DESCRIPTION OF THE 406 MHz PAYLOADS USED IN THE COSPAS-SARSAT MEOSAR SYSTEM

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1. INTRODUCTION

1.1 Overview

This document provides a description of the MEOSAR payloads carried on board these spacecraft.

1.2 Purpose

The purpose of this document is to describe the functionality and performance parameters for each MEOSAR instrument. The document is intended to be used to ensure the necessary compatibility for the 406 MHz beacon to satellite uplink and compatibility for the satellite to MEOSAR local user terminal (MEOLUT) downlink. The document is not intended for use as a specification for procurement of hardware for MEOSAR repeaters.

1.3 Scope

This document presents a technical description of the MEOSAR repeaters used in the Cospas-Sarsat system. Section 2 provides a general overview of the MEOSAR repeater function. Sections 3, 4 and 5 provide descriptions of the repeaters on the USA, European and Russian, satellites.

1.4 Reference Documents

The following documents contain useful information to the understanding of this document:

C/S R.012	Cospas-Sarsat 406 MHz MEOSAR Implementation Plan
C/S T.001	Specification for Cospas-Sarsat 406 MHz Distress Beacons
C/S T.011	Description of the Payloads used in the Cospas-Sarsat GEOSAR System
C/S T.018	Specification for Second-Generation Cospas-Sarsat 406-MHz Distress Beacons
C/S T.019	Cospas-Sarsat MEOLUT Specification and Design Guidelines
C/S T.020	Cospas-Sarsat MEOLUT Commissioning Standard
C/S G.003	Introduction to the Cospas-Sarsat System
C/S S.011	Cospas-Sarsat Glossary

- END OF SECTION 1 -

2. 406 MHZ MEOSAR SYSTEM DESCRIPTION

The Cospas-Sarsat MEOSAR Space Segment consists of SAR instruments on board satellites in medium-earth orbit. The SAR instruments are radio repeaters that receive distress beacon signals in the 406 - 406.1 MHz band and relay these signals to MEOLUTs for processing beacon identification and associated data. A description of the Cospas-Sarsat beacon signal parameters and data protocols is provided in reference document C/S T.001. MEOSAR instruments are flown on the following satellites:

Spacecraft	Country/Organization	Status
Galileo	Europe	In Deployment
Glonass-K	Russia	In Deployment
GPS-II/III (DASS)	USA	Non-operational; data available for operational use
GPS-III	USA/Canada	Planned

Note: The DASS S-band constellation is not planned to be declared as operational, but its data may be used operationally.

2.1 406 MHz MEOSAR Payload Functional Description

The DASS S-band SAR payload is carried on some GPS spacecraft and consists of an uplink 406 MHz receive antenna, a search and rescue repeater (SARR) instrument and a transmit antenna. DASS repeaters have a S-band downlink instead of the 1544-1545 MHz band assigned by the ITU.

The SAR/GPS L-band SAR payload is carried on GPS spacecraft and consists of an uplink 406 MHz receive antenna, a search and rescue repeater (SARR) instrument and a transmit antenna. The SARR instrument consists of a 406 MHz receiver and a frequency translator feeding a 1544 MHz downlink transmitter.

The SAR/Galileo payload consists of the forward link 406 MHz receive antenna, transponder and a 1544 MHz transmit antenna, and a return link for SAR-related acknowledgements and other messages. In terms of hardware, the return link is part of the Galileo ground mission segment (GMS) and navigation payload.

The SAR/Glonass payload include a 406 MHz repeater on the K series (K-1 and K-2) of spacecraft to relay the signals transmitted by 406 MHz distress beacons. Glonass K-2 series spacecraft are expected to also include a return link capability.

2.2 MEOSAR Orbit Information

Satellite positions and other information are needed for location processing and are normally available on the navigation message broadcast by each satellite. To provide redundancy, MEOSAR space segment providers are establishing servers, which can be accessed over the Internet where the orbit parameters would be available.

Annex C contains a table of what MEOLUT operators would like to see provided over the Internet with projected accuracy and, in addition, a table of what data is intended to be provided on the space segment providers' servers. For completeness, information on the navigation messages is presented as well.

2.3 MEOSAR Interoperability Parameters

Document C/S R.012 defines interoperability as follows: "the components of the MEOSAR system conform to a common architecture and comply with agreed performance standards. A set of similar satellite downlink characteristics allows MEOLUTs to track satellites and process signals from interoperable MEOSAR constellations."

Payload characteristics that had been identified in document C/S R.012 that impact MEOSAR interoperability are refined as follows:

- Modulation of the downlinks: non-inverted frequency translation will be used by all L-band constellations so there is no additional modulation of the downlink, except DASS constellation, which inverts the spectrum. This simplified MEOLUT design.

- Downlink frequency: MEOSAR satellite constellations need not have the exact same downlink frequencies to enable MEOLUTs to process their downlinks. SAR/GPS L-band will operate in the 1544.740 - 1544.840 MHz band, SAR/Glonass will operate in the 1544.850 - 1545.950 MHz band and SAR/Galileo will operate in the 1544.050-1544.150 MHz band. These frequencies were chosen to avoid the 1544.5 MHz downlink of the GEOSAR spacecraft. The GPS DASS S-band satellites use S-band 2226 MHz.

- Downlink EIRP: MEOSAR providers have agreed that to ensure interoperability, MEOSAR downlink EIRPs should exceed 15 dB_W for all MEOLUT-to-satellite elevation angles above 5 degrees.

- Downlink polarization: circular. The design for SAR/GPS L-band is to operate with RHCP downlinks, whereas SAR/Galileo and SAR/Glonass plan to operate LHCP downlinks. The DASS S-band satellites operate with LHCP.

- Repeater bandwidth: MEOSAR providers and Cospas-Sarsat have agreed that the 406 MHz L-band SAR repeater bandwidth should be as follows (centered on 406.05 MHz):
  - > 80 kHz (1.0 dB bandwidth),
  - > 90 kHz (3.0 dB bandwidth),
  - < 110 kHz (10 dB bandwidth),

  - < 170 kHz (45 dB bandwidth),
  - < 200 kHz (70 dB bandwidth).

  The bandwidth of the DASS S-band repeater is about 270 kHz, wider than the nominal 100 kHz, so filtering must be done on the downlink to remove the unwanted signals.

- Repeater receiver G/T: MEOSAR providers and Cospas-Sarsat have agreed that a repeater G/T value of -17.7 dB/K (assuming an antenna noise temperature of 400 K) or greater would enable the development of a fully interoperable MEOSAR system that satisfied the performance requirements for compatibility with Cospas-Sarsat.

- System dynamic range: the repeater dynamic range and AGC characteristics determine the MEOSAR system's ability to adequately accommodate interference and varying beacon message traffic loads. MEOSAR providers have agreed that the repeater instantaneous linear range (not including AGC) should meet or exceed 30 dB.

- Repeater AGC characteristics: range >30 dB with a time constant < 80 ms.

- Repeater linearity: MEOSAR providers have agreed that the ratio of power from a relayed beacon to intermodulation products should be greater than 30 dB_c when the repeater is operating beyond its linear range.

- Repeater group delay: repeater group delay characteristics impact upon MEOLUT time-tagging accuracy and, consequently, MEOSAR independent location accuracy performance. To ensure that minimum performance requirements are satisfied regardless of the satellite constellation relaying the beacon signal, MEOSAR providers agreed that repeater group delay variation with frequency should be less than 10 µs in any 4 kHz anywhere within the 1 dB bandwidth. These variations are valid only for in-orbit nominal operational temperature ranges as determined by the respective space segment operators.

- Group delay stability: to ensure negligible impact on TOA/TDOA estimation and effective exchange of TOA data, the MEOSAR providers agreed to a group delay stability with respect to all environmental conditions and ageing with a stability within that range of 500 nanoseconds.

- Uplink polarization: SAR/GPS L-band, SAR/Galileo and SAR/Glonass will all use RHCP with an axial ratio < 2.5 dB over the Earth coverage as the uplink polarization, while DASS S-band uses LHCP as the uplink polarization.

The following satellite parameters are suggested as enhancements that can be considered by space segment providers to possibly enhance system performance:

- Repeater bandwidth: to reduce the impact of side-band interferers, the 406 MHz L-band SAR repeater bandwidth should be as follows (centered on 406.05 MHz):
  - > 90 kHz (1.0 dB bandwidth),
  - < 100 kHz (10 dB bandwidth),

  - < 170 kHz (45 dB bandwidth),
  - < 200 kHz (70 dB bandwidth).

- Repeater bandpass characteristics: to ensure low distortion of the second generation beacon signals, the maximum SAR payload L-band signal amplitude ripple should be ± 0.5 dB (i.e., 1 dB peak to peak) over any 1 kHz within the 80 kHz passband, and the maximum overall amplitude ripple should be ± 1.25 dB (i.e., 2.5 dB peak to peak) within the entire 80 kHz passband.

- Repeater group delay: repeater group delay variation with frequency should be within ± 10 μs in ± 28 kHz band from the center frequency of the 1 dB bandwidth.

- Group delay stability: group delay stability with respect to environmental conditions within the 1 dB bandwidth of < 200 ns peak-to-peak in the medium term (i.e., over any 3 minutes) and < 400 ns peak-to-peak over any 24 hours (i.e., long term).

- END OF SECTION 2 -

3. GPS 406 MHZ MEOSAR REPEATER

3.1 DASS S-Band

DASS S-Band satellites have been on orbit since 2002 and have provided MEOSAR satellite functionality that has been vital to the development of the MEOSAR system, including ground system development and testing of MEOLUTs and MCCs. They were used extensively for the Proof of Concept and the Demonstration and Evaluation phases of MEOSAR system development and testing. They will be replaced as part of the normal GPS constellation replenishment with SAR/GPS MEOSAR satellites that carry a SAR/GPS payload specifically designed for Cospas-Sarsat and delivered to the GPS program from the Canadian Department of National Defence.

The DASS S-band constellation's data may be used operationally. The USA will commission DASS satellites in order to document their performance and support their use as needed. The capability to use the DASS S-band satellites is not required but the SAR payloads are available for continued support of the MEOSAR system development, operations and interference monitoring, as long as they remain in operation.

3.1.1 DASS S-Band Overall Description

DASS satellites contain a non-regenerative repeater that only amplifies, translates in frequency, and retransmits the received beacon message.

The DASS payload will transmit an RF spectrum centered at approximately 1.022 MHz below a center frequency of 2227.494 MHz. The center frequency is being very accurately derived from a phase-lock-loop that is governed by the on board GPS rubidium clock.

- Polarization: Left Hand Circular
- Center Frequency: 2227.494265 MHz
- Carrier Stability: $\pm$ 0.022 Hz (1 part in 10^{11})
- Maximum Doppler shift: $\pm$ 5.7 kHz

The DASS satellite RF spectrum is centered at approximately 1.022 MHz below the center frequency of 2227.494 MHz and is, therefore centered at 2226.472 MHz and has a double-sided -3dB bandwidth of approximately 220 kHz.

