR	245	September 2016	under test
MSG – 1	261	August 2002	operational
MSG - 2	262	December 2005	operational
MSG - 3	263	July 2012	operational
MSG - 4	264	July 2015	under test
Electro - L1	221	January 2011	operational
Electro – L2	224	December 2015	under test
Louch - 5A	222	December 2011	under test
Louch - 5V	223	April 2014	under test

Table 2. List of GEOSAR satellites (Status CSC-57 December 2016).

2.4 MEOSAR SYSTEM

In 2000 the USA, the European Commission (EC) and Russia began consultations with Cospas – Sarsat regarding the feasibility of installing SAR repeater payloads on their respective Medium-altitude Earth Orbit navigation satellite systems (MEOSAR), and incorporating a 406 MHz MEOSAR capability in Cospas – Sarsat. The USA MEOSAR programme is called SAR-GPS, the European programme is called SAR/Galileo, and the Russian programme is referred to as SAR/GLONASS.

The initial investigations identified many possible SAR alerting benefits that might be realized from a MEOSAR system, including:

- Near instantaneous global coverage with accurate independent location capability,
- Robust beacon to satellite communication links, high levels of satellite redundancy and availability,
- Resilience against beacon to satellite obstructions, and
- The possible provision of additional (enhanced) SAR services.

Once fully operational, the MEOSAR system will offer the advantages of both LEOSAR and GEOSAR systems without their current limitations by providing transmission of the distress message, and independent location of the beacon, with a near real time worldwide coverage.

The large number of MEOSAR satellites that will be in orbit when the system is fully operational will allow each distress message to be relayed at the same time by several satellites to several ground antennas, improving the likelihood of detection and the accuracy of the location determination.

The MEOSAR System is currently under implementation. The following operational phases are planned for the Cospas – Sarsat MEOSAR system:

- 2017: EOC (Early Operational Capability)
- 2018 – 2019: IOC (Initial Operational Capability)
- 2020: FOC (Full Operational Capability)

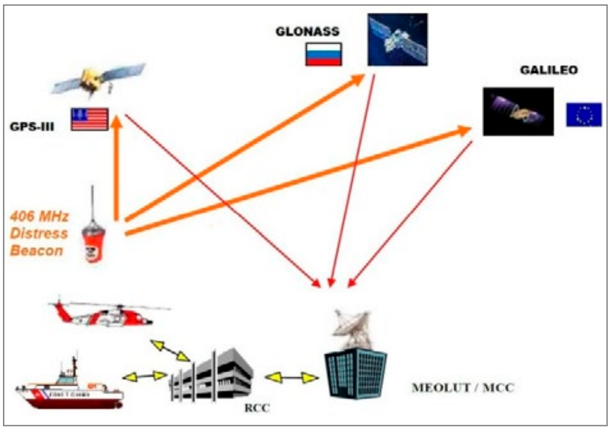


Figure 4. Cospas – Sarsat MEOSAR System using L band satellites.

2.4.1 MEOSAR SATELLITES

MEOSAR satellites orbit the Earth at altitudes ranging from 19,000 to 24,000 km. The primary mission for the satellites used in the three MEOSAR constellations is the Global Navigation Satellite Systems (GNSS). They are the Global Positioning System (GPS), Galileo and GLONASS. A detailed description of the MEOSAR payloads is provided in Annex A[5].

Table 3 shows the characteristics of all constellations:

In addition, it has to be underlined that experimental S-Band SAR payloads are also embarked on board GPS/DASS. These payloads are not considered for the long-term MEOSAR operations (not presented in Table 3) but their operational use on a temporary basis for the MEOSAR EOC and IOC is authorized by Cospas – Sarsat.

All MEOSAR satellite constellations use transparent repeater instruments to relay 406 MHz beacon signals, without on board processing, data storage, or demodulation. The SAR/Galileo and SAR/GLONASS payloads operate with downlinks in the 1544 – 1545 MHz band (L band) and the GPS-DASS uses the S band at 2226 MHz (experimental).

MEOSAR CONSTELLATION	GALILEO (IOV+FOC)	SAR/ GLONASS K	SAR-GPS
Number of currently active satellites	12/24	2/24	0/24
Number of orbital planes	3	3	6
Orbital inclination	56°	64°	55°
Orbital altitude	23.222 km	19.140 km	20.180 km
Period of revolution	14h 22min	11h 15min	11h 58min
Uplink Polarization	RHCP	RHCP	LHCP
Downlink Frequency / Pol.	1544.1 MHz LHCP	1544.9 MHz LHCP	1544.9 MHz RHCP
Status	Operational	Operational	In Development
First Launch date	October 2012	February 2011	Planned 2023

Table 3. Description of MEOSAR constellations.

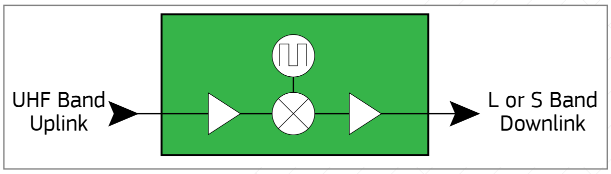


Figure 5. SAR Repeater.

As of the 1st December 2016, the following MEOSAR satellites can be used for MEOSAR operations:

- SAR/Galileo: 12 operational L-Band transponders.
- SAR/Glonass: 2 operational L-Band transponders.
- DASS/GPS: 19 experimental S-Band transponders (limited for use in EOC and IOC phases).

2.4.2 MEOLUT GROUND STATIONS

The downlinks are processed by ground receiving stations called MEO Local User Terminals (MEOLUT), to provide beacon identification and location information. The distress alert information computed by MEOLUTs is forwarded to Cospas – Sarsat Mission Control Centres (MCCs) for distribution to SAR services. The MEOSAR payloads are designed following a number of interoperability requirements which allow the MEOLUTs to compute the location of distress beacons based on any combination of signals received from the MEOSAR satellites.

The MEOSAR system provides independent distress beacon location information using a combination of Time Of Arrival (TOA) and Frequency Of Arrival (FOA) measurements. MEOLUTs calculate the beacon location by measuring and processing the time and frequency differences (TDOA and FDOA) of the same beacon burst relayed by different satellites.

MEOSAR location accuracy is affected by many factors including the signal-to-noise ratio, the number of time and frequency measurements available at the MEOLUT for a given beacon burst, the accuracy of the time and frequency measurements, and the geometry between the beacon and the relaying satellites (Dilution Of Precision).

MEOLUT Specifications are defined in C/S document Annex A[7]. In order to be considered as operational by Cospas – Sarsat, the MEOLUT must be formally commissioned according to MEOLUT Commissioning Standards defined in Annex A[8].

SECTION 3: SAR/GALILEO INITIAL SERVICE

3.1 SERVICE DEFINITION

The SAR/Galileo Initial Service is a contribution to the Cospas – Sarsat MEOSAR Program through the provision of a Forward Link Alert Service.

The SAR/Galileo Initial Service supports the Cospas – Sarsat Search and Rescue program, as it provides:

- Alerts (detection and location data) to the Cospas – Sarsat Mission Control Centre through its ground segment component and based on specific levels of performance as defined in this document in SECTION 5.
- TOA/FOA data to external MEOLUTs as elaborated in this document in section 4.7. Relay of distress signals to other Cospas – Sarsat MEOLUTs by the SAR/Galileo repeaters.
- Relay of Cospas – Sarsat 406MHz distress signals to MEOLUTs worldwide.

The SAR/Galileo Initial Service is based on the infrastructure provided by the Galileo Programme, composed of the following specific elements:

- SAR Repeaters embarked on-board the Galileo satellites (12 operational at 1st October 2016);
- 3 European MEOLUTs deployed in: Maspalomas (Spain), Spitsbergen (Norway) and Larnaca (Cyprus);
- 1 MEOLUT Tracking Coordination Facility (MTCF) located in the SAR/Galileo Service Centre (SGSC) in Toulouse (France);
- 5 SAR/Galileo Reference Beacons located in Maspalomas (Spain), Spitsbergen (Norway), Larnaca (Cyprus), Toulouse (France) and Santa Maria (Portugal);
- 1 SAR Server, providing detailed orbit parameters to the SAR/Galileo and Cospas – Sarsat operational facilities.

Furthermore, the SAR/Galileo Initial Service fully exploits the signals relayed by the other available MEOSAR payloads (GPS/DASS S-Band, SAR/GLONASS) to provide increased service availability to the Cospas – Sarsat Mission Control Centres.

The signals relayed by the MEOSAR satellites are received by the three European MEOLUTs, which ensures

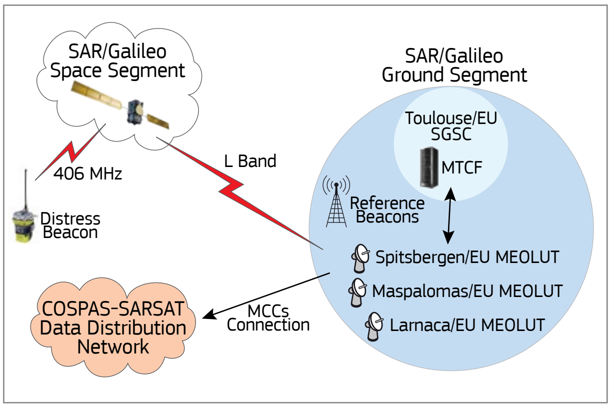


Figure 6. SAR/Galileo architecture.

the provision of the service over the coverage area, referred to as "SAR Galileo Coverage" (SGC, blue contour line on Figure 7), which includes as a minimum all search and rescue areas under the responsibilities of European territories (red contour line on Figure 7). The "SAR Galileo Coverage" is the MEOLUTs coverage declared to Cospas – Sarsat as a contribution to the MEOSAR global coverage.

The coverage is defined by the following coordinates:

- SGC1: 85.00° N; 41.20°E
- SGC2: 29.18° N; 37.07°E
- SGC3: 05.00° N; 38.00°W
- SGC4: 75.76° N; 77.87°W

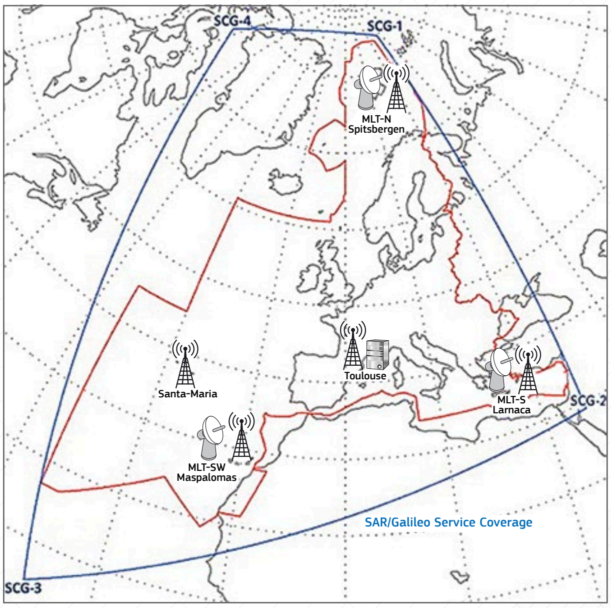


Figure 7. SAR/Galileo Service Coverage and SAR/Galileo Sites

The service coverage could be further enlarged within the Cospas – Sarsat cooperation scheme (with other MEOLUTs).

3.2 SAR/GALILEO INFRASTRUCTURE

3.2.1 SAR/GALILEO SPACE SEGMENT

The SAR/Galileo Space Segment providing the Forward Link Alert Service is composed of Galileo satellites with Search and Rescue Repeaters (SARR). The Galileo SAR Repeaters are bent pipe type transparent transponders. The SARR comprises the SAR Transponder and SAR receiving and transmitting antennas. They receive signals in the 406 MHz band and retransmit in the L-band at 1544.1 MHz. The SAR/Galileo Transponders are commissioned following the Cospas – Sarsat Standard defined in Annex A[6]. A detailed description of the SAR/Galileo payload is provided in Annex A[5] and the main technical parameters are provided in Table 4.

Galileo Repeater Operating Modes

The Galileo Repeater can operate in two bandwidth modes. The operational modes include the Normal (90 kHz) and Narrow (50 kHz) bandwidth modes, as well as the possibility to operate with adjustable Fixed Gain Mode (FGM) or Automatic Level Control (ALC) mode. The operational modes of the SAR Repeater are therefore:

ON mode:

- ALC (Automatic Level Control):

  The transponder gain in ALC mode is self-regulated to ensure stable EIRP, the operational gain is automatically adjusted to obtain a predefine power at the output of the SAR transponder.

  - ALC90: 90 kHz BW (normal bandwidth mode, default mode)
  - ALC50: 50 kHz BW (narrowband mode)

- FGM (Fixed Gain Mode):

  The operational gain in FGM is set by telecommand in a 30 dB range, with nominal step of 1 dB. The range is adjusted so that when the transponder is in the 90 kHz bandwidth mode, and at the input of the repeater there is only thermal noise, the nominal output power of 7 dBW is achieved for a typical gain step of 22 dB. Then, the overall gain of the SAR repeater in the reference gain setting in FGM (including the gains of the receiving and transmitting antennas) is around 182 dB at the edge of coverage.

  - FGM90: 90 kHz BW (normal bandwidth mode)
  - FGM50: 50 kHz BW (narrowband mode)

STANDBY mode:

Transponder is powered up, but RF power is OFF.

SAR/GALILEO PARAMETER	GALILEO IOV SARR CHARACTERISTICS: GSAT 0103 AND 0104	GALILEO FOC SARR CHARACTERISTICS: GSAT 020X	UNIT
Uplink frequency range	406.0 to 406.1	406.0 to 406.1	MHz
Maximum input power at antenna	-153	-153	dBW
System dynamic range	32	30	dB
Receive antenna polarisation	RHCP	RHCP	
Receive antenna edge gain	11.7	11.7	dBi
Receive antenna axial ratio	<1.8	<1.8	dB
Satellite G/T edge of coverage	>-14.9	> -15.3	dB/K
Satellite G/T centre of coverage	>-12.6	>-13.6	dB/K
System Noise Temperature	380	365	K
Transponder gain	165-187	165-187	dB
Transponder linearity	32	28	dBc
Translation frequency	1,138,050,000.0	1,138,049,997.6	Hz
Frequency translation accuracy[2]	$<10^{-11}$	$<10^{-11}$	
Downlink frequency band	1,544.0 to 1,544.2	1,544.0 to 1,544.2	MHz
Downlink antenna polarisation	LHCP	LHCP	
Transmit antenna axial ratio	<1.7	<1.9	dB
Downlink EIRP edge of coverage	18.7	>17.8	dBW
Downlink EIRP centre of coverage	20.3	<19.5	dBW

Table 4. SAR/Galileo Payload Characteristics.

2....... *The frequency translation accuracy depends on the satellite clock drift. The concept implemented in the Galileo system is to let the clocks drift and broadcast the clock corrections. This accuracy is to be achieved when using the broadcast clock correction. In addition, the relativistic effects should be taken into account.*

OFF mode:

Transponder is not powered.

SAR Transponder main characteristics according to the bandwidth mode are shown in Table 5 and defined in detail in Annex A[5].

SAR/GALILEO TRANSPONDER PARAMETER	NORMAL MODE	NARROW-BAND MODE	UNIT
Bandwidth	90	50	kHz
Receive centre frequency	406.050	406.043	MHz
Group delay GSAT0103/0104	27	38	µs
Group delay GSAT02xx	48	68	µs

Table 5. Specific SAR/Galileo Transponder characteristics in normal and narrowband modes.

The fully deployed Galileo constellation will consist of three orbital planes with eight equally spaced operational satellites (Walker 24/3/1 configuration), plus six active spare satellites (two per plane).