The downlink from each satellite contains a copy of the beacon message that has been translated from UHF to S-band according to the following formula.

Downlink frequency = 2226.472340 MHz + 406.05 MHz - UHF uplink frequency

The SV UHF receiver has a band pass filter with a -3 dB bandwidth of 220 kHz. The transmitted power is set at 0.6 W and is shared between all signals and in-band noise detected by the UHF receiver. The total transmitted S-band EIRP at bore sight is 10 dBw.

S-band GPS satellites, also known as DASS satellites, carrying MEOSAR repeaters acquire Cospas-Sarsat designations according to their unique two-digit Space Vehicle ID number (SVID), by preceding the SVID by the number 3.

The satellites listed in Table B.2 carry a repeater suitable for SAR use. Future GPS satellite launches will provide the DASS capability until it is replaced by the SAR/GPS capability, so the list of available satellites will continue to grow and be updated.

The GPS satellites are in six orbital planes with four satellites each. The six orbit planes have approximately 55° inclination and are separated by 60° right ascension of the ascending node (angle along the equator from a reference point to the orbit's intersection). Reference orbital positions for nominal MEOSAR GPS S-band satellites can be found in Annex A of this document.

3.1.2 DASS S-Band Repeater Functional Description

The DASS repeater can only be operated in the Automatic Gain Control (AGC) mode.

3.1.3 DASS S-Band Repeater Operating Modes

The DASS repeater can only be operated in the Automatic Gain Control (AGC) mode.

3.1.4 DASS S-Band Repeater Spectrum Characteristics

The following spectrum photographs show the downlink spectrum of a typical DASS satellite. The signals seen are other signals within the repeaters 220 kHz band, but outside of the 100 kHz SAR band. Both photographs were taken with a real time spectrum analyser.

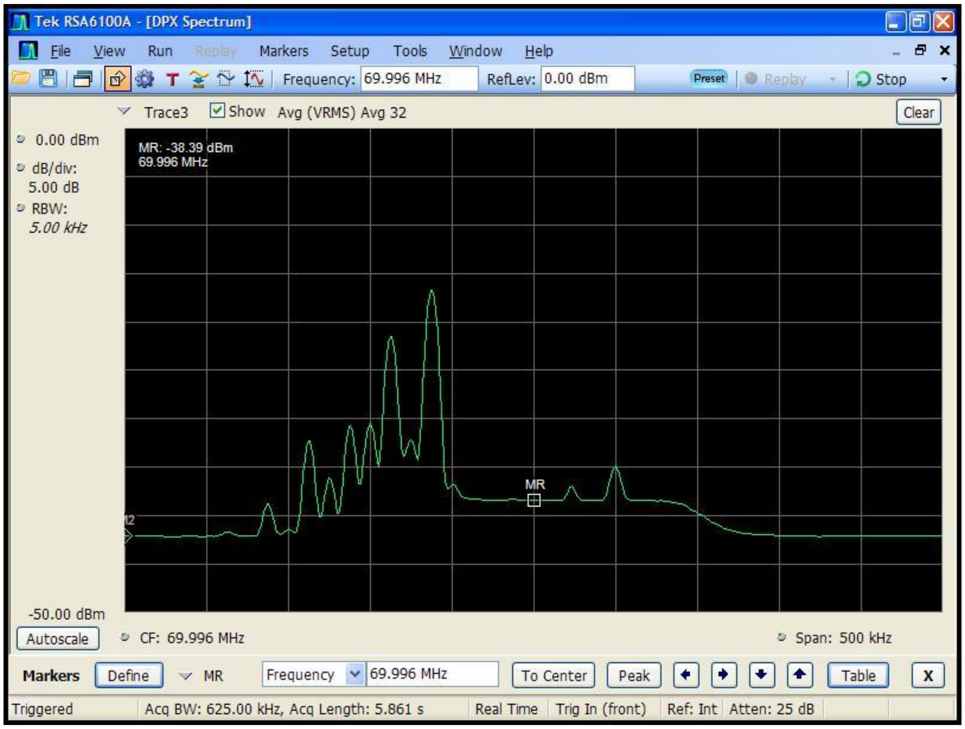


Figure 3.1: DASS S-Band Downlink Spectrum Averaged

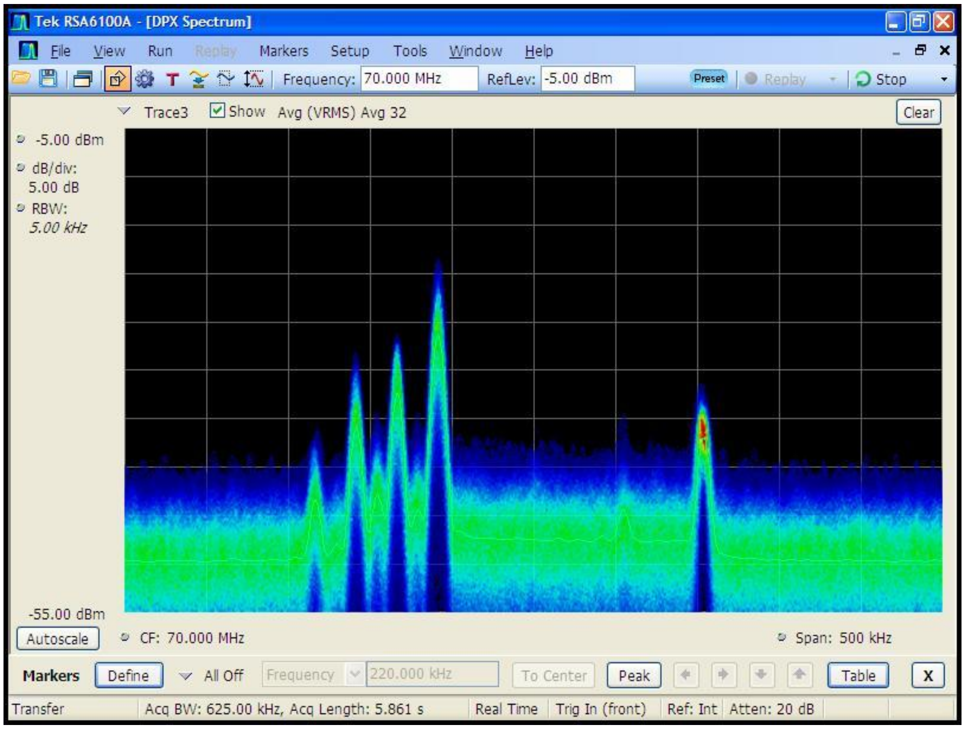


Figure 3.2: DASS S-Band Downlink Spectrum

3.1.5 DASS S-Band Repeater Coverage Area

The DASS S band repeater is designed to cover the full visible Earth's disc both in the uplink and in the downlink. The difference in the path loss between satellites seen on the horizon and those appearing in zenith is 1.9 dB.

3.1.6 DASS S-Band Repeater Performance Parameters

The following data is derived from the on-orbit DASS Commissioning Tests, conducted by the USA in 2014-2016.

A statistical analysis was performed on the data as follows:

1. When multiple measurements were made on one satellite, the results were averaged to get a single reportable result. If one measurement was done, then the reported result is that one measurement.
2. The range of the reported results for all tested satellites are given.
3. The overall average, calculated by taking the reported results for each satellite and averaging them.
4. A standard deviation calculated by taking the reported results from each satellite and finding the standard deviation.

3.1.6.1 DASS S-Band SAR Receiver Parameters

Parameter	Interoperability Requirement	DASS On Orbit Performance	Unit
Uplink frequency range	406.0 to 406.1	405.915 to 406.185	MHz
Receive centre frequency Normal mode	406.050	406.050	MHz
Nominal input power at antenna	-159.0	-	dB_W
Maximum input power at antenna	-148.0		dB_W
System dynamic range	30	Range: 26 to 37 Average:=30.9 Standard Deviation=4	dB
Receive antenna polarisation	RHCP	LHCP	
Receive antenna gain at boresight and EoC		13.5 (boresight) 11.6 (EoC)	dB_i
Receive antenna axial ratio	< 2.5	Not measured on orbit	dB
Satellite G/T At edge of coverage At centre of coverage	>-17.7	Range: -29.6 to -16 Average: = -21.46 Standard Deviation: = 3.3	dB/K
System noise temperature			K

Parameter	Interoperability Requirement	DASS On Orbit Performance	Unit
Bandpass characteristics Normal mode	> 80 kHz (1.0 dB) > 90 kHz (3.0 dB) < 110 kHz (10 dB) < 170 kHz (45 dB) < 200 kHz (70 dB)	220 kHz (3 dB)	
Phase linearity (overall in-band) Normal mode	/		degree
Group delay (turn-around time) Normal mode	/		µs
Group delay uncertainty (95% conf.)	500		ns
Group delay over 4 kHz (slope) Normal mode	10		µs/4kHz
Transponder gain modes			
ALC time constant	< 80		ms
ALC dynamic range	> 30	Range: 26 to 37 Average = 30.9 Standard deviation = 4	dB
Transponder gain (multiple measurements on each sat averaged first)	> 180	Range: 151-159.4 Average = 156.27 Standard Deviation = 1.94	dB
Fixed gain mode adjustment range			dB
Transponder gain at nominal o/p power			dB
Transponder linearity[1]	> 30	In-Band Range: 31 to 36 Average = 33.47 Standard Deviation = 1.81 Out of band: None Seen	dB_c
Translation frequency			Hz
Frequency translation Accuracy Short term stability (100 ms)	$\pm 2 \times 10^{-11}$ 1×10^{-11}	Accuracy $\leq 8.7 \times 10^{-9}$ Average Accuracy = 8×10^{-10} Error range=: -22 to 8 Hz Error average = 2.1 Hz Error Standard Deviation = 8.8 Hz	
Gain variation			dB_{pk-pk}
Translation frequency stability			

Table 3.1: DASS S-Band SAR Receiver Parameters

[1] In-band measured via spectrum analyzer using two tones and comparison of the difference between the intermodulation products and the two tones.

3.1.6.2 DASS S-Band SAR Transmitter Parameters

Parameter	Interoperability Requirement	DASS Performance	Units
Downlink frequency band		2226.47229 to 2226.47239 (SAR band) 2226.472205 to 2226.472475 (repeater)	MHz
Downlink centre frequency Normal mode		2226.47234	MHz
Downlink antenna polarisation		LHCP	
Transmit antenna axial ratio			dB
Downlink EIRP	15 dB_W	Range: 27 to 34.3 Average = 30.3 Standard Deviation = 2.1	dB_m
EIRP stability in ALC mode			dB_{pk-pk}
EIRP stability in FG mode			dB_{pk-pk}
In band Intermod Products		Range: 31 to 36 dB below two tones level Average = 33.47 Standard Deviation = 2.1	dB
Out of band Intermod products		None seen	

Table 3.2: DASS S-Band SAR Transmitter Parameters

3.2 GPS-III L-Band

3.2.1 GPS III Overall Description

(to be provided later)

3.2.2 GPS III Repeater Functional Description

(to be provided later)

3.2.3 GPS III Repeater Operating Modes

(to be provided later)

3.2.4 GPS III Repeater Spectrum Characteristics

(to be provided later)

3.2.5 GPS III Repeater Coverage Area

(to be provided later)

3.2.6 GPS III Repeater Performance Parameters

(to be provided later)

3.2.6.1 GPS III SAR Receiver Parameters

(to be provided later)

3.2.6.2 GPS III SAR Transmitter Parameters

(to be provided later)

3.2.6.3 GPS III SAR Antennas

(to be provided later)

- END OF SECTION 3 –

4. GALILEO 406 MHZ MEOSAR REPEATER

4.1 Galileo Overall Description

Galileo satellites carrying MEOSAR repeaters acquire Cospas-Sarsat designations according to their unique two-digit Space Vehicle ID number (SVID), by preceding the SVID by number 4.

The information presented in this section refers to the Galileo In-Orbit Validation (IOV) satellites and to FOC (Full Operational Capability) satellites.

Only two of four Galileo IOV satellites are equipped with SAR repeaters. These two satellites are designated as Cospas-Sarsat 419 (GSAT0103, SVID-19) and Cospas-Sarsat 420 (GSAT0104, SVID-20).

SAR/Galileo FOC satellites are currently under deployment and they are all equipped with SAR Repeaters.

SAR/Galileo IOV and FOC satellites are in Walker 24/3/1 orbital configuration, with the slots separated by 45 degrees. Reference orbital positions for nominal MEOSAR Galileo satellites[2] can be found in:

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

Note that satellites Cospas-Sarsat 418 (GSAT0201, SVID-18) and Cospas-Sarsat 414 (GSAT0202, SVID-14) are exceptionally in elliptical orbits. Their orbital positions, represented by Keplerian elements for the reference time 1 October 2010 at 00:00:00 UTC, are defined in Table 4.1.

Satellite			**Semi-Major Axis** (km)	**Launch date**	**Eccentricity**	**Inclination** (deg)	**RAAN** (deg)	**Arg. Perigee** (deg)	**True Anomaly** (deg)
	S VID	Slot							
GSAT0201	18	NA	27977.69	22.08.2014	1.57E-01	49.97	70.106	41.121	137.250
GSAT0202	14	NA	27977.61	22.08.2014	1.57E-01	50.03	69.080	42.294	317.263
Note: The coordinate reference frame used is CIRS[3] (true equator).									

Table 4.1: Keplerian Elements of Nominal Orbital Positions for Galileo C/S 418 and C/S 414 Satellites

[2] Nominal MEOSAR Galileo satellites: SAR/Galileo Satellites for which ephemeris are available either through signal in space or through the Galileo Service Centre Server

[3] Dennis D. McCarthy and Gérard Petit (eds.), “IERS CONVENTIONS (2003)” IERS Convention Centre.

The following sections provide information regarding the repeater configuration, modes of operation, and performance characteristics, including group delay characteristics, as recommended by CSC-47.

4.2 Galileo Repeater Functional Description

4.2.1 Payload Configuration

The Galileo satellite has two functional elements relevant to SAR, performing two principal functions pertaining to the SAR/Galileo system: the Navigation Function and the SAR Function. SAR/Galileo utilises both of these elements: the SAR Function for performing of the Forward Link Alert Service and the Navigation Function for performing the Return Link Service.

Figure 4.1 depicts the implementation of the two Galileo SAR functions. This section deals with the SAR Repeater, which performs the Forward Link Alert Service function, and comprises the SAR Transponder (SART) and SAR receive and transmit antennas (SARANT).

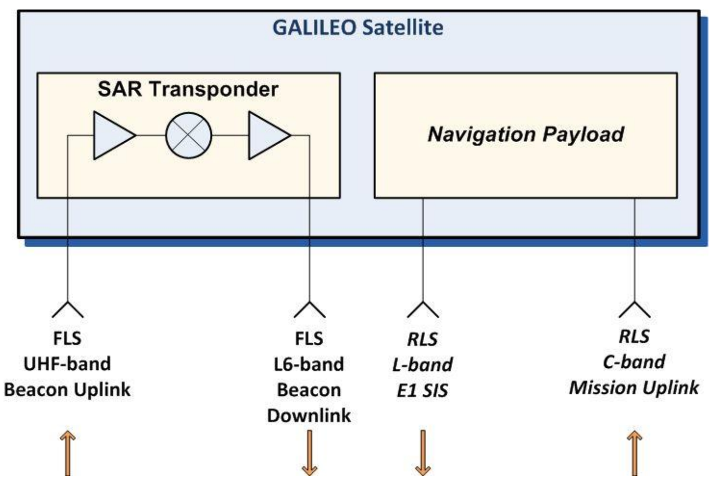


Figure 4.1: Implementation of SAR Functions on the Galileo Satellites

4.2.2 Configuration of Galileo SAR Repeaters

The Galileo SAR repeaters are based on bent pipe type transponders with no frequency inversion. They receive signals at the 406 MHz band and retransmit in the L6 band at 1.5441 GHz (see Table 4.3). They are designed according to the space segment interoperability requirements[4], ensuring MEOSAR compatibility and interoperability.

[4] As defined in Annex F of document C/S R.012.

4.3 Galileo Repeater Operating Mode

The Galileo repeater can operate in two gain and 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 (FGM) or Automatic Level Control (ALC) mode. The operational modes of the SAR repeater are therefore:

ON mode

- ALC (transponder gain is self-regulated to ensure stable EIRP)
  - 90 kHz BW (normal bandwidth mode): ALC90 (default mode)
  - 50 kHz BW (narrowband mode): ALC50

In automatic level control gain mode the operational gain is automatically adjusted to obtain a power of 7 dB_W (IOV) or 6 dB_W (FOC) at the output of the SAR transponder.

- FGM (fixed gain, set by telecommand)
  - 90 kHz BW (normal bandwidth mode): FGM90
  - 50 kHz BW (narrowband mode): FGM50

In fixed gain mode (FGM) the operational gain is set by telecommand in a 31 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 dB_W (IOV) or 6 dB_W (FOC) is achieved when the gain setting is set at the reference step.

The overall gain of the SAR repeater in the nominal gain setting in FGM (including the gains of the receive and transmit antennas) is given in the table below.

	FGM
Edge of coverage	182 dB
Centre of coverage	187 dB

Table 4.2: Typical Overall Repeater Gain at Reference Gain Step in FGM[5]

STANDBY mode (transponder is powered up, but RF power is OFF)

OFF mode (transponder is not powered)

[5] The values provided refer to the center frequency of the repeater band.

4.4 Galileo Repeater Spectrum Characteristics

The downlink spectrum of the Galileo repeaters is dominantly shaped by the intermediate-frequency crystal filters which define the pass band. Figure 4.2 and Figure 4.3 represent an example of the Galileo SAR repeater L-band downlink signal spectrum in narrow- and normal- bandwidth setting.

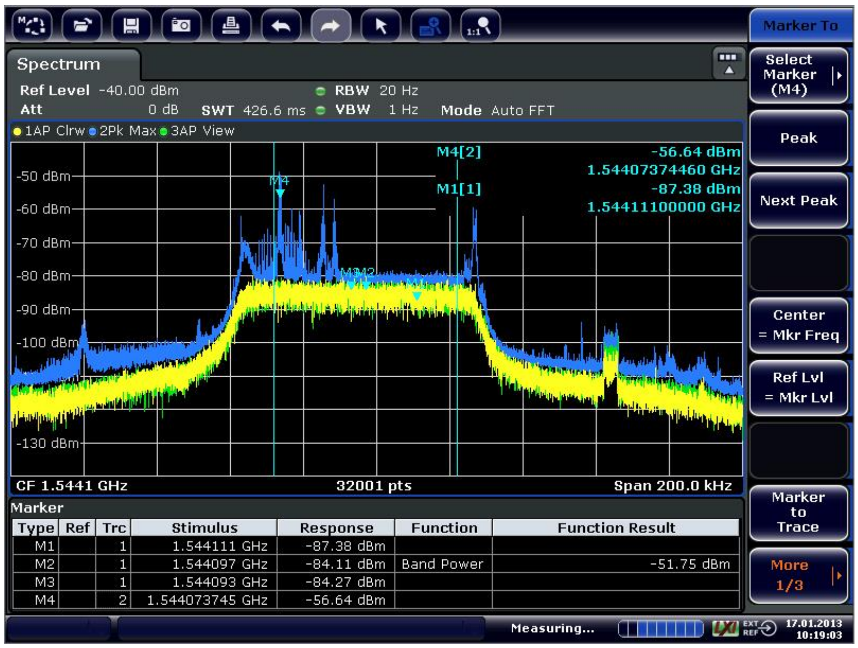


Figure 4.2: Galileo SAR Repeater L-Band Downlink Narrow-Band (50 kHz) Signal Spectrum

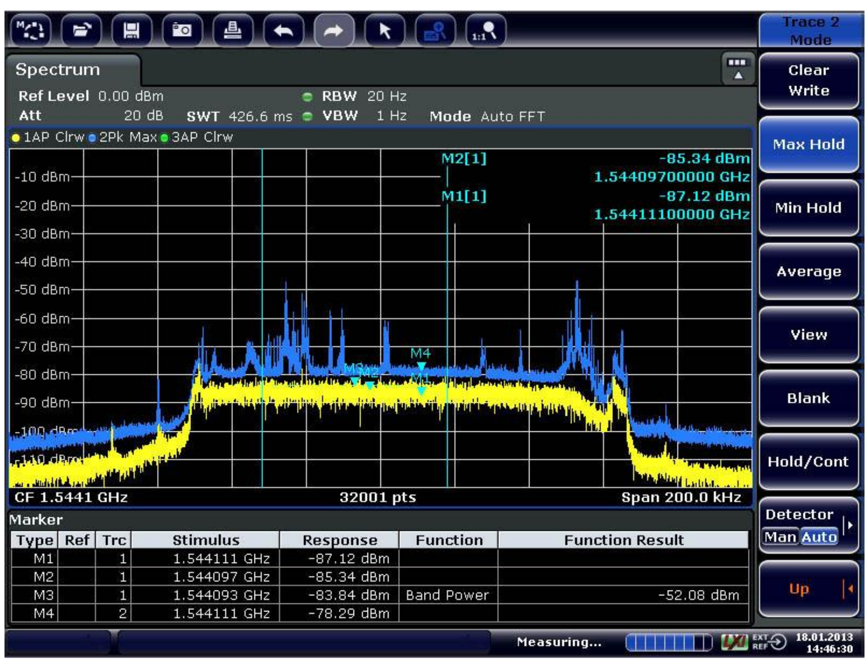


Figure 4.3: Galileo SAR Repeater L-Band Downlink Normal Band (90 kHz) Signal Spectrum

4.5 Galileo Repeater Coverage Area

The Galileo SAR repeater is designed to cover the full visible Earth's disc both in the uplink and in the downlink. From the orbital altitude of the Galileo constellation the visible Earth disc covers approximately 39.2% of Earth's surface. The difference in the path loss between satellites seen on the horizon and those appearing in zenith is 1.9 dB.