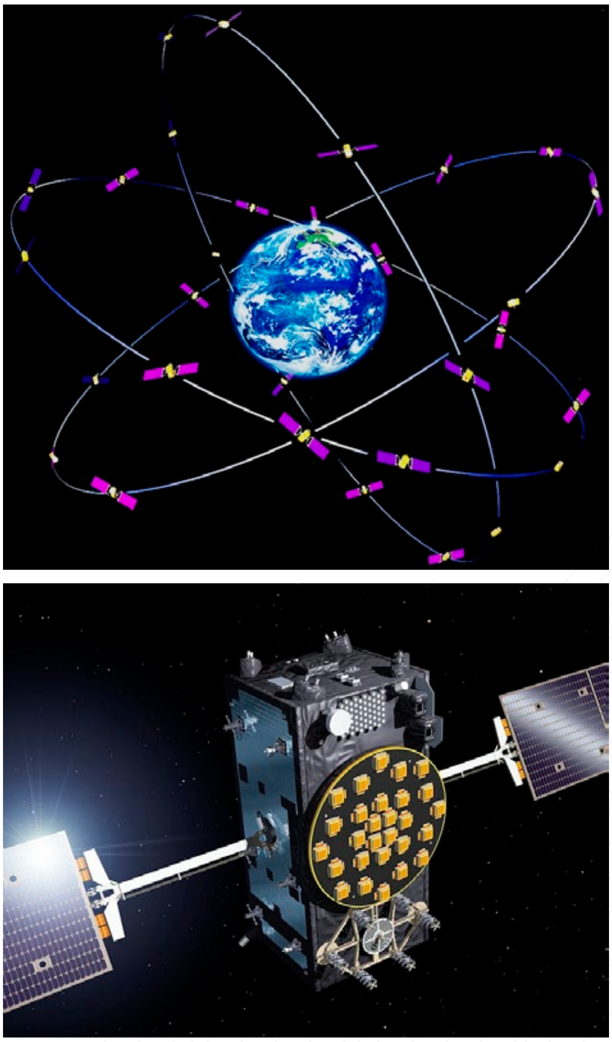


Figure 8. Full Galileo Constellation and satellite overview (Image:© ESA).

The list of operational SAR/Galileo repeaters supporting the SAR/Galileo Initial Service is given in Table 6. They are included in Annex A[5].

GALILEO SATELLITE	C/S ID	SLOT	LAUNCH DATE	STATUS	COMMIS-SIONING REPORT
GSAT 0103	419	C04	October 2012	FOC	Yes
GSAT 0104	420	C05	October 2012	FOC **	Yes
GSAT 0201	418	N/A *	August 2014	FOC **	Yes
GSAT 0202	414	N/A *	August 2014	FOC **	Yes
GSAT 0203	426	B08	March 2015	FOC	Yes
GSAT 0204	422	B03	March 2015	FOC	Yes
GSAT 0205	424	A08	September 2015	FOC	Yes
GSAT 0206	430	A05	September 2015	FOC	Yes
GSAT 0208	408	C07	December 2015	FOC	Yes
GSAT 0209	409	C02	December 2015	FOC	Yes
GSAT 0210	401	A02	May 2016	IOC	No
GSAT 0211	402	A06	May 2016	IOC	No
GSAT 0207	407	C01	November 2016	Under Test	N/A
GSAT 0212	403	C03	November 2016	Under Test	N/A
GSAT 0213	404	C06	November 2016	Under Test	N/A
GSAT 0214	405	C08	November 2016	Under Test	N/A
GSAT 0215	406	A03	End 2017	Planned	N/A
GSAT 0216	428	A07	End 2017	Planned	N/A
GSAT 0217	416	A01	End 2017	Planned	N/A
GSAT 0218	417	A04	End 2017	Planned	N/A
GSAT 0219	410	B01	2018	Planned	N/A
GSAT 0220	413	B04	2018	Planned	N/A
GSAT 0221	415	B02	2018	Planned	N/A
GSAT 0222	429	B07	2018	Planned	N/A

Table 6. List of SAR/Galileo satellites.

*......*For 418 and 414 satellites, different orbital parameters apply.*

**.....*Usable with GSC (Galileo Service Centre) ephemeris recovered from Internet.*

3.2.2 SAR/GALILEO GROUND SEGMENT

3.2.2.1. OVERVIEW

The SAR/Galileo Ground Segment consists of three MEOLUTs all sharing 12 measurements channels (antennas and associated TOA/FOA signal measurement processor) spread over three distinct locations: Maspalomas, Larnaca and Spitzbergen.

The three MEOLUTs receive the TOA/FOA data measured from signals received at each of the twelve antennas, which are distributed through an internal network called the SAR Network (SARN).

Tracking of the twelve antennas is coordinated by a specific facility called "MEOLUT Tracking Coordination Facility" (MTCF). Coordination of antenna tracking between the various sites allows optimization of the service performance and coverage of each MEOLUT.

The European MEOLUT system will therefore consist of the following infrastructure:

- **A MEOLUT Local Facility** which includes the infrastructure located at the site where the European MEOLUT has its connection to its associated MCC (SPMCC, CYMCC and NMCC). The site where the MEOLUT Local Facility is located is called the "MEOLUT Hosting Site". The MEOLUT Local Facility infrastructure includes:
  - shared antennas and associated signal measurements processors (TOA/FOA measurements),
  - 1 TOA/FOA Server for distribution of the TOA/FOA data to the other MEOLUT Local Facilities,
  - 1 processing facility in charge of the beacon localization processing and message generation to the MCC.
- A network infrastructure (SARN), which allows the reception (and transmission) of TOA/FOA data measured on signals received at the antennas from the other MEOLUT Local Facilities.
- A total of 12 shared antennas (including the four from the MEOLUT Local Facility). The eight additional shared antennas and associated signal measurement processors (TOA/FOA measurements) are located at the other MEOLUT Hosting Sites.

The MEOLUT Tracking Coordination Facility (MTCF) acts as a central point in the SAR/Galileo Ground Segment. In addition to the coordination of the tracking plan of the twelve antennas, it also receives through the SAR Network the TOA/FOA data computed by each of the MEOLUT Local Facilities. The MTCF is located at the SAR/Galileo Service Centre (SGSC).

The SAR/Galileo Ground Segment also includes five Reference Beacons (REFBE) located in Toulouse (France), Spitsbergen (Norway), Santa Maria (Portugal), Maspalomas (Spain) and Larnaca (Cyprus). These reference beacons disseminated over the European Coverage Area are used to monitor the performance of the SAR/Galileo Service.

The centre of operations (SGSC) of the SAR/Galileo Ground Segment is located in CNES Toulouse and manages the operations of the various remote entities (MEOLUT Local Facilities and Reference Beacons). All the ground elements communicate via the Search and Rescue Network (SARN).

3.2.2.2. SAR/GALILEO MEOLUT

3.2.2.2.1. MEOLUT FUNCTIONS

The European MEOLUTs of the SAR Ground Segment operate nominally through the exchange of signal measurements data (TOA/FOA) from twelve coordinated antennas and exchanged through the SAR network. Localization processing of the MEOLUT and the data generation to the associated MCC is performed at the MEOLUT Local Facility.

Each MEOLUT Local Facility includes 4 reception antennas of which the tracking is coordinated by the MTCF. In case of SARN network or MTCF outage, the MEOLUT Local Facility is still capable of generating detection and location data to the MCC based on a tracking plan computed locally at the MEOLUT Local Facility. This mode of operation is however not considered as an operational mode for the SAR Ground Segment.

The role of the MEOLUTs is to track MEOSAR satellites in view, detect beacon distress messages, compute the beacon location, and provide alerts to the MCC. The geographical position of the beacon is computed using TOA/FOA measurements and the position of associated satellites at burst time.

The nominal functions of a MEOLUT are:

- Reception of SAR downlink signals,

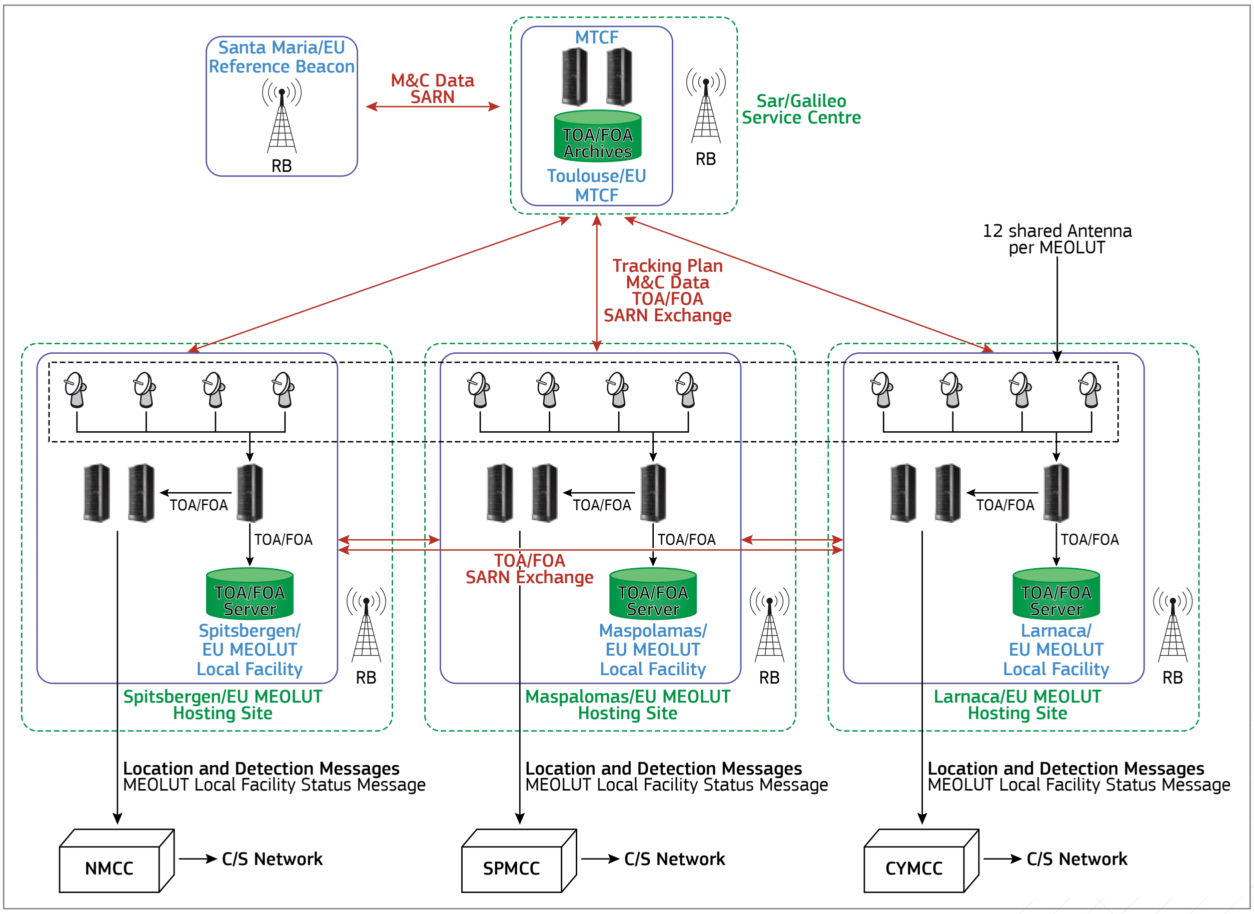


Figure 9. SAR/Galileo Ground Segment Overall Architecture.

- Message detection, demodulation and decoding,
- Beacon location (when at least 3 tracked satellites are in co-visibility with the beacon),
- Maintaining time and frequency references, satellite orbit parameters and local archive,
- Sending beacon alert messages to its associated MCC (see Table 7 for locations) in compliance with Cospas – Sarsat interface requirements. The MEOLUT is able to produce either SIT 145B location messages or 142B detection messages.

In addition, the SAR/Galileo MEOLUTs have some specific features:

- Sharing of antennas between the MEOLUTs and execution of European MEOSAR satellite coordinated tracking plan (generated by MTCF) or a local one (generated by the MEOLUT Local Facility itself, without taking other networked MEOLUTs into account),
- Exchange of TOA/FOA measurements between SAR/Galileo MEOLUTs Local Facilities and with MTCF,
- Transmission of operational status messages to its associated MCC (Table 7):
    - SIT 650 MEOLUT Status (operational status periodically sent),
    - SIT 651 Alarm (sent immediately for significant impact),
    - SIT 652 Warning (sent for a significantimpact foreseen in the near future),
- Locating 406 MHz interferers (SIT 161).
- Interference detection and localization.

Further description of the SIT and Message Field (MF#) is provided in C/S documentation Annex A[1], [2] and [3].

3.2.2.2.2. MEOLUT HOSTING SITES

Table 7 below provides the location of each European MEOLUT Local Facility.

SAR/ GALILEO MEOLUTS	C/S ID	ASSOCIATED MCC	LATITUDE [°]	LONGITUDE [°]	ALTITUDE [M]
Spitsbergen/ EU MEOLUT (Norway)	2574	NMCC	78.2305	15.3707	430
Maspalomas/ EU MEOLUT (Spain)	2244	SPMCC	27.7614	-15.6348	130
Larnaca/ EU MEOLUT (Cyprus)	2091	CYMCC	34.8651	33.3838	277

Table 7. SAR/Galileo Ground Segment locations.

Figure 10. Maspalomas EU/MEOLUT Local Facility.

Figure 11. Spitsbergen EU/MEOLUT Local Facility.

Figure 12. Larnaca EU/MEOLUT Local Facility.

3.2.2.3. MTCF

The basic functions of the MEOLUT Tracking Coordination Facility (MTCF) are:

1) **Tracking Schedule management**. The MTCF is in charge of receiving and processing MEOSAR satellites orbital data though ephemeris, almanacs or TLE files. On that basis, it implements an efficient algorithm to generate an optimized and coordinated MEOSAR satellites tracking plan that is disseminated to the three EU/MEOLUT Local Facilities, taking advantage of the network configuration for optimal service performance and coverage. Moreover, the MTCF enables the addition of a number of External MEOLUTs in the tracking coordination process and for TOA/FOA exchange (refer to section 4.7).

2) **Data provision and archiving**. The MTCF is in charge of hosting the European MEOLUT Network TOA/FOA Server, sharing of the MEOSAR data between the MEOLUTs, as well as providing a long term data archiving (20 years) for EU/ MEOLUTs and MTCF.

3) **Performance and functional monitoring**. The MTCF provides overall SAR mission and tracking performance statistics on the EU/MEOLUTs, as well as the repository for beacon alert messages and TOA/FOA measurements from the European Reference Beacons detected by the EU MEOLUTs. It ensures the overall Cospas – Sarsat and SGS system monitoring, based on the observations of those Reference Beacons.

3.2.2.4. SAR/GALILEO NETWORK

All communications between the European MEOLUT Local Facilities and MTCF are facilitated through the SAR/Galileo Network (SARN).

The SARN is based on an IP Wide Area Network. Each SGS Hosting Entity is linked to its own country's NREN (National Research and Education Network). The NRENs are then connected together at European level with the GEANT (Gigabit European Advanced Network Technology) backbone.