4.6 Galileo Repeater Performance Parameters

Table 4.3 presents the typical measured satellite payload performances based on in-orbit and on-ground equipment testing.

Parameter	Interoperability Requirement[(a)]	Galileo IOV Performance	Galileo FOC Performance	Unit
Uplink frequency range	406.0 to 406.1	406.0 to 406.1		MHz
Receive centre frequency Normal mode Narrowband mode	 406.050 406.043	 406.050 406.043		MHz
Nominal input power at antenna	-159.0	-		dB_W
Maximum input power at antenna	-148.0	-153.0		dB_W
System dynamic range	30	32	30	dB
Receive antenna polarisation	RHCP	RHCP		
Receive antenna gain at EoC [(b)]		11.7		dB_i
Receive antenna axial ratio	< 2.5	< 1.8		dB
Satellite G/T [(c)] At edge of coverage [(a)] At centre of coverage	 >-17.7	 > -14.9 > -12.6	 > -15.3 > -13.6	dB/K
System noise temperature [(c, d)]		380	365	K
Bandpass characteristics Normal mode Narrowband mode	 > 80 kHz (1.0 dB) > 90 kHz (3.0 dB) < 110 kHz (10 dB) < 170 kHz (45 dB) < 200 kHz (70 dB) > 50 kHz (1.0 dB) < 75 kHz (10 dB) < 130 kHz (45 dB) < 160 kHz (70 dB)	 > 80 kHz (10 dB) > 95 kHz (3 dB) < 110 kHz (10 dB) < 150 kHz (45 dB) < 200 kHz (70 dB) > 50 kHz (1.0 dB) < 70 kHz (10 dB) < 100 kHz (45 dB) < 180kHz (70 dB)	 > 80 kHz (1.0 dB) > 90 kHz (3 dB) < 110 kHz (10 dB) < 150 kHz (45 dB) < 180 kHz (70 dB) > 50 kHz (1.0 dB) < 75 kHz (10 dB) < 110 kHz (45 dB) < 130 kHz (70 dB)	
Phase linearity (overall in-band) Normal mode Narrowband mode	 / /	 28 18	 / /	degree
Group delay (turn-around time) [(e)] Normal mode Narrowband mode	 / /	 27 38	 48 68	µs
Group delay uncertainty (95% conf.)	500	< 150	< 163	ns

Parameter	Interoperability Requirement[a]	Galileo IOV Performance	Galileo FOC Performance	Unit
Group delay over 4 kHz [f] (slope) Normal mode Narrowband mode	 10	 5 9	 2.5 3.5	µs/4kHz
Transponder gain modes		FGM ALC		
ALC time constant	< 80	40	55	ms
ALC dynamic range	> 30	32		dB
Transponder gain	> 180	165 - 187		dB
Fixed gain mode adjustment range		31 (FGM: -1… +30)	31 (FGM: +1…+31)	dB
Transponder gain at nominal o/p power		160		dB
Transponder linearity (C/I3)	> 30	32	28	dB_c
Translation frequency		1,138,050,000.0	1,138,049,997.6	Hz
Frequency translation Accuracy Short term stability (100ms)	 ± 2 x10^{-11} 1 x10^{-11}	 < ±2 x10^{-11} 2 x10^{-11}	 < ±1 x10^{-12} 4 x10^{-12}	 [h]
Gain variation [g]		0.3		dB_{pk-pk}
Translation frequency stability		RAFS: < 1.0 x10^{-11} PHM: < 1.0 x10^{-14}		
Downlink frequency band		1,544.0 to 1,544.2		MHz
Downlink centre frequency Normal mode Narrowband mode		 1,544.100 1,544.093		MHz
Downlink antenna polarisation		LHCP		
Transmit antenna axial ratio		< 1.7	< 1.9	dB
Downlink EIRP	15	> 18.7 [i] < 20.3 [j]	> 17.8 (i) < 19.5(j)	dB_W
EIRP stability in ALC mode		0.3		dB_{pk-pk}
EIRP stability in FG mode		1.5	1.2	dB_{pk-pk}

Table 4.3: Typical SAR/Galileo IOV Repeater Characteristics

(a) MEOSAR space segment interoperability requirements.
(b) The receive antenna edge of coverage (EoC) is defined at a beacon elevation angle of 5°.
(c) G/T as measured in orbit. The MEOSAR space segment interoperability requirement is defined assuming antenna external noise temperature Ta = 400 K.
(d) System temperature computed at transponder input.
(e) These values refer to the center frequency. The full characterization of each launched SAR payload with respect to delay is reported in accordance with the format proposed in document C/S R.018.
(f) In the 1 dB band.
(g) Gain variation in any 3 kHz within the operating band.
(h) Depending on the configuration settings of the on-board clocks may be significantly better.
(i) In ALC mode or in FGM at nominal gain setting, over full Earth disc, including pointing error.
(k) In ALC mode or in FGM at nominal gain setting, at the centre of the beam (boresight).

4.7 Galileo SAR Receiver Parameters

SAR/Galileo receiver parameters are specified in Table 4.3.

4.7.1 Galileo SAR Bandpass Parameters

Bandpass characteristics of the Galileo transponders are presented in Figure 4.4 for both the normal (90 kHz) and the narrow (50 kHz) bands. These are typical values, considering that there are small variations with temperature and from unit to unit.

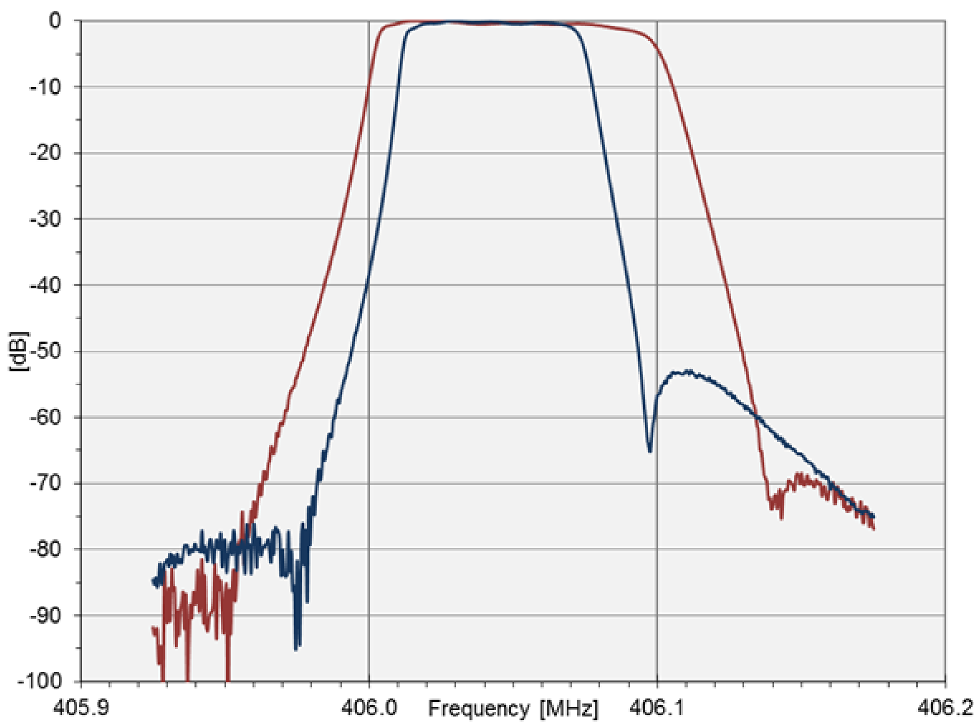


Figure 4.4: Galileo SAR Repeater Normal and Narrow Bandpass Filtering Performance

4.7.2 Galileo SAR Transmitter Parameters

SAR/Galileo transmitter parameters are specified in Table 4.3.

4.7.3 Galileo SAR Antennas

As an example of the Galileo IOV satellites, Figure 4.5 and Figure 4.6 show the SAR UHF receive and L-band transmit antenna co-polar gain plots on Galileo IOV 419 satellite in four characteristic cross-sections.

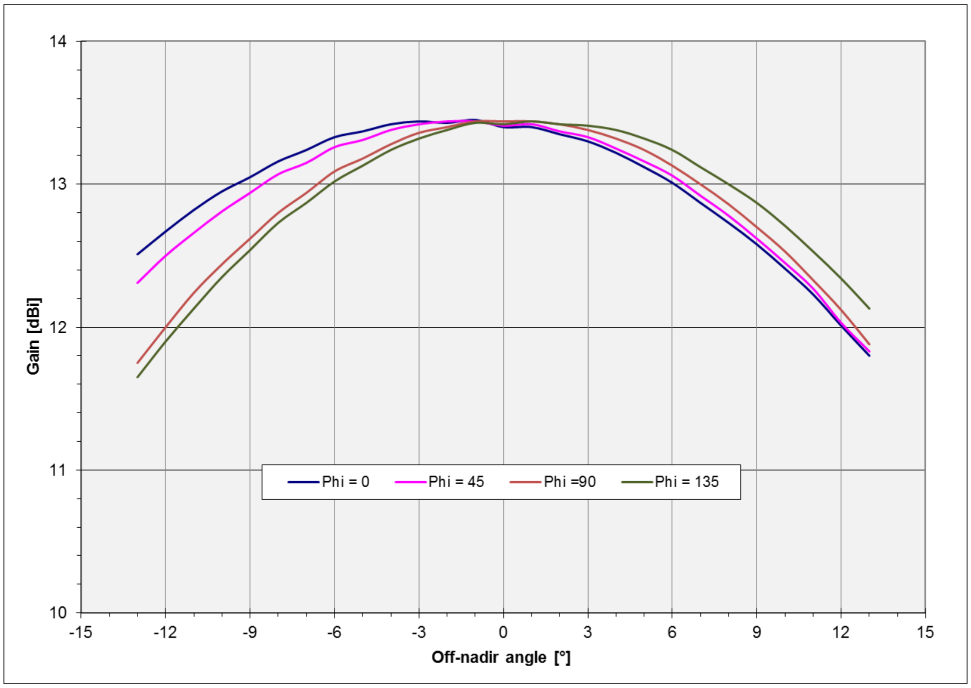


Figure 4.5: SAR Rx Antenna Gain on Galileo IOV 419 Satellite (Four Cross-Sections)