A NREN is a network infrastructure dedicated to supporting the needs of the research and education communities within its own country and is operated by a public body. The interface point of a Hosting Entity local loop and a NREN is provided by a Point of Presence (POP). The NRENs used within the SARN are :

- CYNET for Cyprus
- REDIRIS for Spain
- NORDUNET for Norway
- RENATER for France

GEANT (Gigabit European Advanced Network Technology) is the fast and reliable pan-European communications infrastructure that interconnects Europeans NRENs. Therefore, each NREN is connected to the GEANT network through a specific POP in order to communicate with other NRENs (RI-GE-POP, CY-GE-POP, REN-GE-POP, NRD-GE-POP)

As depicted in Figure 13, GEANT is also connected to the rest of the Internet, making possible the exchange of data with external Entities. Consequently, the GEANT network and the involved NRENs together form a fast, reliable and resilient network for the establishment of communication links at European scale between SGS sites themselves and between SGS sites and External entities.

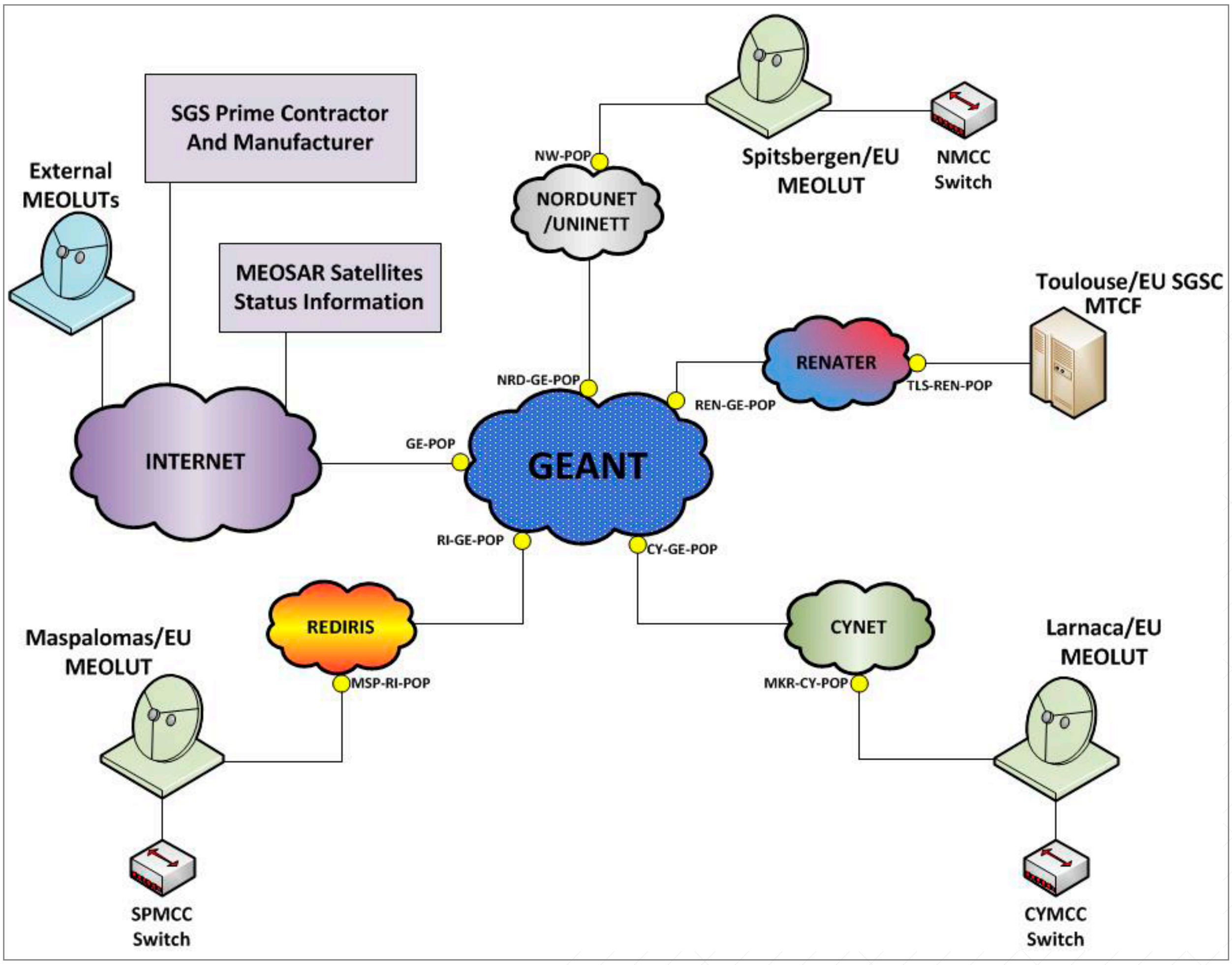


Figure 13. SARN synoptic.

3.2.2.5. SAR/GALILEO REFERENCE BEACONS

Five SAR/Galileo reference beacons are used for continuous monitoring of the service (see section 6.2). They are synchronized with UTC and transmit on a permanent basis.

Table 8 describes the main parameters of these 5 reference beacons.

SGS REF. BEACONS	BEACON ID	FREQUENCY [MHZ]	SYNCHRONIZATION	LATITUDE [°]	LONGITUDE [°]	ALTITUDE * [M]
GAL-EU1 Toulouse – France	9C62BE29630F1D0	406.034	HH : 00': 07"	43.5605	1.4809	209
GAL-EU2 Spitsbergen – Norway	A042BE29630F190	406.034	HH : 10': 19"	78.2308	15.3706	486
GAL-EU3 Santa Maria – Portugal	9982BE29630F100	406.034	HH : 20': 31"	36.9964	-25.1358	348
GAL-EU4 Maspalomas – Spain	9C02BE29630F0A0	406.034	HH : 00': 43"	27.7615	-15.6343	180
GAL-EU5 Larnaca – Cyprus	9A22BE29630F010	406.034	HH : 10': 54"	34.8654	33.3838	322

Table 8. Reference beacon characteristics.

*……*Altitude above WGS84 ellipsoid.*

Each reference beacon transmits 1 burst every 50 seconds, according to a specific schedule described hereafter.

At the “Synchronization Start Time” shown in Table 8 and Figure 14, a transmission starts for a duration of 10 minutes, then stops and resumes after 30 minutes (2x10 minutes of transmission per hour or 2x12 bursts per hour).

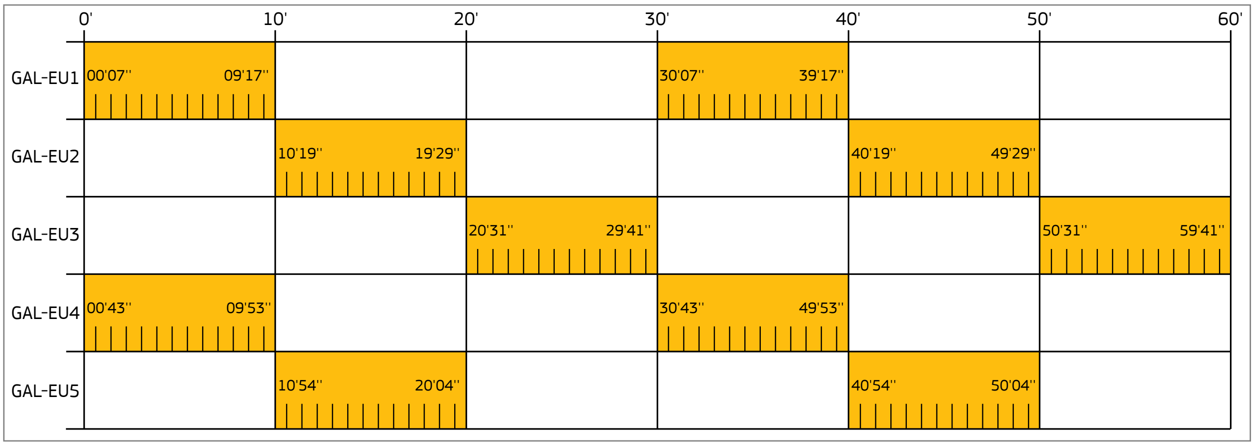


Figure 14. Reference beacons transmission schedule within 1 hour.

Each beacon is provided with a vertical linear polarized antenna with a radiation pattern equivalent to a standard C/S beacon (see Annex A[4]).

3.2.2.6. SAR SERVER

The SAR Server is an infrastructure of the SAR/Galileo Ground Segment, located at the European GNSS Agency in Prague (Czech Republic).

The server is accessible to SAR/Galileo Service Centre (SGSC) through Internet and used at MTCF level to recover the most recent SAR/Galileo satellites orbital parameters if they cannot be recovered from the satellite navigation signals due to various possible reasons such as no GNSS receiver available, satellite not broadcasting ephemeris/almanacs, satellite on particular orbit, outdated ephemeris.

SECTION 4: SAR/GALILEO SERVICE OPERATIONS CONCEPT

4.1 SAR/GALILEO SERVICE CENTRE

The SAR/Galileo Service Centre (SGSC), located in Toulouse (France) at CNES premises is the centre where the management of the operations of the SAR/Galileo Service is performed. It hosts the MTCF, the Toulouse/EU reference beacon and the Central Warehouse. The SGSC Hosting Entity supports therefore the SGDSP which is located in the SGSC.

4.2 SAR/GALILEO DATA SERVICE PROVIDER

The SAR/Galileo Data Service Provider (SGDSP) is the entity in charge of the coordination of the operations related to the SAR/Galileo service. As far as SAR/Galileo operations are concerned, the SGDSP is responsiblefor the following:

1) Management and coordination of SAR/Galileo Ground Segment operations,
2) Monitoring of the SAR/Galileo Service Performance through Key Performance Indicators,
3) Management and coordination of the SAR/Galileo Ground Segment Maintenance and execution of level 2 maintenance.

4.3 SAR/GALILEO GROUND SEGMENT HOSTING SITE ENTITIES

The SAR/Galileo Ground Segment Hosting Entities are the providers of the hosting sites and operations of the remote SAR Ground Segment facilities.

4.4 SAR/GALILEO GROUND SEGMENT MAINTENANCE

Three levels of maintenance, managed through escalation, are implemented as part of the SAR/Galileo Service maintenance operations:

- Level 1 maintenance:

  Managed and performed by the Hosting Site Providers. These maintenance activities follow the instructions provided in the SAR facilities user manuals and maintenance plan. This maintenance typically consists of the replacement of failed hardware or preventive replacement of aging units. The operators of the Hosting Site Provider received adequate training and are fully qualified to perform these maintenance activities and will have on-line support from manufacturers.

- Level 2 maintenance:

  Performed by the SGDSP with support from the SAR Ground Segment Manufactuer and the Hosting Entities. This is a system level maintenance that requires coordination of several sites/facilities (e.g. verification of the tracking coordination scheme, investigation of eventual SAR/Galileo service underperformance).

- Level 3 maintenance:

  Coordinated by the SGDSP and performed by the SGS Prime contractor and manufacturers. This maintenance includes both corrective maintenance (resolution of software non-conformance, investigation of failed items, etc.) and evolutive maintenance (upgrades) for the treatment of obsolescence and to ensure the continuous compliance of the facilities with the Cospas – Sarsat standards.

4.5 SGDSP INTERFACES

SGDSP interfaces with various entities to ensure system operations, maintenance and performance monitoring. (see Figure 15).

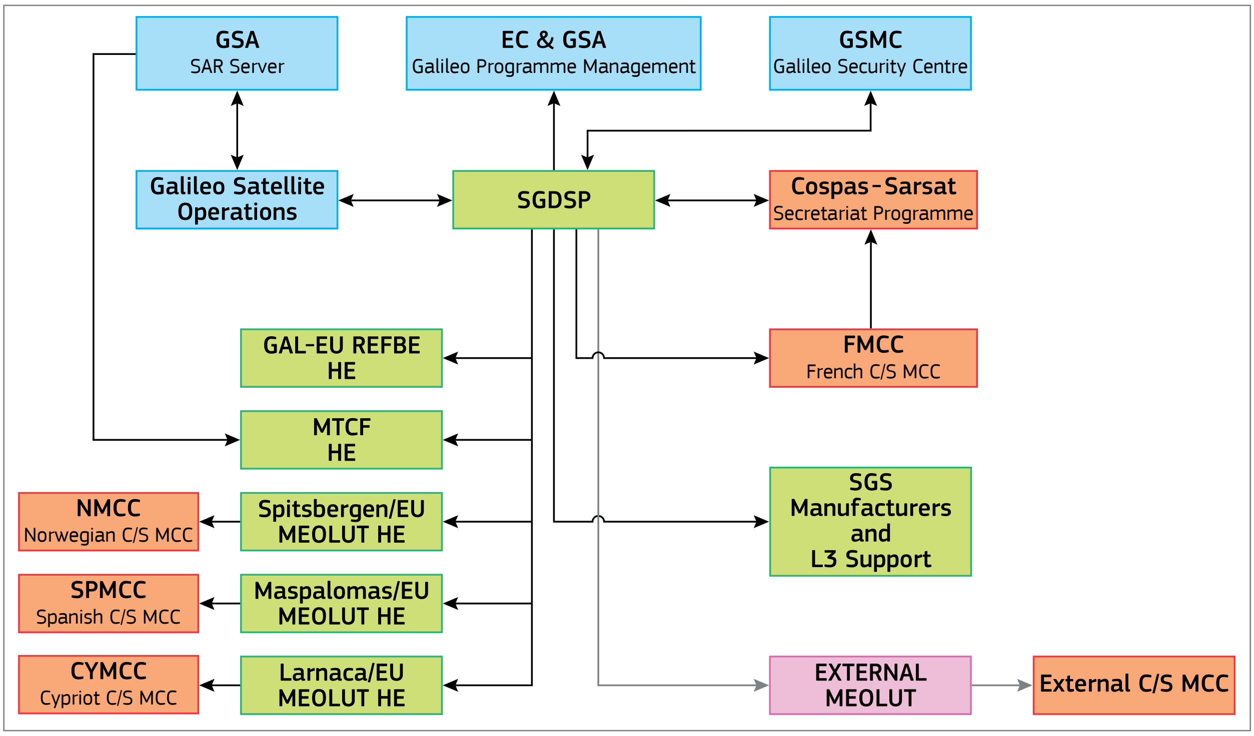


Figure 15. Interfaces of the SAR/Galileo Operations.

SGDSP directly interfaces with:

1) Entities directly involved in the provision of the service:
   - SGS Hosting Entities (MEOLUTs, MTCF),
   - SGS Prime Contractor Maintenance and Support Desks,
   - Galileo Core Infrastructure (GCI).
   - Galileo Service Centre

The perimeter of the Galileo Core Infrastructure is composed of the following main segments: the Galileo Ground Control Segment (GCS), the Galileo Ground Mission Segment (GMS) and the Galileo Space Segment (GSS).

2) Cospas – Sarsat Entities:
   - External MEOLUT Hosting Entity (HE) for operations only,
   - FMCC to spread general status messages (SIT 605) to C/S community (MCCs),
   - SPMCC, NMCC, CYMCC linked to the European MEOLUTs (see Table 8),
   - Cospas – Sarsat Programme (commissioning report and other evaluation reports).

3) Galileo Programme:
   - Galileo programme management (EC/GSA)
   - Galileo programme security (GSMC)

4.6 OPERATIONAL SCENARIOS RELEVANT TO COSPAS – SARSAT OPERATIONS

The Galileo Core Infrastructure Operator informs SGDSP about any significant event occurring at Galileo space segment level that impacts the SAR/Galileo Service.

SGDSP, as SAR/Galileo Operations manager, interfaces with the Cospas – Sarsat operators (MCC), any time a major events are impacts either the Space or the Ground segment of SAR/Galileo.

These major events are notified to the Cospas – Sarsat community using the SIT messages distribution network operationally used between MCCs. The distribution is initiated by the SGDSP which sends a request to the FMCC to send notification SIT 605 messages to all other MCCs (an example of SIT 605 is given in Annex F).