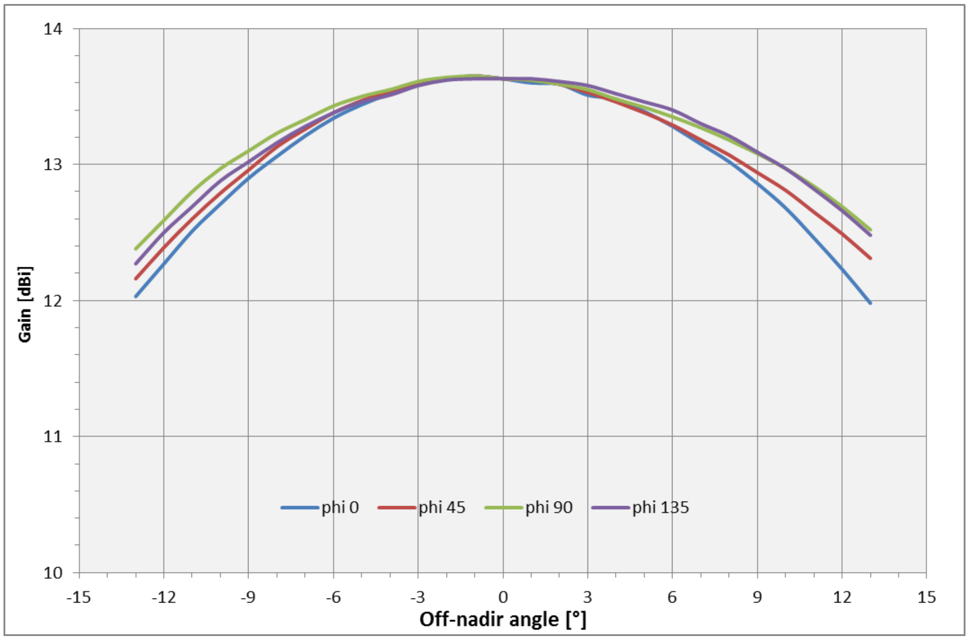


Figure 4.6: SAR Tx Antenna Gain on Galileo IOV 419 Satellite (Four Cross-Sections)

As an example of the Galileo FOC satellites Figure 4.7 and Figure 4.8 show the SAR UHF receive and L-band transmit antenna co-polar gain plots of Galileo FOC 426 satellite in four characteristic cross-sections.

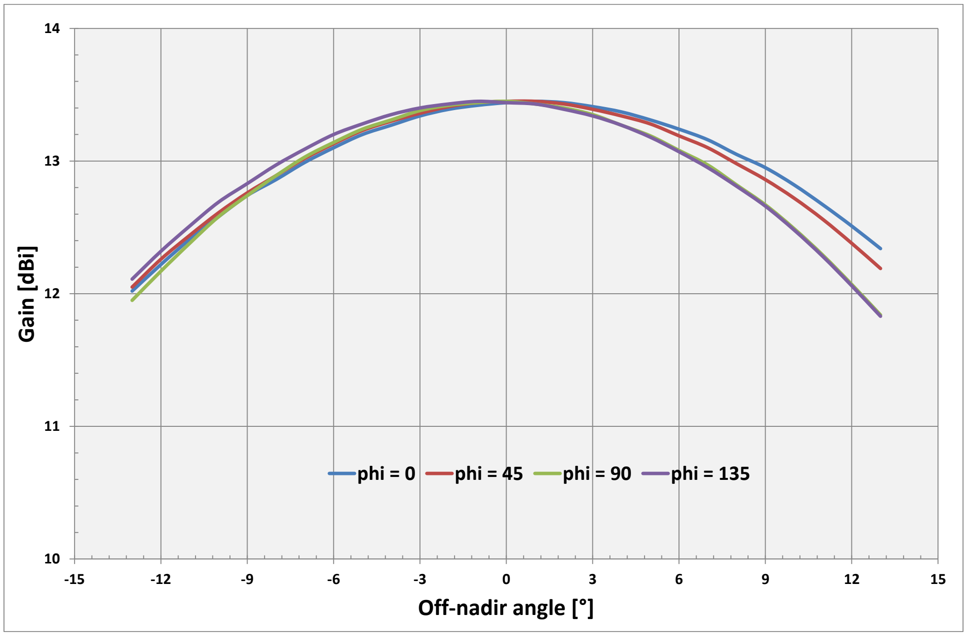


Figure 4.7: SAR Rx Antenna Gain on Galileo FOC 426 Satellite (Four Cross-Sections)

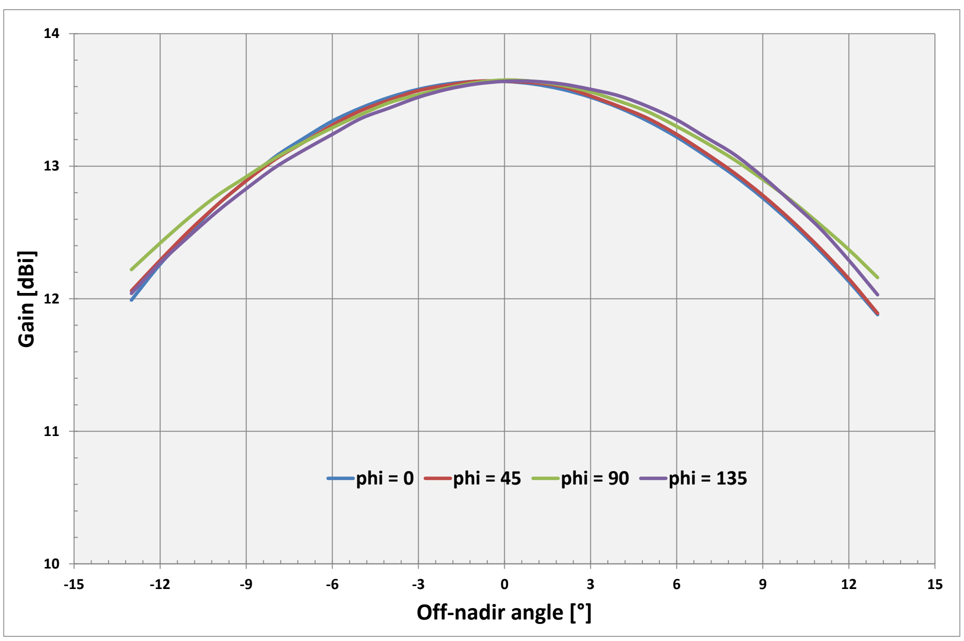


Figure 4.8: SAR Tx Antenna Gain on Galileo FOC 426 Satellite (Four Cross-Sections)

- END OF SECTION 4 -

5. GLONASS 406 MHZ MEOSAR REPEATER

5.1 Glonass Overall Description

The information presented in this section refers to the Glonass K-series satellites. Currently two Glonass-K satellites are equipped with SAR repeater. These two satellites are designated as Cospas-Sarsat 501 and Cospas-Sarsat 502. Their nominal orbital parameters are defined in Table 5.1.

Table 5.1: Orbital Parameters of Glonass-K Satellites 501 and 502

S/C	Plane	Slot	Altitude (km)	Eccentricity	Inclination (deg)	RAAN (deg)*	Arg. Perigee (deg)	Argument of latitude (deg)**	Orbital period
502	2	09	19100	0	64.8	11° 15’ 00”	0.0	160° 26‘ 37”	11 h. 15 m. 44 s.
501	3	20				131° 15’ 00”		40° 26‘ 37”	

* RAAN are done according the formula:
251° 15’ 00”+ 120° (i - 1)
where (i = 1, 2, 3) as of 00: 00: 00 on 1 January 1983 (UTC + 3h)

** True anomaly for circular orbit is equal to argument of latitude and is given for the epoch of 00:00:00 on 1 January 1983 (UTC+3h).

The following sections provide information regarding the repeater configuration, modes of operation and performance characteristics.

5.2 Glonass Repeater Functional Description

Figure 5.1 depicts the implementation of the Glonass-K SAR repeater.

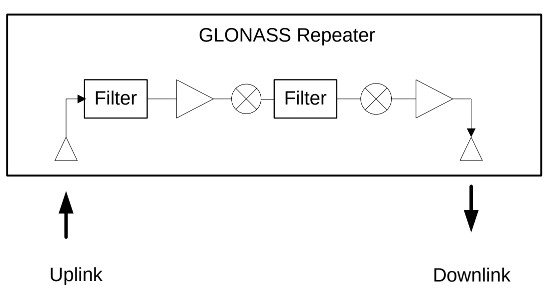


Figure 5.1: Implementation of SAR Functions on the Glonass-K Satellites

5.3 Glonass Repeater Operating Modes

The Glonass-K repeater can operate in one gain and two bandwidth modes. The operational modes include the Normal and Narrow Bandwidth modes. Repeater gain is self-regulated by Automatic Level Control (ALC). The repeater gain is automatically adjusted to obtain a power of 7 dB_W at the output of the SAR transponder.

5.4 Glonass Repeater Spectrum Characteristics

Figure 5.2 and Figure 5.3 depict an example of the Glonass SAR repeater L-band downlink signal spectrum in narrow- and normal-bandwidth setting.

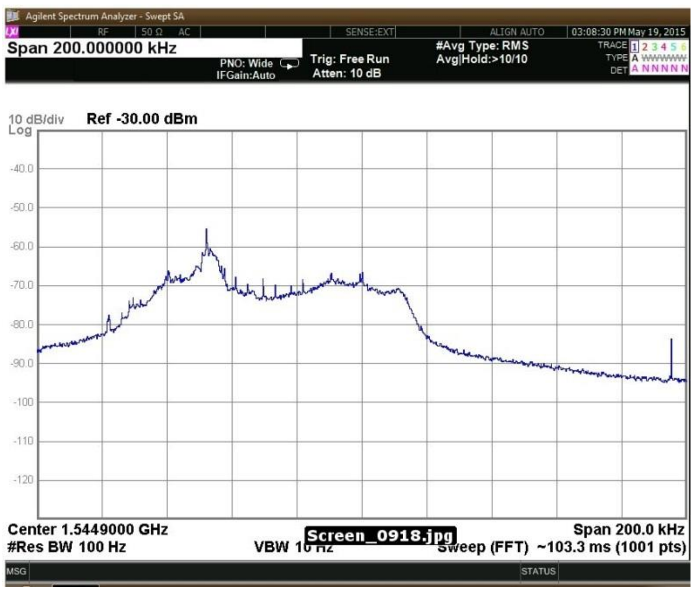


Figure 5.2: Glonass-K SAR Repeater L-Band Downlink Narrow Band Signal Spectrum

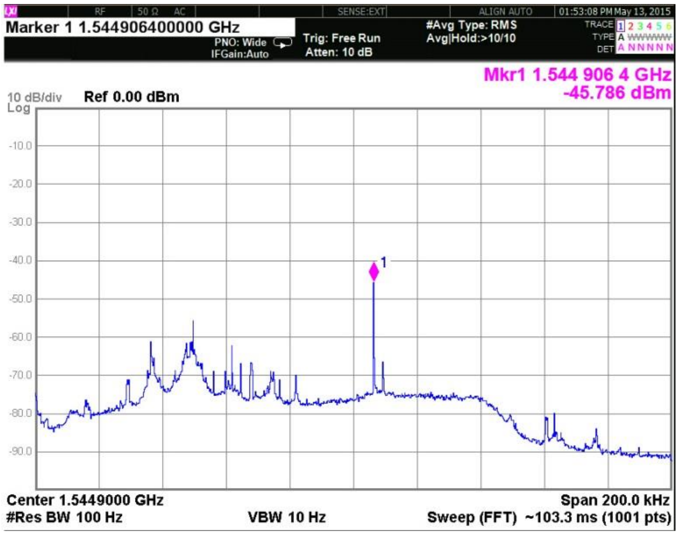


Figure 5.3: Glonass-K SAR Repeater L-Band Downlink Wide Band Signal Spectrum

5.5 Glonass Repeater Coverage Area

Figure 5.4 depicts the example of 0˚ elevation coverage area for Glonass-K.

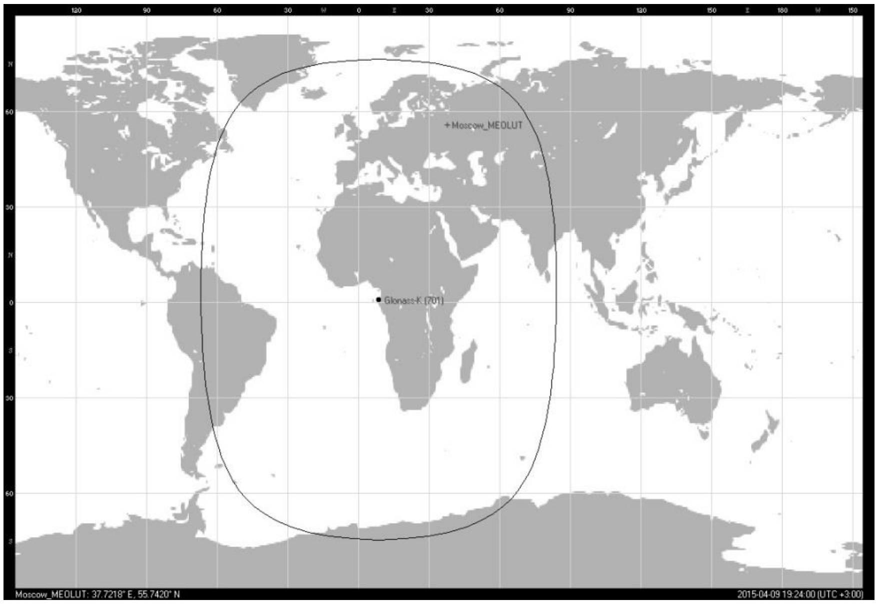


Figure 5.4: Glonass-K 0˚ Elevation Coverage Area

(an example of coverage area taken near the equator)

5.6 Glonass Repeater Performance Parameters

Table 5.2 presents the typical measured satellite payload performances based on in-orbit and on-ground equipment testing.

Table 5.2: Glonass-K SAR Repeater Characteristics

Parameter	Unit	Value
Uplink frequency range	MHz	406.0 to 406.1
Receive centre frequency Normal mode Narrowband mode	MHz	 406.050 406.043
Nominal input power at antenna	dB_W	-160
Maximum input power at antenna	dB_W	-140.0
System dynamic range	dB	30
Receive antenna polarisation		RHCP
Receive antenna gain at edge of coverage (EoC) [6]	dB_i	10.6
Receive antenna axial ratio	dB	3
Receive antenna G/T[7] At edge of coverage At centre of coverage	dB/K	 -16.3 -14.3
System noise temperature	K	490
Bandpass characteristics Normal mode Narrowband mode		 > 120 kHz (3 dB) < 150 kHz (10 dB) < 340 kHz (30 dB) < 450 kHz (40 dB) > 80 kHz (3 dB) < 95 kHz (10 dB) < 230 kHz (30 dB) < 330 kHz (40 dB
Group delay uncertainty (95% conf.)	ns	< 100
Group delay over 4 kHz (slope) Normal mode Narrowband mode	µs/4kHz	In uplink frequency range < 10 < 10
Transponder gain mode		ALC
ALC time constant	ms	< 80
ALC dynamic range	dB	> 30
Transponder gain	dB	175
Transponder linearity (C/I3)	dB_c	> 30
Translation frequency	Hz	1 138 849 998.5
Frequency translation Accuracy Short term stability (100 ms)	 Hz	 1.53 $\pm 5 \times 10^{-12}$
Gain variation (in any 3 kHz)	dB pk-pk	0.53

[6] The receive antenna edge of coverage (EoC) is defined at a beacon elevation angle of 5°.
[7] G/T as measured in orbit.

Downlink frequency band	MHz	1544.85-1544.95
Downlink centre frequency Normal mode Narrowband mode	MHz	 1544.900 1544.893
Downlink antenna polarisation		LHCP
Downlink EIRP (at edge of coverage)	dB_W	18.2

5.6.1 Glonass SAR Receiver Parameters

Bandpass characteristics of the Glonass-K transponder are presented in Figure 5.5 and Figure 5.6 for both narrow and normal bands respectively.

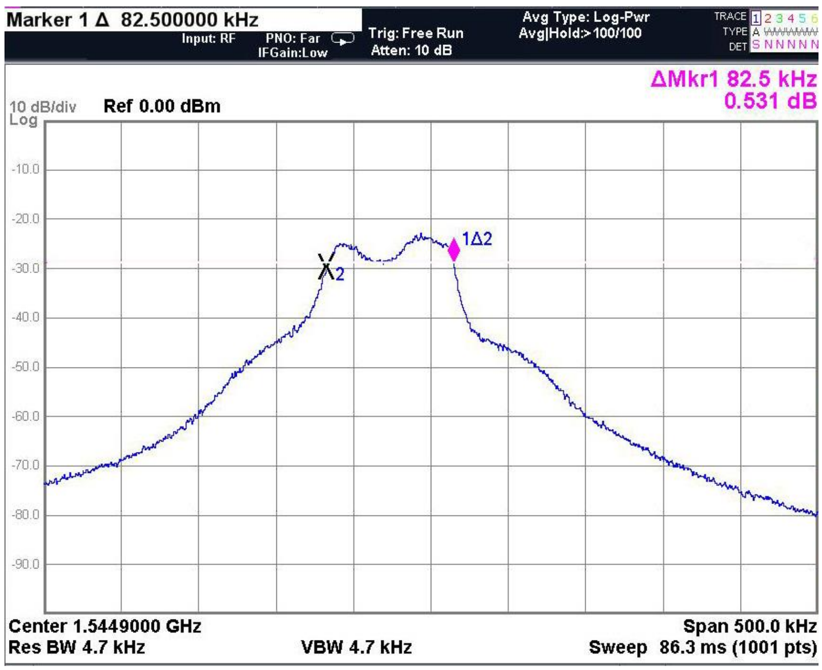


Figure 5.5: Glonass-K SAR Repeater Narrow Bandpass Filtering Performance

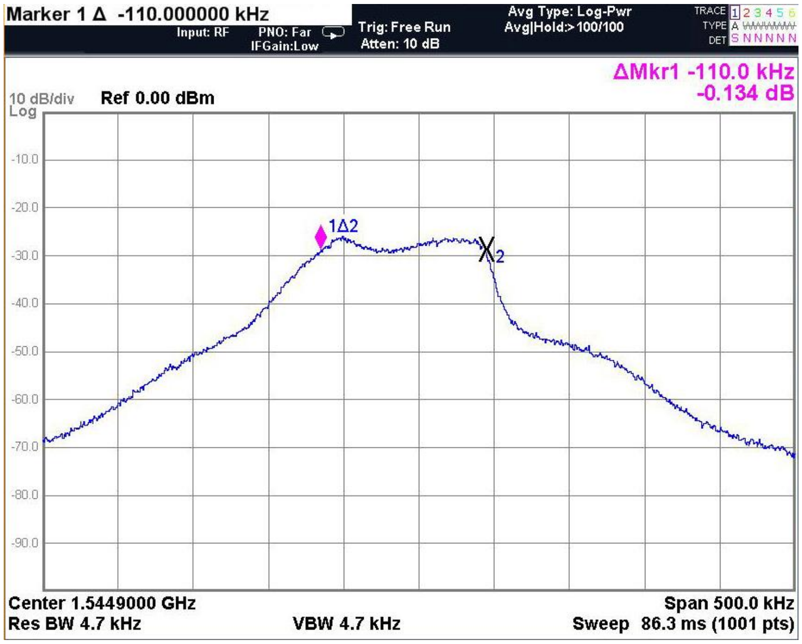


Figure 5.6: Glonass SAR Repeater Normal Bandpass Filtering Performance

5.6.2 Glonass SAR Transmitter Parameters

Glonass-K SAR transmitter parameters are specified in Table 5.2.

5.6.3 Glonass SAR Antennas

Figure 5.7 and Figure 5.8 show the SAR receive and L-band transmit antenna gain plots for Glonass-K satellites in four characteristic cross-sections.