The main operational scenarios are:

1) **Information about satellite status:** a SIT 605 is sent by the FMCC on behalf of SGDSP to inform the C/S community about any Galileo satellite status changes impacting the SAR/Galileo Service:
   - New Galileo SARR Availability,
   - SARR configuration change,
   - SARR outage,
   - SARR planned maintenance,
   - SAR/Galileo Service Full Operational Capability.
2) Information about SGS status: a SIT 605 is sent from the FMCC/Hosting Entity associated MCC [3] on behalf of SGDSP to inform the C/S community about system level unplanned events leading to a severe degradation of the SAR/Galileo Service (see section 6.1):
3) SGS level unplanned event (anomaly) with impact on the Service,
   - SGS planned maintenance,
   - SGS Shutdown,
   - SGS Start-up.

4.7 INTERFACE FOR EXTERNAL MEOLUTS

The SAR/Galileo Initial Service is based on tracking coordination and TOA/FOA data exchange between the three European MEOLUT Local Facilities to emulate three MEOLUTs with 12 shared antennas spread over three sites in Europe, enhancing location performance. In order to allow extension of the service coverage and performance, external Cospas – Sarsat MEOLUTs can also take part in the tracking coordination scheme provided by the MTCF and/or exchange TOA/FOA data with the TOA/FOA server available at the MTCF.

External MEOLUT operators can request exchange of data with the SAR Galileo Ground Segment:

- SAR/Galileo network TOA/FOA files through the TOA/FOA server of MTCF,
- Coordinated and local Tracking Plans generated by the MTCF.

A description of the exchanged files format is given in Annex E.

The Tracking Plans are distributed to external MEOLUTs wishing to take part in the tracking coordination scheme. The following levels of participation in the tracking coordination scheme are foreseen for an external MEOLUT:

- Level 1: The external MEOLUT can provide its plans to the MTCF and the MTCF uses this information to calculate its coordinated tracking plan.

3....... *Information about any MEOLUT status is generally notified to the C/S community by its associated MCC.*

- Level 2: Tracking Plans are generated by MTCF for the external MEOLUT for information.
- Level 3: Tracking Plans are generated by MTCF for the external MEOLUT for implementation.

A description of the prerequisites, TOA/FOA exchange protocol and Tracking Plan file format are provided in Annex E.

The coordinated tracking plan is computed by the MTCF. Its objective is to provide a coordinated tracking plan taking into account all involved MEOLUTs (both European and external MEOLUTs) in order to achieve the best extended coverage (SAR Galileo Coverage + external MEOLUT coverage) with the best performance.

An external MEOLUT is neither monitored nor controlled by the MTCF and does not provide its local archive and daily performance reports to the MTCF. The operational status of an external MEOLUT is known by the MTCF through operational coordination between the operators of the two entities.

SECTION 5: SAR/GALILEO INITIAL SERVICE PERFORMANCE

5.1 DETECTION AND LOCATION PERFORMANCE

The following expected values for both detection and location performance are derived from the current setup of the MEOSAR Space Segment and simulations based on current MEOLUT performance measurements.

These expected values are suitable targets and should not be taken as commitments. They are to be put into perspective with the real system KPI observations in Annex C of this document, which are mostly impacted by functional anomalies (antenna outage, network congestion etc.) that are not taken into account by the simulator used here.

5.1.1 DETECTION PERFORMANCE

The detection performance is measured on the basis of the messages single burst detection probability, i.e. the percentage of transmitted bursts that are detected by at least one of the SGS MEOLUTs.

The system Initial Service detection performance expectations for the networked SGS are defined in Table 9:

SAR/GALILEO INITIAL SERVICE DETECTION PERFORMANCE	EXPECTED VALUE
Valid message detection probability after 1 transmitted burst (≈1min)	> 99%

Table 9. SAR/Galileo Initial Service detection performance expectations.

The KPI for detection probability after 1 transmitted burst KPI for a given beacon over a period is computed as follows: N is the number of transmission sequences (each sequence consists of 12 bursts) during the period that produced at least one valid message after the first transmitted burst. M is the total number of transmission sequences for that beacon (2 sequences per hour are sent by the REFBE, see section 3.2.2.5). The valid message detection probability after 1 burst is given by the ratio N/M.

5.1.2 LOCATION PERFORMANCE

The location error is the difference between the real position of a beacon and its position as calculated by any of the SGS MEOLUTs. The accuracy is associated with the probability of a location error (accuracy) below 5 km and 2 km.

The location accuracy within X kilometers is defined as the ratio of the locations that are computed with a location error lower than X, over the total number of computed locations by the SGS.

The system Initial Service location performance expectations are defined in Table 10.

SAR/GALILEO INITIAL SERVICE LOCATION PERFORMANCE	EXPECTED VALUE
Location probability after 1 transmitted burst	> 75%
Location probability after 12 transmitted bursts (≈10 minutes)	> 98%
Location accuracy after 1 transmitted burst within 5 km	> 70%
Location accuracy after 12 transmitted bursts (≈10 minutes) within 5 km	> 95%
Location accuracy after 12 transmitted bursts (≈10 minutes) within 2 km	> 80%

Table 10. SAR/Galileo Initial Service location performance expectations.

For the location minimum performance, the nominal mode networked of SGS is considered, with tracking coordination and TOA/FOA measurements exchange between MEOLUTs. This means that a location can be computed from data received by any SGS MEOLUT.

Those location KPIs are computed as follows:

If there is 1 burst location between the first emission date and first emission date + 90s, consider the sequence located after 1 burst, and the linked locations will belong to the "*after 1 transmitted burst*" class.

If there is up to 12 bursts location between the *first emission date* and *First emission date + 11* burst_rate + 22.5s*, consider the sequence located after 12 bursts, and the linked locations will belong to the "*after 12 transmitted bursts*" class.

The location probability after K (K = 1 or 12) bursts for a beacon is equal to the ratio **N/M** with **N** number of transmitting sequences localized for this class K and **M** the total number of sequences for that beacon (2 sequences per hour, see section 3.2.2.5).

The probability of locating a burst within X km for a beacon is given by the ratio **Q/R** with **Q** the number of localizations with accuracy better than or equal to X km. **R** is the total number of computed localizations in the class (i.e. either “after 1 transmitted burst” or “after 12 transmitted bursts” classes).

5.1.3 PERFORMANCE OVER SERVICE COVERAGE AREA

Figures 16 , 17 and 18 show the availability of the service of the SAR/Galileo Coverage Area as simulated in terms of:

- Detection probability
- Location probability
- Location accuracy

The simulations are realized over a period of 10 days with the space segment as available in October 2016.

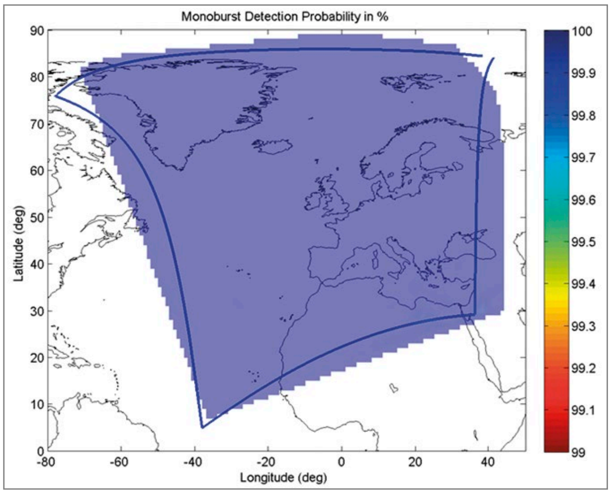


Figure 16. Single-burst Detection Probability (Space Segment of October 2016).

The simulations show slightly lower (although still adequate) performance expectations over the Mediterranean Sea. This observation is due to the current Space Segment geometrical configurations with incomplete MEOSAR constellations and will improve as new satellites are added.

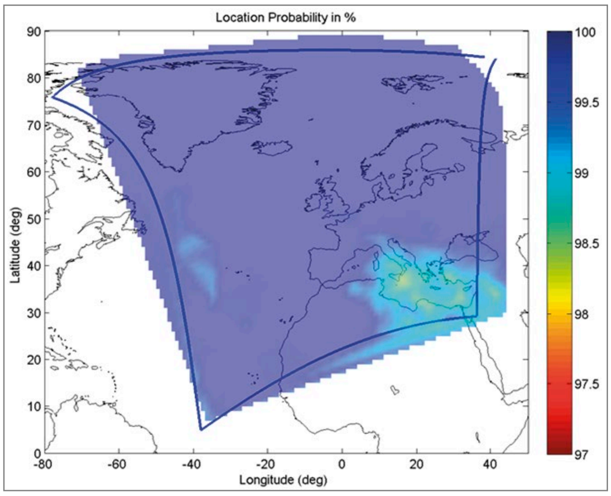


Figure 17. Simulated Location Probability after 10 minutes (Space Segment of October 2016).

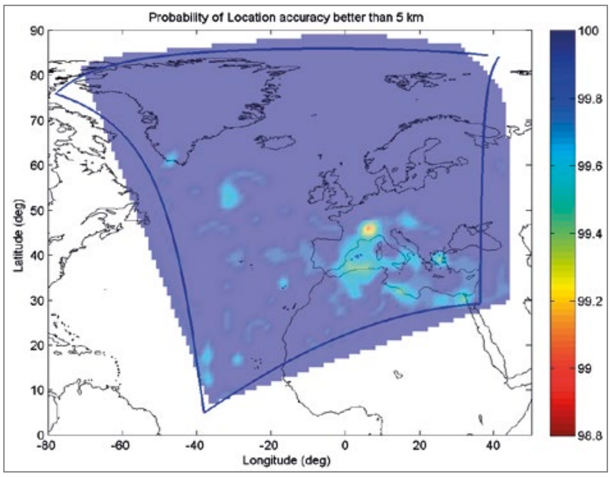


Figure 18. Simulated probability of Location Accuracy within 5 km after 10 minutes (Space Segment of October 2016).

5.2 SEGMENTS AVAILABILITY

5.2.1 AVAILABILITY OF THE SAR/ GALILEO SPACE SEGMENT

SAR/GALILEO SPACE SEGMENT AVAILABILITY	EXPECTED VALUE
Average SAR Transponder Availability	> 90%

Table 11. SAR/Galileo Tranponder Minimum Expected Availability.

The status of the SAR/Galileo Space Segment is available from the European GNSS Service Centre website where up to date constellation status and active NAGU are available at:

http://www.gsc-europa.eu/system-status/Constellation-Information

Satellites orbital parameters can be acquired by a MEOLUT following the decision tree shown in Figure 19:

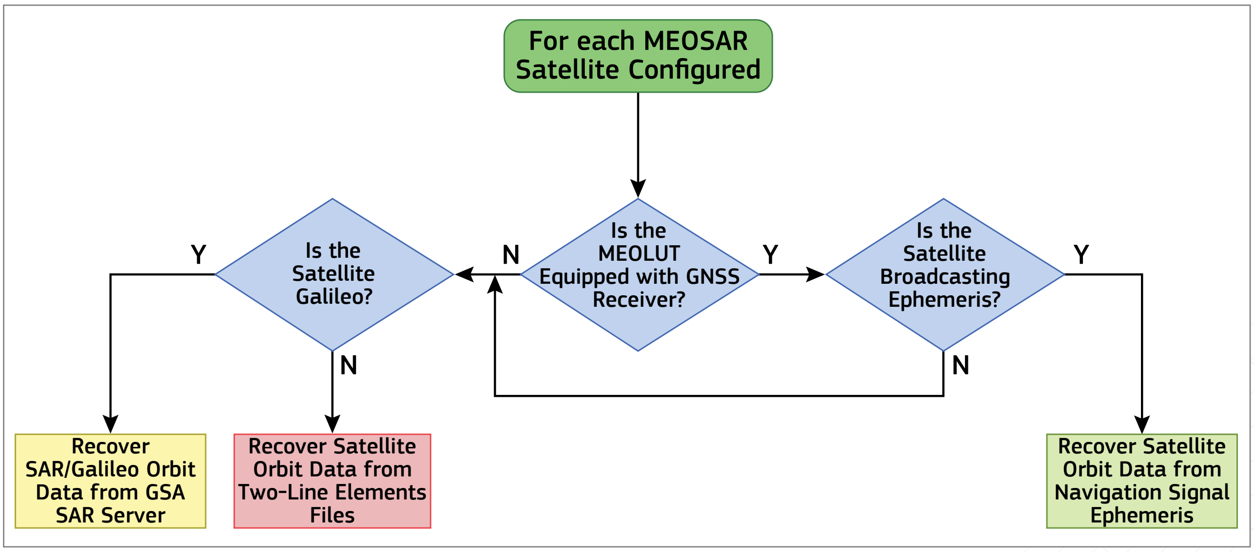


Figure 19. EU/MEOLUT satellite orbit data recovery process.

- *Note 1: Two-Line Element files for Galileo satellites can be found at: http://celestrak.com/NORAD/elements/galileo.txt*
- *Note 2: The GSA SAR Server availability is not guaranteed.*
- *Note 3: All the European MEOLUTs are equipped with triple-constellation compatible GNSS receivers.*

For Galileo satellites, orbital data (recovered from the ephemeris through the Signal in Space or from the GSA SAR Server) is available only if the spacecraft is in operational status.

5.2.2 AVAILABILITY OF THE SAR GROUND SEGMENT AND SAR/GALILEO SERVICE STATUS MODES

The availability of the SAR Ground Segment (SGS) depends on its status (operational/not-operational).

The operational status of the European MEOLUTs is notified to Cospas – Sarsat through a SIT 605 sent from a MEOLUT Hosting Entity to its corresponding MCC (CYMCC, NMCC or SPMCC). The operational status of other SGS facilities (REFBE, SAR Repeater, and SARN) is notified to Cospas-Sarsat from the French MCC (FMCC) on behalf of the SGDSP with a SIT 605 or through the Cospas/Sarsat website (http://www.cospas-sarsat.int/en/pro) in the MEOSAR System status section.

The definition of the SAR/Galileo Initial Service Status and modes is provided below in Table 12. It relies on:

- The definition of the MEOLUT states and associated availability requirements, as presented in Table 13.
- The definition of the SARN states and associated availability requirements, as presented below in Table 14.

- The definition of the MTCF operational status and modes and associated availability requirements, as presented below in Table 15.

SAR GALILEO INITIAL SERVICE STATUS		DESCRIPTION
Nominal		All MEOLUT Local Facilities fully operational and MTCF/SARN available for coordinated tracking plan distribution and TOA/FOA data exchange. In this situation, the 3 European MEOLUT have full access to their 12 shared antenna and Availability of at least 10 operational SARR Galileo spacecraft for Detection/ Localization computing.
Degraded	SART	Availability of 9 or less Galileo satellites, reducing the number of available SARR spacecraft for detection/localization computing or Unavailability of precise ephemeris signal and use of two-line element files, or corrupted ephemeris or Interference signals in both the uplink (beacon-satellite) and downlink bands, caused by radar or other R/F means.
	MEOLUT	SGS is working nominally, but 1 or 2 of the EU/MEOLUT Local Facilities are running in Local Tracking execution mode (either using backup tracking plan, or in standalone mode) or, 1, 2 or 3 MEOLUTs are not fully functioning.
	SARN	A single link between the MTCF and an EU/MEOLUT Local Facility is not available or Links between any EU/MEOLUT Facility and the two others are lost or a combination of the two above cases.
	MTCF	One or both of the following functions are not available: • TOA/FOA exchange via MTCF. • MTCF Tracking plan generation.
	REFBE	Only 2 REFBE or less are available
Severe Degradation or not operational	SART	Availability of 2 or less Galileo satellites per each orbital plane.
	MEOLUT	Outage of one EU/MEOLUT Local Facility Or All EU/MEOLUTs Local Facilities in local tracking standalone mode.
	SARN	EU/MEOLUT Local Facility local loop network segment not available or SARN outage, no exchange of TOA/ FOA files between EU/MEOLUTs Local Facilities.
	MTCF	MTCF severe degradation: unavailability of coordinated tracking plan computation for more than 10 days.