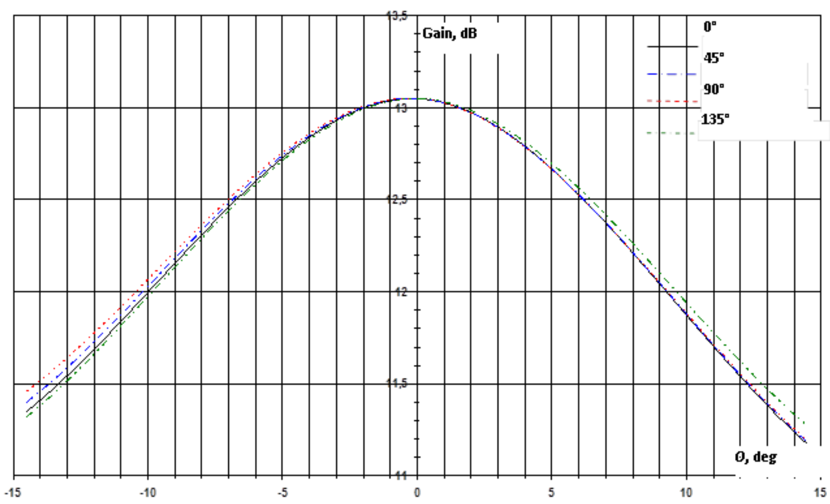


Figure 5.7: Glonass-K SAR Repeater Receiving Antenna Gain (Four Cross-Sections)

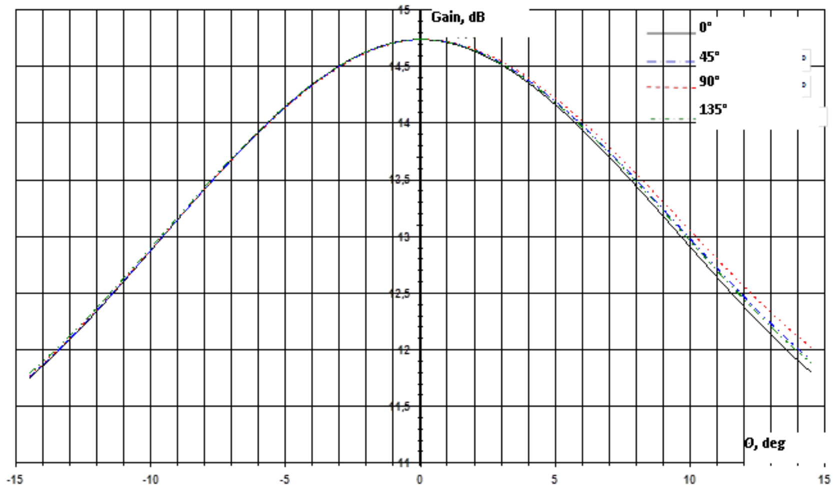


Figure 5.8: SAR Repeater Transmitting Antenna Gain (Four Cross-Sections)

- END OF SECTION 5 -

ANNEX A

INFORMATION FOR MEOLUT OPERATORS

The complete list of all operational satellites in each constellation with current status as of publication date is provided in Table B-1. A dynamic list is maintained on the Cospas-Sarsat website.

Additional sources regarding the current status of MEOSAR satellites are available on the following websites:

- for Galileo satellites:
  - http://www.gsc-europa.eu/system-status/Constellation-Information
- for Glonass satellites:
  - http://glonass-iac.ru/en/GLONASS/
- for GPS satellites:
  - http://www.navcen.uscg.gov/?Do=constellationStatus
  - http://en.wikipedia.org/wiki/List_of_GPS_satellites

Information regarding the orbital parameters of MEOSAR satellites is available from:

- the navigation signals broadcasted from MEOSAR satellites, or
- http://www.celestrak.com/NORAD/elements/sarsat.txt (data are retrieved from JSpOC via www.space-track.org) The orbit data are providing using the two-line format, which is defined at:
  - http://spaceflight.nasa.gov/realdata/sightings/SSapplications/Post/JavaSSOP/SSOP_Help/tle_def.html
  - http://celestrak.com/NORAD/documentation/tle-fmt.asp
- the laser-ranging community in CPF format (a derivative of SP3) for Galileo and Glonass satellites, at:
  - ftp://cddis.gsfc.nasa.gov/pub/slr/cpf_predicts/
  - ftp://edc.dgfi.badw.de/pub/slr/cpf_predicts/

- END OF ANNEX A -

ANNEX B

MEOSAR SATELLITE TECHNICAL PARAMETERS

B.1 MEOSAR Satellite Identification Parameters

	Cospas-Sarsat Satellite ID code (note 1)	NORAD ID (NASA Catalogue Number) (note 2)	International Designator (note 3)	Satellite Name (note 4)	Space Vehicle Number (SVN) (note 5)	Other Names	Other Names	Other Names	PRN Number (note 6)	Launch Date
DASS S-Band	301	37753	11036A	GPS BIIF-2	63	GPS 2F-2	Navstar 66	USA 232	1	2011-07-16
	302	28474	04045A	GPS BIIR-13	61	GPS 2R-13	Navstar 56	USA 180	2	2004-11-06
	303	40294	14068A	GPS-BIIF-8	69	GPS 2F-8	Navstar 72	USA 258	3	2014-10-29
	306	39741	14026A	GPS BIIF-6	67	GPS 2F-6	Navstar 70	USA 251	6	2014-05-17
	308	40730	15033A	GPS IIF-10	72	GPS 2F-10	Navstar 74	USA 262	8	2015-07-15
	310	41019	2015-062A	GPS IIF-11	73	GPS 2F-11	Navstar 75	USA 265	10	2015-10-30
	309	40105	14045A	GPS BIIF-7	68	GPS 2F-7	Navstar 71	USA 256	9	2014-08-02
	312	29601	06052A	GPS BIIRM-3	58	GPS 2R-16	Navstar 59	USA 192	12	2006-11-17
	315	32260	07047A	GPS BIIRM-4	55	GPS 2R-17	Navstar 60	USA 196	15	2007-10-17
	316	27663	03005A	GPS BIIR-8	56	GPS 2-R-8	Navstar 51	USA 166	16	2003-01-29
	317	28874	05038A	GPS BIIRM-1	53	GPS 2R-14	Navstar 57	USA 183	17	2005-09-26
	318	26690	01004A	GPS BIIR-7	54	GPS 2-28	Navstar 50	USA 156	18	2001-01-30
	319	28190	04009A	GPS BIIR-11	59	GPS 2R-11	Navstar 54	USA 177	19	2004-03-20
	323	28361	04023A	GPS BIIR-12	60	GPS 2R-12	Navstar 55	USA 178	23	2004-06-23
	324	38833	12053A	GPS BIIF-3	65	GPS 2F-3	Navstar 67	USA 239	24	2012-10-04
	326	40534	15013A	GPS IIF-9	71	GPS 2F-9	Navstar 73	USA 260	26	2015-03-25
	327	39166	13023A	GPS-BIIF-4	66	GPS 2F-4	Navstar 68	USA 242	27	2013-05-15
	329	32384	07062A	GPS BIIRM-5	57	GPS 2R-M	Navstar 61	USA 199	29	2007-12-20

	Cospas-Sarsat Satellite ID code (note 1)	NORAD ID (NASA Catalogue Number) (note 2)	International Designator (note 3)	Satellite Name (note 4)	Space Vehicle Number (SVN) (note 5)	Other Names	Other Names	Other Names	PRN Number (note 6)	Launch Date
	330	39533	14008A	GPS BIIF-5	64	GPS 2F-5	Navstar 69	USA 248	30	2014-02-21
	332	41328	16007A	GPS IIF-12	70	GPS 2F-12	Navstar 76	USA 266	32	2016-02-05
Galileo	401	41550	2016-030B	GSAT0210	1	Galileo-FOC FM11	Galileo 13	Danielė		2016-05-24
	402	41549	2016-030A	GSAT0211	2	Galileo-FOC FM10	Galileo 14	Alizée		2016-05-24
	403	41860	2016-069B	GSAT0212	3	Galileo-FOC FM12	Galileo 16	Lisa	-	2016-11-17
	404	41861	2016-069C	GSAT0213	4	Galileo-FOC FM13	Galileo 17	Kimberley	-	2016-11-17
	405	41862	2016-069D	GSAT0214	5	Galileo-FOC FM14	Galileo 18	Tijmen	-	2016-11-17
	407	41859	2016-069A	GSAT0207	7	Galileo-FOC FM7	Galileo 15	Antonianna	-	2016-11-17
	408	41175	15079B	GSAT0208	8	Galileo-FOC FM7	Galileo 11	Andriana	-	2015-12-17
	409	41174	15079A	GSAT0209	9	Galileo-FOC FM8	Galileo 12	Liene	-	2015-12-17
	411 (note 7)	37846	11060A	GSAT0101	11	Galileo-IOV PFM	IOV-1	Thijs	-	2011-10-21
	412 (note 7)	37847	11060B	GSAT0102	12	Galileo-IOV FM2	IOV-2	Natalia	-	2011-10-21
	414	40129	14050B	GSAT0202	14	Galileo-FOC FM2	Galileo 6	Milena	-	2014-08-22
	418	40128	14050A	GSAT0201	18	Galileo-FOC FM1	Galileo 5	Doresa	-	2014-08-22
	419	38857	12055A	GSAT0103	19	Galileo-IOV FM3	IOV-3	David	-	2012-10-12
	420	38858	12055B	GSAT0104	20	Galileo-IOV FM4	IOV-4	Sif	-	2012-10-12
	421	43055	17079A	GSAT0215	21	Galileo-FOC FM15	Galileo 19	Nicole	-	2017-12-12
	422	40545	15017B	GSAT0204	22	Galileo-FOC FM4	Galileo 8	Anastasia	-	2015-03-27
	424	40889	15045A	GSAT0205	24	Galileo-FOC FM5	Galileo 9	Alba		2015-09-11
	425	43056	17079B	GSAT0216	25	Galileo-FOC FM16	Galileo 20	Zofia	-	2017-12-12
	426	40544	15017A	GSAT0203	26	Galileo-FOC FM3	Galileo 7	Adam	-	2015-03-27
	427	43057	17079C	GSAT0217	27	Galileo-FOC FM17	Galileo 21	Alexandre	-	2017-12-12
	430	40890	15045B	GSAT0206	30	Galileo-FOC FM6	Galileo 10	Oriana	-	2015-09-11
	431	43058	17079D	GSAT0218	31	Galileo-FOC FM18	Galileo 22	Irina	-	2017-12-12

	Cospas-Sarsat Satellite ID code (note 1)	NORAD ID (NASA Catalogue Number) (note 2)	International Designator (note 3)	Satellite Name (note 4)	Space Vehicle Number (SVN) (note 5)	Other Names	Other Names	Other Names	PRN Number (note 6)	Launch Date
Glonass	501	37372	11009A	Glonass-K1	701	Cosmos 2471	Glonass-K1-#11L	Uragan-K1 11L	-	2011-02-26
	502	40315	14075A	Glonass-K1-#2	702	Cosmos 2501	Glonass-K1-#12L	Uragan-K1 12L	-	2014-11-30

Table B-1: MEOSAR Satellite Identification Parameters

The up-to-date version of this table is available on the Cospas-Sarsat website www.cospas-sarsat.int.

Notes:

1 Cospas-Sarsat Satellite ID Code number is a unique 3-digit number allocated by Cospas-Sarsat for each operating, SAR-equipped satellite (as defined in document C/S R.012, page M-2), based on PRN or SVN, so PRNs would get re-assigned to future replacement satellites.

2 A unique 5-digit ID number for each satellite, permanently assigned to that object in orbit.

3 5-digit designator comprising the last 2 digits of the launch year and 3 digits of the launch number in that year plus one letter for each piece of the launch (A, B, C...).

4 Satellites have various names and designations by different users in different databases, as shown in the ¨Other Names¨ columns. DASS refers to an experimental S-band payload on some GPS Block 2 satellites.

5 SVN is a unique satellite or space vehicle number assigned by the satellite constellation owner or operator.

6 PRN is a pseudo-random noise code number assigned by the satellite owner or operator to identify the code for GNSS receivers to decode the navigation signal. As there is a limited supply of PRN numbers, they get gets reassigned to new satellites that replace older, decommissioned satellites. Final PRN numbers are not yet assigned to the initial Galileo and Glonass satellites.