Table 12. SAR/Galileo Service Global Status.

MEOLUT STATE	MEOLUT LOCAL FACILITY MODE	DESCRIPTION
Operational Requirement: 97.5%	Full Operational Requirement: 95.0%	All MEOLUT Local Facility receiver chains are available and are correctly working AND the other MEOLUT Local Facilities components involved in detection, location, TOA/ FOA estimation, acquisition and dissemination are also working correctly.
	Degraded	Only 3 MEOLUT receiver chains are available and are correctly working in the MEOLUT Local Facility AND the other MEOLUT Local Facilities components involved in detection, location from the available receiver chains, TOA/FOA estimation, acquisition and dissemination are working correctly.
Not Operational	Not Operational	Less than 3 receiver chains on one EU/MEOLUT MEOLUT Local Facility are available OR Failure/outage of any other MEOLUT Local Facility components that prevent detection and/or location processes and/or TOA/FOA computation.

Table 13. MEOLUT Status requirements over a period of 1 year.

SARN STATUS	SARN MODE	DESCRIPTION
Operational Requirement: 99.4%	Nominal	All links between the MTCF and the European MEOLUT Local Facilities are available.
	Degraded	A single link between the MTCF and a European MEOLUT Facility is not available.
Not Operational	Failure	Two or more links between the MTCF and the European MEOLUT Local Facilities are not available.

Table 14. SARN Status over a period of 1 year.

MTCF STATUS	MTCF MODE	DESCRIPTION
Operational Requirement: 99.95%	Nominal	The following conditions are verified: • The TOA/FOA exchange is correctly performed. • At least one tracking plan was disseminated within the last 24 hours. • Monitoring and control functions.
Not Operational	Failure	One or both of the following functions are not available: • TOA/FOA exchange. • Tracking plan generation.

Table 15. MTCF Status over a period of 1 year.

5.3 SAR/GALILEO INITIAL SERVICE LIMITATIONS

The SAR/Galileo Initial Service has been designed to give better detection rate and accuracy of locations over the SAR Galileo Coverage area. In the vast majority of cases, this service will be available and will provide performance in line with or beyond the minimum performance levels described in the previous sections of this document. However, in a limited number of situations, users may experience non-nominal detection and location performance levels.

5.3.1 SERVICE LIMITATION CASES

ROOT CAUSE	MOST LIKELY SYMPTOMS
Outage of any satellites, reducing the number of available SARR spacecraft for location computing.	Degradation of detection and location services.
Unavailability of precise ephemeris signal and use of two-line element files, or corrupted ephemeris.	Degradation of location accuracy.
SARN outage, no exchange of TOA/FOA files between MEOLUT Local Facilities.	Standalone location computing. Degradation of location accuracy. No archived files to MTCF.
Outage of one MEOLUT Local Facility or some antennas.	Degradation of detection and location services. No provision notifications to local MCCs.
Unavailability of tracking plan computation.	Degradation of location service and accuracy.
Interference signals in both the uplink (beacon-satellite) and downlink bands, caused by radar signals or other RF means.	Degradation of detection and location services. Degradation of location accuracy. The problem is under the responsibility of local authorities.
Very bad weather conditions, such as rain or snowfall.	Degradation of detection and location services Degradation of location accuracy.
Geographical and natural obstacles (rift, forest…) depending on the user beacon location.	Degradation of detection and location services. Degradation of location accuracy.

Table 16. SAR/Galileo Initial Service Limitations.

SECTION 6: SAR/GALILEO INITIAL SERVICE PERFORMANCE MONITORING

6.1 KEY PERFORMANCE INDICATORS COLLECTION

The SAR/Galileo Data Service Provider (SGDSP) is responsible for collecting, integrating and reporting the SAR/Galileo Initial Service Key Performance Indicators (KPIs) to the European Commission.

Any SAR/Galileo Initial Service severe degradations (planned or unplanned) are reported by the SGDSP to the EC and notified to the 3 European MCCs through a SIT 605 (SAR/Galileo service performance degradation).

The Service Severe Degradation is defined as:

- Detection Service Availability drops below 90% of nominal performance as measured over the 5 reference beacons over any 1 calendar month.
- Location Service Availability drops below 80% of nominal performance as measured over the 5 reference beacons over any 1 calendar month.
- Loss of one operational MEOLUT (see MEOLUT and SGS Status section 5.2.2) for more than 24h.
- Loss of the Communication Link between any of the MEOLUT and its associated MCC for more than 24h.
- Loss of the SARN Communication Link between two or more MEOLUTs Local Facilities and the MTCF (see SARN and SGS Status section 5.2.2) for more than 24h.

As shown in Figure 20, the SAR/Galileo Initial Service KPIs will be either collected directly from the concerned entity, or from measurements/information provided by the various actors involved in the provision of the SAR/Galileo Initial Service. Actors are:

1) Galileo System Operator: The Key Performance Indicators related to the satellite operations and performance are monitored by the Galileo System Operator and the performance information related to the SAR payloads (e.g. SARR health status, planned satellite outages and manoeuvres) is collected and processed to produce KPIs, then provided by the Galileo System Operator to the SGDSP.
2) MEOLUT (Local Facility) Hosting Entities: The Key Performance Indicators related to operations and performance of the MEOLUTs (including LAN and Local Loops) are generated by the concerned Hosting Sites and reported to the SGDSP Provider.
3) SGDSP: The Key Performance Indicators (KPI) associated with the SAR/Galileo Service system level performance and operations are collected and generated by the SGDSP and monitored by the EC. They are integrated with the KPIs reported by the Galileo System Operator for the SARR and with the information (KPIs and ad-hoc raw data) provided by the MEOLUTs (Local Facility) HEs in order to generate the overall SAR/Galileo Initial Service reports.

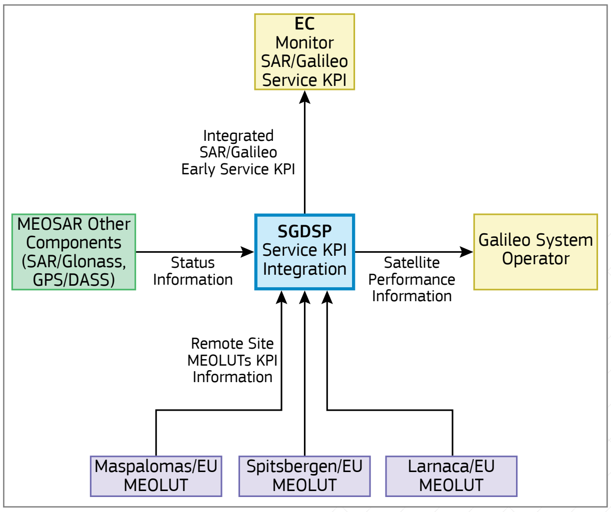


Figure 20. SGDSP KPI Service.

6.2 KPI COLLECTION PLATFORM (KCP) DESCRIPTION

The Performance KPIs are generated by a specific software platform (KCP: KPIs Collection Platform) hosted on the MTCF. The data produced by each of the three European MEOLUTs are periodically transferred to the MTCF (mainly for archiving and generation of KPIs) through the SARN.

The Performance KPIs generation is based on the reception by the three European MEOLUTs of the bursts transmitted by the five SAR/Galileo reference beacons (see section 3.2.2.5).

The KCP provides real-time monitoring and editing daily and monthly reports. The three main parameters are:

- Statistics of detection performance,
- Statistics of location performance,
- Statistics on the availability of each MEOLUT.

SECTION 7: SAR/GALILEO SERVICE EVOLUTION

7.1 SAR/GALILEO SERVICE ROADMAP

Table 17 shows the main milestones to be considered for the evolution of the SAR/Galileo Service.

SAR/GALILEO PROGRAMME LEVEL	SAR/GALILEO SPACE SEGMENT
SAR/Galileo Initial Service – 2016: Start of the Initial Service with SAR/Galileo payloads and SAR Ground Segment in support of the Cospas-Sarsat MEOSAR Early Operational Capability Phase (EOC).	10+2 [4]
SAR/Galileo Enhanced Service – 2018: Increased service availability for the Forward Link Service in support of the MEOSAR Initial Operational Capability phase (IOC). Introduction of the initial Return Link Service.	22+2 [4]
SAR/Galileo Full Service – 2020: Increased service availability for the Forward Link Service in support of the MEOSAR Full Operational Capability phase (FOC). Increased Ground Segment Capability to support the Second Generation of Beacons. Fully nominal Return Link Service.	24+2 [4]

Table 17. SAR/Galileo Service Roadmap.

7.2 RETURN LINK SERVICE

The SAR/Galileo Service roadmap foresees the introduction of an additional service called "Return Link Service" to the currently provided Forward Link Alert Service. This provides an acknowledgment capability to the distress beacons confirming that the alert has been detected and located by the system. This service, which will be provided worldwide, will rely on the Galileo E1-B navigation signal (see Annex A[9]) to transmit the acknowledgment messages to the distress beacon and will therefore only be available for RLS enabled beacons (refer to C/S documentation Annex A [2], [3} and [4]).

This new service is planned to be introduced by mid-2018.

7.3 SATELLITE COVERAGE WITH INCREASED NUMBER OF SAR/GALILEO REPEATERS

With an increased number of SAR/Galileo payloads, more satellites will be visible at any time, and this will have a strong impact on the performance and availability of locations.

Table 18 shows the time availability for at least 3 and 4 satellites visibility simulated ECA from virtual beacons (a set of 464 beacons uniformly spread inside SGC) by the 3 European MEOLUTs.

For beacons and ground stations, 5° elevation masks are considered, and the simulator uses a measured beacon antenna radiation diagram (Toulouse French beacon simulator, equipped with a typical EPIRB antenna).

Four simulation scenarios were carried out. The first one corresponds to the current configuration of spacecraft at MTCF level, and the three others foresee Galileo Space Segment deployment after each launch from mid 2017. The GPS/DASS and SAR/GLONASS constellations have been assumed constant in the different scenarios as there is no information about future potential orbital slots to be occupied by any new spacecraft.

Some coverage maps are given in Annex D.

Table 19 shows the satellite slots used for the evaluation.

4. *Galileo GSAT0201/GSAT0202 are not located in the nominal Galileo orbital slots.*

SPACE SEGMENT CONFIGURATION	CURRENT CONFIGURATION (DECEMBER 2016)	MID 2017 (AFTER LAUNCH #8)	END 2017 (AFTER LAUNCH #9)	COMPLETE GALILEO CONSTELLATION
SAR/Galileo	12	16	20	26
GPS/DASS	19	19	19	19
SAR/Glonass	1	1	1	1
MEOSAR total	32	37	41	46
Time availability with more than 3 Satellites	99.8%	99.8%	100%	100%
Time availability with more than 4 Satellites	98.4%	99.3%	100%	100%

Table 18. Simulation of 3 and 4 Satellites Coverage Availability Though Time from SGC.

Note: The two satellites GSAT0201/0202 are not located in the nominal Galileo orbital slots but nevertheless contribute to the SAR/Galileo Space Segment.

GALILEO SPACE SEGMENT CONFIGURATION	SATELLITES ORBITAL SLOTS WALKER CONSTELLATION (24/3/1)
12 Galileo	C4, C5, B3, B8, X1*, X2*, A5, A8, **C2**, **C7**, **A2, A6**
16 Galileo	C4, C5, B3, B8, X1*, X2*, A5, A8, C2, C7, A2, A6, **C1, C3, C6, C8**
20 Galileo	C4, C5, B3, B8, X1*, X2*, A5, A8, C2, C7, A2, A6, C1, C3, C6, C8, **A1, A3, A4, A7**
26 Galileo	C4, C5, B3, B8, X1*, X2*, A5, A8, C2, C7, A2, A6, C1, C3, C6, C8, A1, A3, A4, A7, **B1, B2, B4, B7, B5, B6**

Table 19. Satellite slots considered in the evaluation.

*........... *The two satellites GSAT0201/0202 are not located in the nominal Galileo orbital slots but nevertheless contribute to the SAR/Galileo Space Segment.*

ANNEX A: REFERENCE DOCUMENTS

[1] *Cospas – Sarsat MCC Standard Interface Description,* December 2016, Issue 6, Rev. 1, *C/S A.002*

[2] *Cospas – Sarsat 406 Mhz Meosar Implementation Plan,* December 2015, Issue 1, Rev. 11, *C/S R.012*

[3] *Cospas – Sarsat Demonstration and Evaluation Plan for the 406 Mhz MEOSAR System,* December 2016, Issue 2, Rev. 4, *C/S R.018*

[4] *Specification for CospasSarsat 406 MHz Distress Beacons,* 1st December 2015, Issue 3, Rev. 16, *C/S T.001*

[5] *Description of the 406 MHz Payload Used in the Cospas – Sarsat MEOSAR System,* December 2016, Issue 1, Rev. 2, *C/S T.016*

[6] *Cospas – Sarsat MEOSAR Space Segment Commissioning Standard,* December 2016, Issue 1, Rev. 3, *C/S T.017*

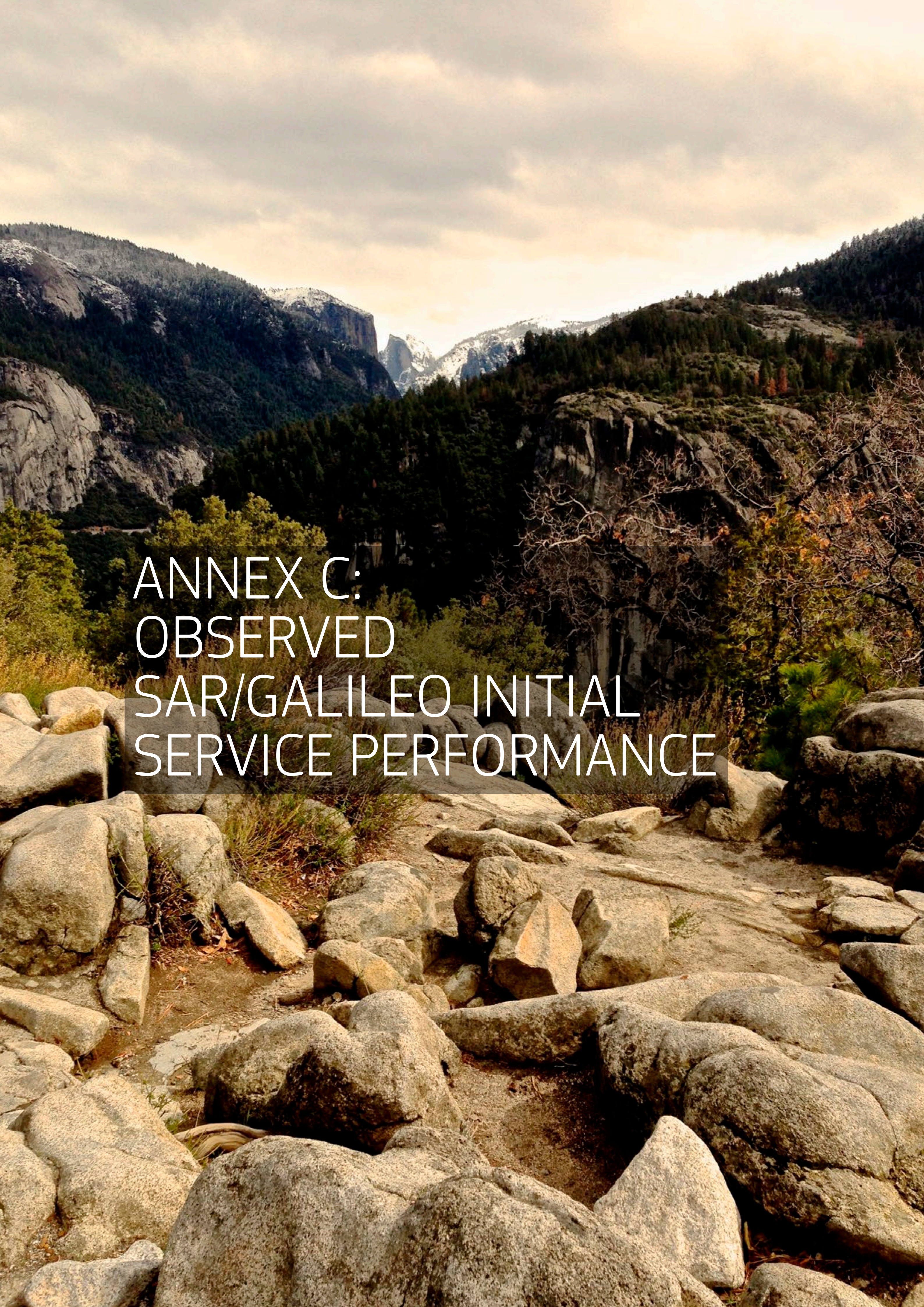
[7] *Cospas – Sarsat MEOLUT Performance Specification and Design Guidelines,* December 2016, Issue 1.1, *C/S T.019*

[8] *Cospas – Sarsat MEOLUT Commissioning Standard,* December 2016, Issue 1.1, *C/S T.020*

[9] *Galileo Open Service Signal-in-Space Interface Control Document,* December 2016, Issue 1, Rev. 3, OS SIS ICD

ANNEX B: ACRONYMS

ALC	Automatic Level Control
C/S	Cospas Sarsat
CNES	Centre National d'Etudes Spatiales (French National Space Agency)
CYMCC	Cypriot COSPAS – SARSAT Mission Control Centre
DASS	Distress Alerting Satellite System (based on GPS satellites)
DR	Reference Document
EC	European Commission
ECA	European SAR Coverage Area
EIRP	Equivalent Isotropic Radiated Power
EU	European Union
FGM	Fixed Gain Mode
FMCC	French MCC
FOA	Frequency Of Arrival
FOC	Full Operational Capability
GCS	Ground Control Segment
GEANT	Pan-European data network for the research and education community
GLONASS	Global Navigation Satellite System (Russian Federation)
GMS	Ground Mission Segment
GNSS	Global Navigation Satellite System
GPS	Navstar Global Positioning System (United States)
GSMC	Galileo Security Monitoring Centre
GSS	Galileo Space Segment
ICD	Interface Control Document
IOC	Initial Operational Capability
IOV	In Orbit Validation
JDOP	Joint Dilution of Precision
KCP	KPI Collection Platform (hosted by MTCF)
KPI	Key Performance Indicator
LAN	Local Area Network
LEO	Low-altitude Earth Orbit
LEOSAR	LEO Search And Rescue (satellite system)
LHCP	Left Hand Circular Polarisation
LUT	Local User Terminal
MCC	Mission Control Centre
MEO	Medium-altitude Earth Orbit
MEOLUT	Medium-altitude Earth Orbit Local User Terminal
MEOSAR	MEO Search And Rescue
MMI	Man – Machine Interface
MTCF	MEOLUT Tracking Coordination Facility
NAGU	Notice Advisory to Galileo Users
NMCC	Norwegian COSPAS – SARSAT Mission Control Centre
NREN	National Research and Education Network
POP	Point of Presence
RF	Radio-Frequency
RHCP	Right Hand Circular Polarisation
RLS	Return Link Service
SAR	Search And Rescue
SARN	SAR/Galileo Network (for data distribution)
SARR	Search and Rescue Repeaters
SGC	SAR Galileo Coverage
SGDSP	SAR/Galileo Data Service Provider
SGS	SAR Ground Segment
SGSC	SAR/Galileo Service Centre
SIT	Subject Indicator Type, Cospas – Sarsat alert message type indicator code
SPMCC	Spanish COSPAS – SARSAT Mission Control Centre
TBC	To Be Confirmed
TBD	To Be Defined
TLE	Two-Line Element
TO	Test Operator
TOA	Time Of Arrival
TP	Tracking Plan
XML	eXtensible Markup Language



ANNEX C: OBSERVED SAR/GALILEO INITIAL SERVICE PERFORMANCE

This annex provides the SAR/Galileo Service performance measured during a KPI Collection campaign in August 2016.

During this observation period the configured MEOSAR Space Segment consisted of 20 GPS/DASS, 10 SAR/Galileo and 1 SAR/GLONASS. The SGS was in nominal configuration with the use of coordinated Tracking Plan.

These results are provided by the SGS Key Performance Indicators Collection Platform. Note that the "detection probability" KPI results take into account the five European Reference Beacons (see section 3.2.2.5) and the two Cospas – Sarsat calibration beacons in Toulouse (IDs 9C6000000000001 and 9C634E2AB509240). All other results take into account the European Reference Beacons only.

C.1. OBSERVED SERVICE AVAILABILITY

Table 20 presents the detection probabilities during the KPI collection period as observed through the KCP tool with the five European Reference Beacons and the two Cospas – Sarsat calibration beacons located in Toulouse.

PERFORMANCE PARAMETERS	TARGET VALUE (INITIAL SERVICE)	SGS KPI RESULT OVER THE PERIOD
Detection probability Single Burst (valid message)	99%	99.6%

Table 20. KPI Collection Period (August 2016) Detection Service Performance.

The current service shows suitable detection probabilities for valid messages with higher probability than expected.

C.2. OBSERVED LOCATION PROBABILITY ACCURACY

Table 21 presents the location probabilities and accuracies as observed through the KCP tool with the five European Reference Beacons during the KPI collection period.

PERFORMANCE PARAMETERS	TARGET VALUE (INITIAL SERVICE)	SGS KPI RESULT OVER THE PERIOD
Location probability after 12 transmitted bursts (≈10 minutes)	98%	99.3%
Location probability after 1 transmitted burst	75%	96.8%
Location accuracy after 1 transmitted burst within 5 km	70%	96.1%
Location accuracy after 1 to 12 transmitted bursts within 5 km	95%	96.6 %
Location accuracy after 1 to 12 transmitted bursts within 2 km	80%	88.1 %

Table 21. KPI Collection Period (August 2016) Location Service Performance.

The current service shows better location probabilities than expected.

C.3. OBSERVED MEOLUT AVAILABILITY

Table 22 below shows the European MEOLUTs Availability Status over the KPI Collection Period in August 2016 (refer to section 5.2.2 Table 13 of this document for details about the MEOLUT availability status requirements):

MEOLUT NAME	%TARGET (NOMINAL)	% NOMINAL	% DEGRADED	% UNAVAILABLE	% UNKNOWN
Larnaca	95.0	92.5	1.8	5.4	0.3
Maspalomas	95.0	97.5	2.5	0.0	0.0
Spitsbergen	95.0	96.5	3.2	0.0	0.3

Table 22. MEOLUT Availability Status over the KPI Collection Period in August 2016.

ANNEX D: COVERAGE SIMULATIONS

D.1. CURRENT SPACE SEGMENT COVERAGE

This Annex presents some simulations of co-visibility situations between uniformly spread beacons (antenna pattern considered only from 5° to 60°) over the SGC and at least one European MEOLUT.

The beacon antenna radiating pattern used by the simulator corresponds to an actual measurement of the Cospas – Sarsat datation beacon antenna located in Toulouse.

The data presented in this section show the percentage of time a given beacon is in co-visibility situation with at least one European MEOLUT using at least 3 or 4 satellites, for various foreseen MEOSAR space segment configurations after new Galileo launches (refer to section 7.3 of this document for more details). The simulation is run over a 10-day period so that all possible geometric configurations are taken into account in the statistics.

The current MEOSAR Space Segment already provides a quasi-total geometrical coverage of the SGC. This simulation result is confirmed by the current detection and location probabilities computed during the KPI Collection with networked MEOLUTs. Near future deployments of the Space Segment will ensure a geometrical coverage of this area at all times with more than 4 satellites in co-visibility with at least one of the European MEOLUTs.

In addition, the increase of the number of visible MEOSAR satellites will enable the MTCF to generate even more optimized solutions in order to provide a coordinated Tracking Plan that will improve the location accuracy performance over the SGC.

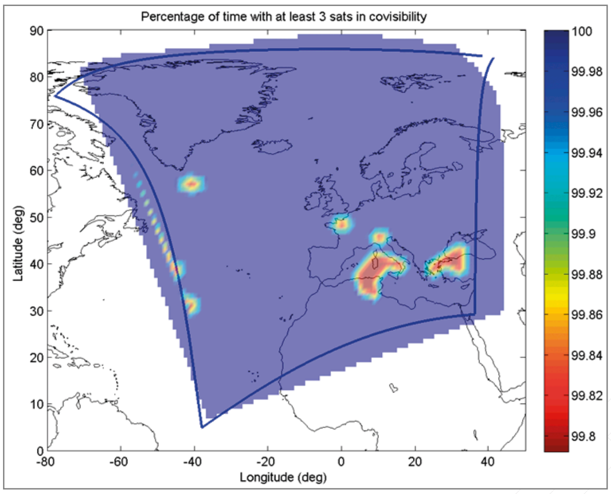


Figure 21. December 2016 - Space Segment co-visibility (at least 3 satellites).

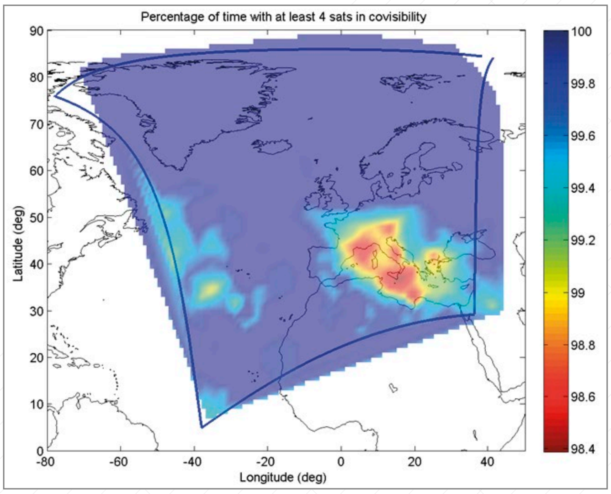


Figure 22. December 2016 - Space Segment co-visibility (at least 4 satellites).

D.2. EXPECTED COVERAGE OF SPACE SEGMENT IN MID 2017

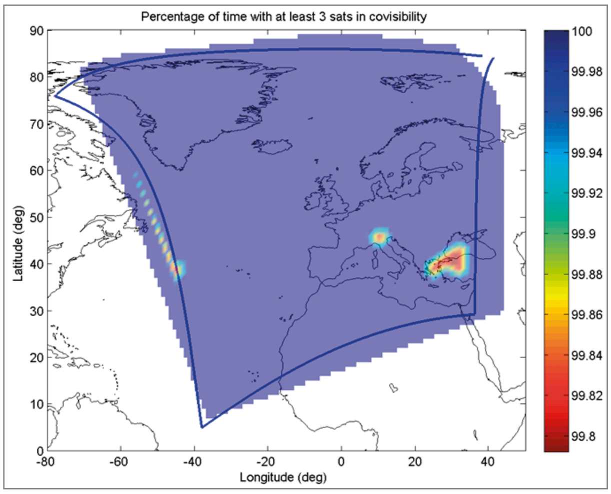


Figure 23. Mid 2017 Expected Space Segment co-visibility (at least 3 satellites).

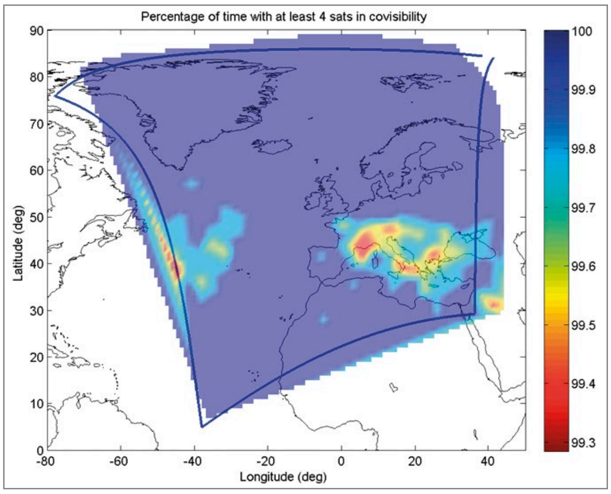


Figure 24. Mid 2017 Expected Space Segment co-visibility (at least 4 satellites).

D.3. EXPECTED COVERAGE OF SPACE SEGMENT AT END OF YEAR 2017

As of late 2017, the SAR/Galileo constellation is expected to have acquired four additional satellites. Simulation results show than every beacon in the GSC always has at least 4 satellites in view in co-visibility with at least one European MEOLUT.

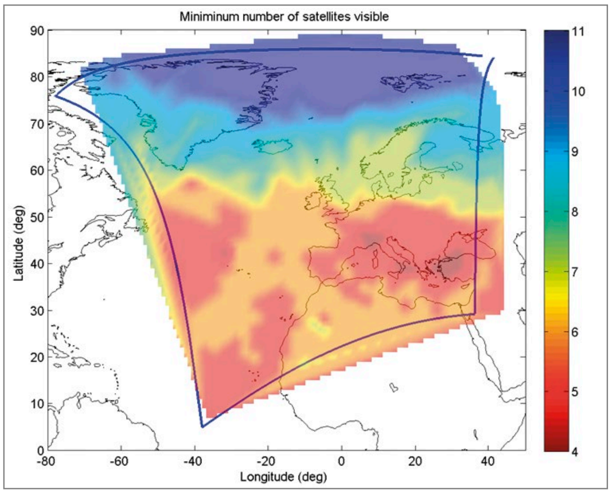


Figure 25. Expected Worst Case Minimum number of visible satellites for End of Year2017 space segment.

D.4. FULL SAR/GALILEO SPACE SEGMENT COVERAGE

In 2020, the SAR/Galileo constellation is expected to be completed by the deployment of additional satellites. In this configuration, simulation results show than every beacon in the GSC always has **at least 5 satellites** in view, in co-visibility with at least one European MEOLUT.

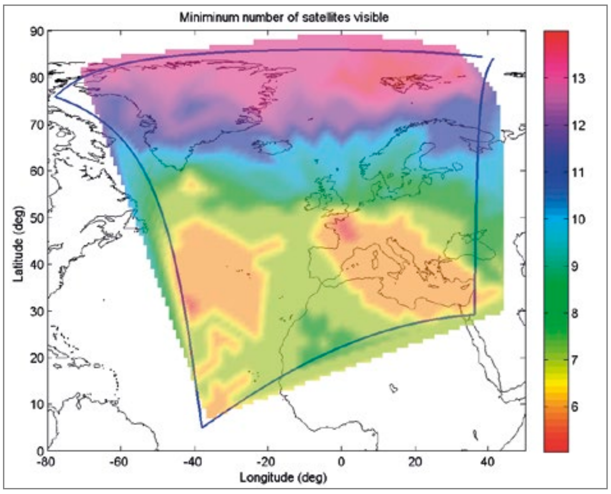


Figure 26. Minimum number of visible satellites for full SAR/Galileo constellation.

ANNEX E: EXTERNAL DATA EXCHANGE

This Annex presents some examples of a TOA/FOA file and a MTCF Tracking Plan file.

E.1. TOA/FOA EXCHANGE AND MTCF TRACKING PLAN FILES

a) TOA/FOA exchange XML file format example:


```
<?xml version="1.0" encoding="UTF-8"?>
- <ns3:TOA_FOA_DATA>
    <ns3:MF6>329</ns3:MF6>
    <ns3:MF11>2714</ns3:MF11>
    <ns3:MF71>57</ns3:MF71>
    <ns3:MF22>ADDC00606060601</ns3:MF22>
    <ns3:MF77>FFFE2F56EE00303030300CD2AD8000000000</ns3:MF77>
    <ns3:MF67>14 133 1726 05.303943</ns3:MF67>
    <ns3:MF68>406038516.236</ns3:MF68>
    <ns3:MF69>0.068603</ns3:MF69>
    <ns3:MF70>-3944.898</ns3:MF70>
    <ns3:MF72>37.3</ns3:MF72>
    <ns3:MF73>399.935</ns3:MF73>
    <ns3:MF75>+17049.1144 +02721.6811 +20210.0130</ns3:MF75>
    <ns3:MF76>-001.954871 +003.103061 +001.238365</ns3:MF76>
  </ns3:TOA_FOA_DATA>
```


Message fields definitions:

MF 06: Spacecraft ID

MF 11: Source ID

MF 71: Antenna ID

MF 22: Beacon ID

MF 77: Full 406 message

MF 67: Uplink TOA

MF 68: Uplink FOA

MF 69: Time offset

MF 70: Frequency offset

MF 72: C/N0

MF 73: Bit rate

MF 75: Satellite position

MF 76: Satellite velocity

For further description refer to Cospas – Sarsat documentation: [Annex A([1] Annex C) and ([2] Annex M)].

b) **MTCF Tracking Plan XML file format example:**


```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
- <ns6:trackingPlanExt xmlns="urn:commonLut" xmlns:ns2="urn:trackingPlan" xmlns:ns3="http://sargs/mtcf/trackingplanbroadcast/"
   xmlns:ns4="http://sargs/mtcf/trackingplan/" xmlns:ns5="urn:sargsDocument" xmlns:ns6="urn:trackingPlanExt" xmlns:ns7="http:///sargs/mtcf/commons"
   xmlns:ns8="http:///sargs/mtcf/operationalparam">
 - <ns5:Header>
     <ns5:InterfaceType>COORDINATED_TRACKING_PLAN</ns5:InterfaceType>
     <ns5:InterfaceVersion>01.01</ns5:InterfaceVersion>
     <ns5:Timestamp>2014-05-23T11:38:40.965Z</ns5:Timestamp>
     <ns5:OriginType>MTCF</ns5:OriginType>
     <ns5:OriginId>2279</ns5:OriginId>
   </ns5:Header>
 - <ns6:body>
   - <ns2:trackingPlan planId="319_2574_N" planDate="2014-05-23T11:31:16.673" active="true" type="NOMINAL" source="MTCF" filterSelfTestOutput="false">
     - <ns2:passList>
       - <satellitePass satId="419" antennaId="2" tracked="true" aos="2014-05-24T18:01:16.673" los="2014-05-24T20:21:16.673">
           <maxElevation timestamp="2014-05-24T18:21:16.673" azimuth="168.8794249594244" elevation="71.52909144539171" />
           <minElevation timestamp="2014-05-24T20:11:16.673" azimuth="107.95736406011248" elevation="24.547564919810835" />
         </satellitePass>
       - <satellitePass satId="420" antennaId="2" tracked="true" aos="2014-05-25T16:21:16.673" los="2014-05-25T18:51:16.673">
           <maxElevation timestamp="2014-05-25T16:51:16.673" azimuth="136.04821339701815" elevation="68.84434724780017" />
           <minElevation timestamp="2014-05-25T18:41:16.673" azimuth="86.71820893305137" elevation="20.50083521330928" />
         </satellitePass>
       - <satellitePass satId="420" antennaId="3" tracked="true" aos="2014-05-23T11:36:33.000000000Z" los="2014-05-23T11:54:27.000000000Z">
           <maxElevation timestamp="2014-05-23T12:24:33.000000000Z" azimuth="202.983837120716" elevation="58.1514713654437" />
           <minElevation timestamp="2014-05-23T14:14:33.000000000Z" azimuth="160.601516756496" elevation="20.9042347879318" />
         </satellitePass>
       - <satellitePass satId="419" antennaId="1" tracked="true" aos="2014-05-23T11:43:33.000000000Z" los="2014-05-23T12:01:27.000000000Z">
           <maxElevation timestamp="2014-05-23T11:34:33.000000000Z" azimuth="195.354158873623" elevation="30.6274000084903" />
           <minElevation timestamp="2014-05-23T12:04:33.000000000Z" azimuth="190.818375750173" elevation="18.3342978122389" />
         </satellitePass>
       </ns2:passList>
     - <ns2:orbitVectorList>
       - <orbitVector satId="419" date="2014-05-23T11:09:44.000">
         - <vectorPosVel>
             <pos x="6062165.094201796" y="-1.699232955778215E7" z="2.3468055042562872E7" />
             <vel x="2341.7779222397035" y="-230.27634669269852" z="-772.9929715745822" />
           </vectorPosVel>
         </orbitVector>
       - <orbitVector satId="420" date="2014-05-23T11:09:44.000">
         - <vectorPosVel>
             <pos x="2.3215192054014087E7" y="-1.1915278603193821E7" z="1.3964348714974863E7" />
             <vel x="1390.3885185391182" y="-176.2223679315683" z="-2462.8024079345737" />
           </vectorPosVel>
         </orbitVector>
       </ns2:orbitVectorList>
     </ns2:trackingPlan>
   </ns6:body>
 </ns6:trackingPlanExt>
```


E.2. EXTERNAL MEOLUT CONNECTION

The SGS offers the possibility to connect an external MEOLUT to the current system. In the case of level 3 coordination (see section 4.7), the MTCF will optimize a Tracking Plan taking that additional MEOLUT into account and will provide it to the new station for it to follow. Some conditions have to be fulfilled in order to make this connection.

- Prerequisites for the External MEOLUT:
  1) The external MEOLUT complies with Cospas – Sarsat specifications and SAR/Galileo interfaces for tracking plans.
  2) A dedicated GEANT Network access for MTCF connectivity with the SARN through a VPN link.
  3) Define a coverage area (at least 4 coordinates of geographic points).
  4) Geographic coordinates of the MEOLUT antennas.
  5) Horizontal profile mask over 360° of the minimum tracking elevation.
- Prerequisites for the MTCF:

  Change configuration to include this external MEOLUT.
- MEOLUT Tracking Plan exchanges protocol:

  The External MEOLUT shall exchange Tracking Plans with the MTCF in two directions:
  1) At least once every day, the MTCF shall provide to the External MEOLUTs updates of the MEOSAR satellite tracking plans (including updated backup plans) based on the latest available input data.

2) The MEOLUT shall receive the MEOSAR Tracking Plan ZIP file sent by the MTCF, using secure FTP exchanges. The ZIP file shall includes:

    a) The tracking plan file itself in XML format.

    b) A computed MD5 checksum associated with it.

    Upon reception, the MEOLUT shall verify the MD5 hash against the tracking plan file. In case of a failed verification, the MEOLUT shall reject the tracking plan, raising the proper errors.

3) The External MEOLUT shall send to MTCF the current tracking plan applied regardless if it is locally computed or received from the MTCF.

ANNEX F:
SAMPLE NARRATIVE MESSAGE SIT 605

......5......1......5......2......5......3......5......4......5......5......5......6......5.....69

/50227 00000/2270/14 322 1350

/605/2240

/ADDITION OF GSAT NOTIFICATION MESSAGE

DATE: 0900 UTC, 20 SEPT 201x

FROM: FMCC ON BEHALF OF SGDSP

TO ALL MCCS MEO

SUBJECT: SAR/GALILEO SYSTEM CONFIGURATION CHANGE – 20 SEPT 201x.

A. OBJECTIVE: ADDITION OF GSAT 020x (C/S ID 4yy) TO MEOSAR SPACE SYSTEM.

B. DESCRIPTION: TODAY, STARTING FROM 15:00 UTC,

GSAT 020x (C/S ID 4yy) WILL BE ADDED TO THE SGS CONFIGURATION.

SUCCESSFUL INTEGRATION WILL BE NOTIFIED VIA SIT 605 LATER ON.

C. POINT OF CONTACT: SGDSP

SGS@CNES.FR

+33 561 2xx xxx

BEST REGARDS

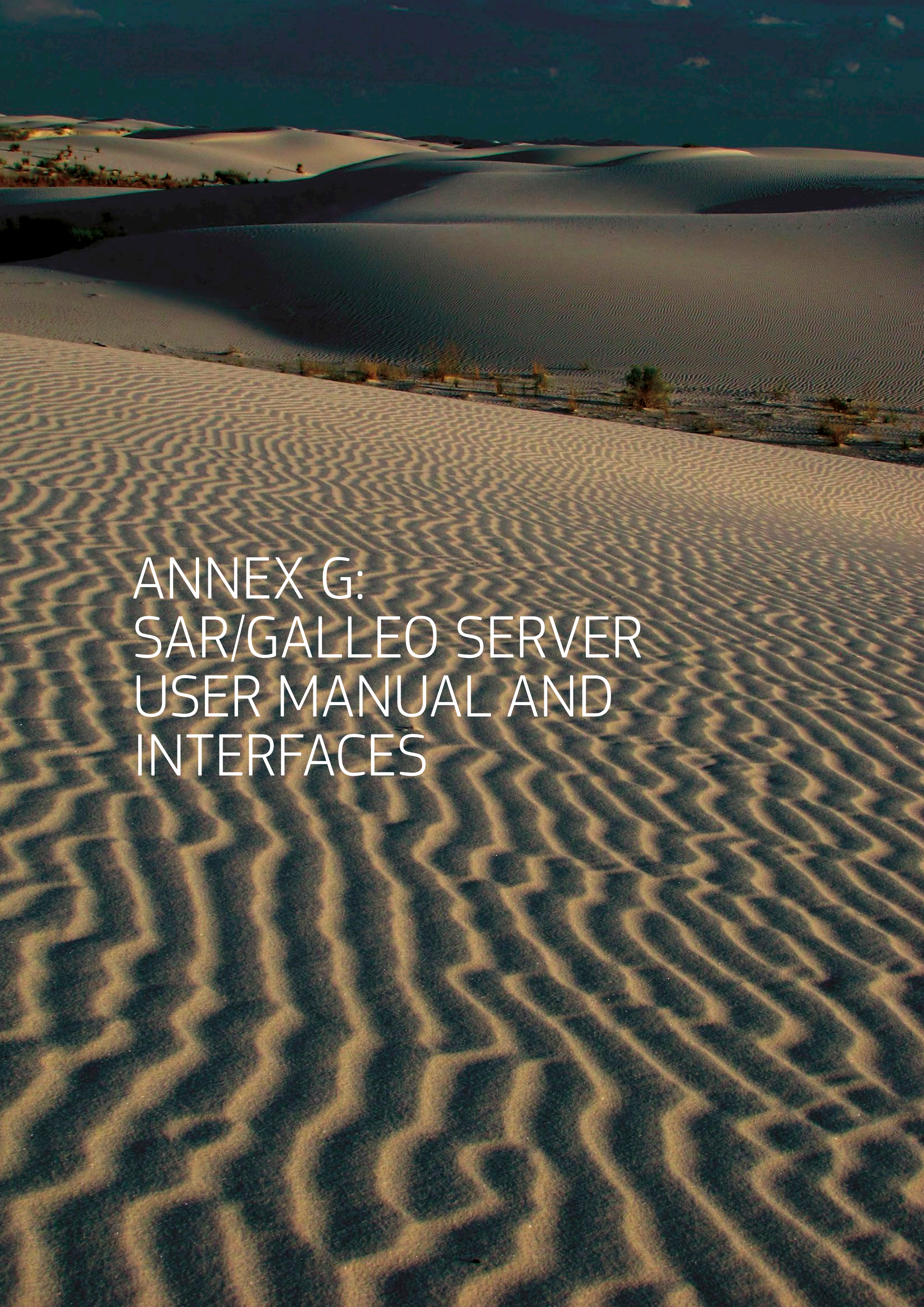
FMCC

QQQQQ

/LASSIT

/ENDMSG

END OF DOCUMENT



ANNEX G: SAR/GALLEO SERVER USER MANUAL AND INTERFACES

G.1. GSC – SAR SERVER OVERVIEW

By this interface, SAR users will be able to retrieve orbital data by means of sFTP protocol (sFTP version TBC).

User will find the following content in the GSC – SAR server:

- Galileo orbital products.
- Md5 hash files associated to each orbital product.
- Validity log file and welcome message.
- Additional server information.

G.1.1 GSC – SAR SERVER CONTENT

G.1.1.1. GALILEO ORBITAL PRODUCTS

The Galileo orbital products that will be available in the GSC – SAR server, together with their respective file naming convention, format and nominal refresh rate are provided in Table 23.

PRODUCT	FILE NAMING CONVENTION	FILE CONTENT	FORMAT (SEE G.2)	NOMINAL REFRESH RATE
RINEX Navigation Message (NAVRE)	NAVRE_YYYYMMDDhhmmss_TGVFIYYDDDh_S.yyl.gz	Ephemeris data for Galileo satellites [5].	Rinex 3.0	Hourly
Predicted Satellite Orbits (PRDOB)	PRDOB_YYYYMMDDhhmmss_TGVFIYYDDDh_S.sp3.gz	Galileo predicted orbit for Galileo satellites.	Sp3	Hourly
Predicted Satellite Clock (PSATC)	PSATC_YYYYMMDDhhmmss_TGVFIYYDDDh_S.clk.gz	Galileo predicted clock file for Galileo satellites.	Rinex 3.0 (clock extensions)	Hourly
Almanac (INF_AlmanacData)	INF_AlmanacData_YYYYMMDDhhmmss_TGVFIYYDDDh_S.xml.gz	Almanac data for Galileo satellites. [5]	XML	Hourly
Ephemeris Data (NAV_EphemToRlsp)	NAV_EphemToRlsp_YYYYMMDDhhmmss_TGVFIYYDDDh_SNN.xml.gz	Includes the following data for the Galileo constellation: • Ephemeris data • GST-UTC conversion parameters • Week Number and IOD of the ephemeris data (IODE)	XML	Hourly

Table 23. GSC – SAR server orbital products.

The meaning of the acronyms used in the file naming convention are as follows:

- "DDD" stands for Day Of the calendar Year (DOY). Day of year ranges from 1 to 365 (366 for leap years).
- "YYYYMMDDhhmmss" refers to the start of the product validity time (it corresponds to the start of the prediction arc for the data contained in the file):
  - YYYY: 4-digit year
  - MM: 2-digit month
  - DD: 2-digit day
  - hh: 2-digit hour
  - mm: 2-digit minute

5 *Please note that these data do not correspond to the navigation messages broadcast by the SIS.*

- ss: 2-digit second

- "yyl" stands for the data product year plus "l" character. E.g. for 2016: "16l".
- "TGVFIYYDDDh":
  - I values can be either 1 or 2. Not relevant for the content of the file.
  - YYDDDh: it corresponds to the start date of data set used for product generation.
    - YY: 2-digit year (16 for 2016),
    - DDD: Day Of the calendar Year (DOY).
    - h: An hour code (A=00:00, B=01:00, C=02:00 …).
- "S" stands for Service identifier (F for F/NAV, I for I/NAV).
- "NN" stands for the data set identifier.

G.1.1.2. HASH FILES

Every orbital product placed in the GSC – SAR server will be accompanied by a unique hash file. Its intended use is to check that the product was not corrupted during the user´s retrieval process.

The hash file is computed following RFC 1321 norm over the associated product.

The md5 hash file will be named as its associated product but with "md5" extension.

G.1.1.3. WELCOME MESSAGE AND VALIDITY LOG FILE

Once connected to the GSC – SAR server, a welcome message will be prompted in the user terminal, providing the user with the applicable validity period of each product type. The validity period is applicable from the specific date depicted in the welcome message.

The content of the welcome message, a sample of which is shown in Figure 27, will be updated whenever necessary, i.e. every time the validity period information changes.

```
Welcome to the GSC SAR sFTP server.
These are the current validity
periods for GALILEO orbital products:



=> Navigation Message (RINEX 3.0):       4.00 hours since 08/02/2016 09:00:00
=> Predicted Orbits (SP3c):      168.00 hours since 08/02/2016 09:00:00
=> Predicted clocks (RINEX 3.0):         168.00 hours since 08/02/2016 09:00:00
=> Predicted Almanac (xml):       24.00 hours since 08/02/2016 09:00:00
=> NAV_Ephem:    4.00 hours since 08/02/2016 09:00:00


Should you want to use old products please
refer to the validity log for details
on the applicable validity period.
For details on how to use the
GSC SAR sFTP server please refer
to  http://gsc-europa.eu/
```

Figure 27. GSC – SAR Server Welcome Message

Additionally, a "*validity.log*" file can be found in the GSC – SAR server root directory containing an historical record of the changes in the validity periods for the different types of products. See section G.2.3 for the format of the validity log file.

G.1.2 SERVER FOLDERS STRUCTURE

The GSC – SAR server contains a single data base structured in a folders tree, containing all the products and the additional information related to these products. Figure 28 shows an example of the GSC server folder organization:

```
.
└──┬── last
   │   ├── INF_AlmanacData_YYYYMMDDhhmmss_TGVFIYYDDDh_S.xml.gz
   │   ├── INF_AlmanacData_YYYYMMDDhhmmss_TGVFIYYDDDh_S.xml.gz.md5
   │   ├── NAV_EphemToRlsp_YYYYMMDDhhmmss_TGVFIYYDDDh_SNN.xml.gz
   │   ├── NAV_EphemToRlsp_YYYYMMDDhhmmss_TGVFIYYDDDh_SNN.xml.gz.md5
   │   ├── NAVRE_YYYYMMDDhhmmss_TGVFIYYDDDh_S.yyl.gz
   │   ├── NAVRE_YYYYMMDDhhmmss_TGVFIYYDDDh_S.yyl.gz.md5
   │   ├── PRDOB_YYYYMMDDhhmmss_TGVFIYYDDDh_S.sp3.gz
   │   ├── PRDOB_YYYYMMDDhhmmss_TGVFIYYDDDh_S.sp3.gz.md5
   │   ├── PSATC_YYYYMMDDhhmmss_TGVFIYYDDDh_S.clk.gz
   │   └── PSATC_YYYYMMDDhhmmss_TGVFIYYDDDh_S.clk.gz.md5
   ├── readme.html
   ├── readme.txt
   ├── validity.log
   ├── YYYY1
   │   ├── 001
   │   │   ├── INF_AlmanacData_YYYYMMDDhhmmss_TGVFIYYDDDh_S.xml.gz
   │   │   ├── INF_AlmanacData_YYYYMMDDhhmmss_TGVFIYYDDDh_S.xml.gz.md5
   │   │   ├── NAV_EphemToRlsp_YYYYMMDDhhmmss_TGVFIYYDDDh_SNN.xml.gz
   │   │   ├── NAV_EphemToRlsp_YYYYMMDDhhmmss_TGVFIYYDDDh_SNN.xml.gz.md5
   │   │   ├── NAVRE_YYYYMMDDhhmmss_TGVFIYYDDDh_S.yyl.gz
   │   │   ├── NAVRE_YYYYMMDDhhmmss_TGVFIYYDDDh_S.yyl.gz.md5
   │   │   ├── PRDOB_YYYYMMDDhhmmss_TGVFIYYDDDh_S.sp3.gz
   │   │   ├── PRDOB_YYYYMMDDhhmmss_TGVFIYYDDDh_S.sp3.gz.md5
   │   │   ├── PSATC_YYYYMMDDhhmmss_TGVFIYYDDDh_S.clk.gz
   │   │   └── PSATC_YYYYMMDDhhmmss_TGVFIYYDDDh_S.clk.gz.md5
   │   ├── ...
   │   ├── 003
   │   └── 365
   └── YYYY2
```

Figure 28. GSC – SAR Server Folders Structure.

There are three different type of folders:

- **"last" folder:** This folder will contain the last available version of each product type according to the start of the product validity time.
- **YYYY/DOY folders:** The YYYY/DOY folders are archives for the GSC products according to the GSC – SAR storage rules. They will contain sub-folders per Day of Year (YYYY/DOY). See section G.1.3.

G.1.3 SERVER STORAGE RULES

Orbital products are archived in the GSC – SAR server YYYY/DOY subfolder according to the start of the product validity time reflected in the product file name as described in section G.1.1.

G.1.4 SERVER USER COMMANDS

All granted users shall restrict their actions on the server to the following commands:

- bye: to exit or logout of the session
- cd: to change the directory in a command line
- exit: to close a program or file
- get: to download a file from the server
- mget: multiple get
- ls: lists the files and directories in the current directory.
- pwd: to print the directory you are currently working in
- quit: ending a session or program by purposely closing the application
- version: Shows the sftp version.

G.2. GSC – SAR SERVER FILES FORMAT

This section provides detailed definition of the format of the different files stored in the server.

G.2.1 GALILEO ORBITAL PRODUCTS

G.2.1.1. RINEX NAVIGATION MESSAGE (NAVRE)

This product is compliant with the RINEX, the Receiver Independent Exchange Format, Version 3.00.

G.2.1.2. PREDICTED SATELLITE ORBITS (PRDOB)

This product is compliant with the Extended Standard Product 3 Orbit Format (SP3-c).

G.2.1.3. PREDICTED SATELLITE CLOCK (PSATC)

This product is compliant with RINEX Extensions to Handle Clock Information, Version 3.00.

G.2.1.4. ALMANAC (INF_ALMANACDATA)

This product is compliant with the INF_AlmanacData_V01.03.xsd XML schema.

(*This file can be found in the attachments area of the on-line version of this document*).

G.2.1.5. EPHEMERIS DATA (NAV_EPHEMTORLSP)

This product is compliant with NAV_EphemToRlsp_V01.00.xsd XML schema.

(*This file can be found in the attachments area of the on-line version of this document*).

G.2.2 HASH FILES

The hash file computed over each orbital product file will contain a lower case sequence of ASCII characters (following RFC 1321 norm computed over the associated product) and a Line Feed character (LF: 0x0d) at the end of the line, as shown in Figure 29.

```
53afdb185dd1f9490cb79b8e4e247f47
```

Figure 29. Md5 Hash Example File

G.2.3 VALIDITY LOG FILE

```
#Validity_change (UTC)      New_validity_period(Hours) Affected_Products
12/04/2016 09:00:00          168.0000                    PRDOB_orbit
04/03/2016 15:42:00          84.0000                     PRDOB_orbit
08/02/2016 09:00:00          4.0000                      NAV_EphemToRlsp
08/02/2016 09:00:00          168.0000                    PRDOB_orbit
08/02/2016 09:00:00          24.0000                     PSATC_clk
08/02/2016 09:00:00          4.0000                      NAV_EphemToRlsp
```

Figure 30. Validity Log File Example.

Figure 30 provides an example of the validity log file:

- The first column provides the applicable date (UTC) of the product validity change.
- The second column refers to the new applicable validity time period (in hours).
- The third column contains the products affected by the new validity time change.

G.3. USER INTERFACES

G.3.1 USER ACCESS REQUEST

The SAR Community users need a login and password to access the GSC server. In order to get these credentials, the SAR Community users shall access the GSC web portal and, after registration, shall request, by using the Helpdesk service, a user and password for accessing the server. An email will be received by the requestor stating that the request is being processed.

Note that all user accounts shall be related to a physical person (as requested in the form below, Figure 31) who will be responsible for the proper use of the account. During the registration process, the user will have to provide signed version of a Non-Disclosure Undertaking (NDU) on the server connection details (GSC – SAR server IP address, user and password) and the proper use of the server account (only data reading purposes).

Users shall follow these steps in order to request a user account in the GSC SAR Server:

1) Register at the following address: http://gsc-europa.eu/helpdesk/contact-form.
2) Fill in the helpdesk form, as specified in Table 24.

3) The user will receive an email acknowledging the access request. In order to proceed with the request, the user will be requested to sign a NDU form. Signed copy of the NDU shall be sent by the user to the email address gsc-operations@gsa.europa.eu (subject: NDU for SAR server access) in order to proceed with the registration process.

4) If the user request is approved, the GSC – SAR server login credentials will be provided by email. And finally the server IP address and user password will be provided by telephone on the number provided during the registration process.

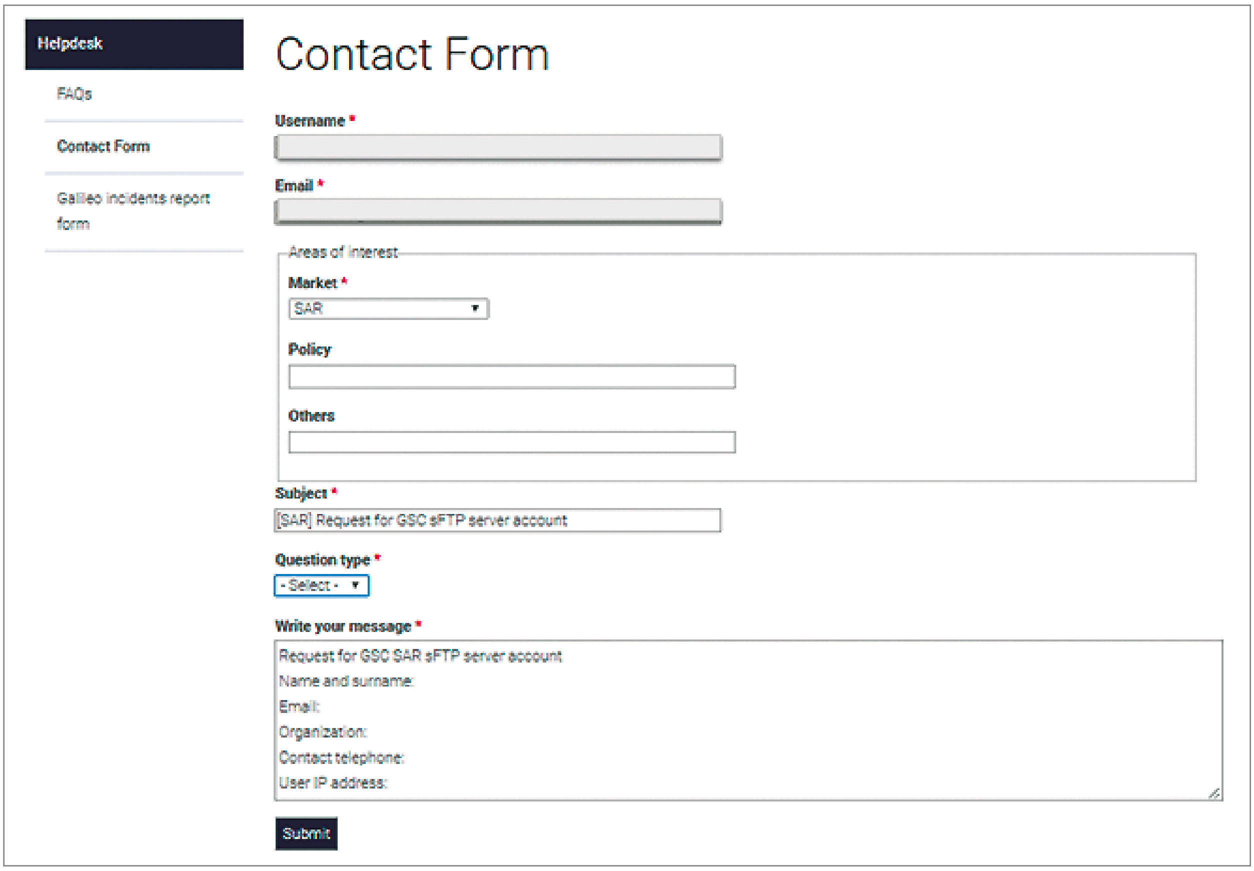


Figure 31. SAR Server – User Access Request.

Note that all user passwords will expire after 6 months and renewed passwords will be provided by the GSC to the user before the expiration date. Users will be contacted in advance before the password expiration to receive a renovated password.

The requester shall fill in the following Helpdesk form:

Note that it is mandatory to fill in the following fields as follows:

Market:	SAR
Others:	[SAR] Request for GSC sFTP server account
Subject:	[SAR] Request for GSC sFTP server account
Question type:	Technical

Table 24. SAR Server User Registration Form Content.

The following fields shall be specified in the field “write your message”:

- Name and surname,
- Email,
- Organization.

- Contact telephone.
- User IP address to be used for the connection to the SAR server. [6]

G.3.2 SERVICE INVESTIGATION REQUEST FROM SAR USERS

The SAR Community users will be able to ask for an investigation request on the SAR orbital products service provision (e.g missing products, wrong product content, connection problems with the server).

The SAR users shall go to the GSC-n WebPortal and send their request using the Helpdesk form. The guidelines to fill in the form are detailed in the Annex G.4.

This interface should not be addressed for other requests than those related to the SAR orbital product service provision.

G.3.3 SERVICE NOTIFICATION

In case of planned or unplanned outage of the server, service notifications will be sent to the SAR Community.

For planned events, the notification is sent not less than 1 day before the start time of the outage. For unplanned events, the notification is sent not less than 4 working days after the detection of the event.

This service will be implemented by means of an email sent to the address provided during the registration process.

The interface is an email with:

- Subject: [SAR][GSC][SERVICE NOTIFICATION] "Free text with details on the service notification"
- From: gsc-operations@gsa.europa.eu
- To: SAR Users email addresses
- CC: galileo_operations@gsa.europa.eu
- Content: information on the service notification: description, impact, start and end times.

It is not expected that SAR Users provide any answer to the Service Notification.

G.4. SAR COMMUNITY INVESTIGATION REQUEST CONTENT

For a SAR User to submit an investigation request, it is needed to fill in the GSC Helpdesk form as follows:

- **Market:** SAR.
- **Subject:** [GSC][IR] "title"; Please note that "title" field should reflect the scope of the Investigation Request, as provided by the user.
- **Question type:** Technical.

6 Note that the SAR server will reject connections from non-authorized IP addresses.

- Fill in the "**Write your message**" field following the structure of Table 25: SAR Community Investigation Request.

Requester Name	Name of the IR requester
Requester Contacts	Email of the requester
Requester Organization	Name of the IR requester organization
Title	Title of the IR
Submittal date	Date of IR submission
Urgency	("Urgent" or "Not Urgent")
Affected Products	(If applicable)
Observed Start/End Dates and Times	Event start and finish dates
Description	Detailed description

Table 25. SAR Community Investigation Request.

ANNEX H: FURTHER INFORMATION REQUEST ON THE SAR/GALILEO SERVICE

In case of questions on the SAR/Galileo Service, users are invited to contact the following entities:

For general and programmatic questions on SAR/Galileo system, users can address the Galileo Service Centre (GSC) Helpdesk on: http://gsc-europa.eu/helpdesk/contact-form.

For technical questions related to performance/interfaces, users can directly address the SAR/Galileo Data Service Provider (SGDSP) at the following address: sgdsp_info@cnes.fr.