7 Galileo 411 and 412 should not be tracked by MEOLUTs as they are not equipped with a SAR repeater. However, Galileo 411 and 412 will be used for the return link service provided by Galileo.

B.2 RF Configuration of the MEOSAR satellites

	Cospas-Sarsat Satellite ID code (note 1)	Downlink Frequency Band (note 2)	Nominal Downlink Centre Freq (MHz) (notes 3 & 4)	Repeater Frequency Translation (note 5)	Uplink Antenna Polarization (note 6)	Downlink Antenna Polarization (note 6)	Current BW (kHz) @Centre Frequency (MHz) (note 7)	Current mode (note 8)	Comments
DASS S-Band	301	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	302	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	303	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	306	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	308	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	309	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	310	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	312	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	315	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	316	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	317	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	318	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	319	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	323	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	326	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	324	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	327	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	329	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	330	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
	332	S-band	2226.47234	Inverted	LHCP	LHCP	270 @ 406.050		
Galileo	401	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	402	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	403	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	404	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	405	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	407	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	408	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	409	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	414	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	Elliptical orbit, all navigation signals with

	Cospas-Sarsat Satellite ID code (note 1)	Downlink Frequency Band (note 2)	Nominal Downlink Centre Freq (MHz) (notes 3 & 4)	Repeater Frequency Translation (note 5)	Uplink Antenna Polarization (note 6)	Downlink Antenna Polarization (note 6)	Current BW (kHz) @Centre Frequency (MHz) (note 7)	Current mode (note 8)	Comments
									dummy navigation message
	418	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	Elliptical orbit, all navigation signals with dummy navigation message
	419	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	420	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	Only the E1 navigation signal with dummy navigation message
	421	L-band	1545.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	422	L-band	1544.1	Not inverted	RHCP	LHCP	90 @ 406.050	OFF	
	424	L-band	1545.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	425	L-band	1545.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	426	L-band	1545.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	427	L-band	1545.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	430	L-band	1545.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
	431	L-band	1545.1	Not inverted	RHCP	LHCP	90 @ 406.050	WA	
Glonass	501	L-band	1544.9	Not inverted	RHCP	LHCP	100 @ 406.050	UT	
	502	L-band	1544.9	Not inverted	RHCP	LHCP	100 @ 406.050	UT	

Table B.2: Current RF Configuration of the MEOSAR Satellites

The up-to-date version of this table is available on the Cospas-Sarsat website www.cospas-sarsat.int.

Notes:

1 Cospas-Sarsat Satellite ID Code number is a unique 3-digit number allocated by Cospas-Sarsat for each operating, SAR-equipped satellite (as defined in document C/S R.012, page M-2), based on PRN or SVN, so PRNs would get re-assigned to future replacement satellites.

2 The S-band downlink is in a band normally used for telemetry, whereas the L-band is in the 1 MHz bandwidth allocated by ITU for Distress and Safety, space-to-Earth, so has protection from harmful interference.

3 The nominal downlink centre frequency corresponds to the 406.050 MHz received frequency, which is the centre of the 100 kHz SAR band allocated for distress beacons. The exact centre frequency can be derived from information provided in the tables providing the SAR Receiver Parameters in section 4.6, Table 4.3.

4 The repeater bandwidth of the S-band satellites is about 270 kHz; Galileo is about 80 kHz, or else 50 kHz in narrowband mode (with centre frequency shifted 7 kHz lower) and Glonass is about 100 kHz, or else 60 kHz in narrowband mode (with centre frequency shifted 7 kHz lower).

5 The S-band payloads on the Block 2 GPS satellites have “inverted” frequency translation of the relayed 406 MHz frequencies, whereas the L-band satellites, including the future SAR/GPS, are designed for SAR purposes, and do not invert the relayed band.

6 Future SAR/GPS L-band satellites will have an RHCP downlink, and transmit on the same downlink frequency as Glonass, but with opposite polarization.

7 Downlink frequency is that frequency referenced to 406.05 MHz. Downlink frequency may not be exact. It is to be noted that any satellite may have a nominal offset of [± 100 Hz]. However, once this value is set for each repeater, the frequency translation accuracy requirement applies. The format is [1544.xxxxxxx MHz] (8 decimal places) (TBC).

8 Current mode:

- WA = Wideband filter and ALC
- NA = Narrowband filter and ALC
- WF = Wideband filter and fixed gain
- NF = Narrowband filter and fixed gain
- UT = under test
- OFF

1	2	3	4	5	6a	6b	6c	6d	6e	7	8	9	10a	10b	10c	10d	11
SAT_ID	MODE_ID	BW (kHz)	Centre Frequency (MHz)	Group Delay @ Centre Frequency Coeff. a0 (µs)	Group Delay Data Curve Fit Coeff.					Group Delay Uncertainty (ns)	FG Setting (dB)	Short Term Stability	Pre-Filter Characteristics				Historical
					a1	a2	a3	a4	a5				3 dB BW (kHz)	10 dB BW (kHz)	45 dB BW (kHz)	BWn (kHz)	
301	N/A	220	406.05	-0.005	-0.2192	1.1542	493.3834	-886.597	-320629.183	51.4 ns max 14.27 ns min 28.4 ns mean	N/A						
302	N/A	220	406.05	-0.00896	-0.21184	25.63615	350.6372	-7594.18	-396545	46.594 ns max 11.965 ns min 22.551 ns mean	N/A						
303	N/A	220	406.05	-0.00086	0.103367	-10.3822	-780.963	455.8738	250858.3	51.91 ns max 14.88 ns min 27.718 ns mean	N/A						
306	N/A	220	406.05	-0.00654	-0.16909	-5.70608	-791.629	30.51025	290217	43.16 ns max 14.645 ns min 24.86 ns mean	N/A						
308	N/A	220	406.05	-0.00373	-0.51519	-0.54614	75.00309	337.03	154677.9	82.33 ns max 14.1 ns min 34.55 ns mean	N/A						
309	N/A	220	406.05	0.000113	0.052405	-5.54656	-228.412	2803.145	30197.94	44.3 ns max 6.6 ns min 21.554 ns mean	N/A						
310	N/A	220	406.05	-0.01299	0.539607	25.46485	-1189.79	-9971.64	288517.5	36.82 ns max 11.36 ns min 20.14 ns mean	N/A						
312	N/A	220	406.05	-0.00857	0.8797914	14.90418	-192.054	-2454.543	-473521	66.405 ns max 12.21 ns min 33.02 ns mean	N/A						
315	N/A	220	406.05	-0.00348	-0.27872	15.02778	333.66	-2625	-289181	86.33.6 ns max 12.66 ns min 38.41 ns mean	N/A						
316	N/A	220	406.05	0.000787	-0.31098	-10.026	302.0494	-10165.57	-366459	45.83 ns max 13.8 min 28.978 ns mean	N/A						
317	N/A	220	406.05	0.001551	-0.23787	-32.6013	-209.281	15252.03	-141627	41.85 ns max 7.88 ns min 20.485 ns mean	N/A						
318	N/A	220	406.05	0.000748	-0.12848	4.960886	426.9746	-5325.82	-418820	56.44 ns max 10.3681 ns min 22.4819 ns mean	N/A						
319	N/A	220	406.05	-0.0089	0.151411	29.5321	-613.758	-9559.54	109356.8	54.9 ns max 13.614 ns min 33.505 ns mean	N/A						
323	N/A	220	406.05	-0.00252	-0.32083	0.692121	663.8085	1869.856	-392929	38.69 ns max 10.49 ns min 20.6 ns mean	N/A						

324	N/A	220	406.05	-0.01049	-0.30279	24.49997	616.4667	-3566.64	-496752	85.5 ns max 12.166 ns min 29.717 ns mean	N/A						
326	N/A	220	406.05	-0.00697	0.538951	4.134474	-1193.19	7599.547	324374.3	70.8 ns max 13.84 ns min 29.367 ns mean	N/A						
327	N/A	220	406.05	-0.00975	0.540512	20.50684	-1052.41	-4914.69	199568	99.6 ns max 9.26 ns min 37.899 ns mean	N/A						
329	N/A	220	406.05	-0.00073	0.887097	31.50943	-1239.59	-15497.7	315735.5	42.138 ns max 6.17ns min 21.528 ns mean	N/A						
330	N/A	220	406.05	-0.00017	0.21817	2.410392	-799.367	-5551.72	199903.4	34.088 ns max 14 ns min 24.28 ns mean	N/A						
332	N/A	220	406.05	-0.00895	0.153283	21.54115	-289.14	-8428.72	112272.7649	96 ns max 7.98 ns min 28.88 ns mean	N/A						

Table B.3: DASS S-Band Filter Settings (To Be Completed)

The up-to-date version of this table is available on the Cospas-Sarsat website www.cospas-sarsat.int.

1	2	3	4	5	6a	6b	6c	6d	6e	7	8	9	10a	10b	10c	10d	11
SAT_ID	MODE_ID	BW (kHz)	Centre Frequency (MHz)	Group Delay @ Centre Frequency Coeff. a0 (µs)	Group Delay Data Curve Fit Coeff.					Group Delay Uncertainty (ns)	FG Setting (dB)	Short Term Stability	Pre-Filter Characteristics				Historical
					a1	a2	a3	a4	a5				3 dB BW (kHz)	10 dB BW (kHz)	45 dB BW (kHz)	BWn (kHz)	
401	WA	90	406.05	47.7	23.49	3877.34	-19536.48	2465150.57	-1411912.27	162.05	N/A	4.62E-12	94.8	103	138.7	169.1	TBD
401	NA	50	406.043	67.9	0.71	17412.66	63538.84	-3583350.71	-171715230.45	162.05	N/A	4.62E-12	65.3	72.1	98.4	119.8	TBD
401	WF	90	406.05	47.7	23.49	3877.34	-19536.48	2465150.57	-1411912.27	162.05	160.7	4.62E-12	94.8	103	138.7	169.1	TBD
401	NF	50	406.043	67.9	0.71	17412.66	63538.84	-3583350.71	-171715230.45	162.05	161.6	4.62E-12	65.3	72.1	98.4	119.8	TBD
402	WA	90	406.05	47.7	7.64	4825.99	73539.03	1513819.12	-69027945.66	162.05	N/A	3.97E-12	94.1	102.5	140.3	173.5	TBD
402	NA	50	406.043	67.9	85.40	15578.33	-444133.87	3332836.80	638159829.80	162.05	N/A	3.97E-12	65.6	72.4	98.5	120	TBD
402	WF	90	406.05	47.7	7.64	4825.99	73539.03	1513819.12	-69027945.66	162.05	161.0	3.97E-12	94.1	102.5	140.3	173.5	TBD
402	NF	50	406.043	67.9	85.40	15578.33	-444133.87	3332836.80	638159829.80	162.05	161.5	3.97E-12	65.6	72.4	98.5	120	TBD
403	WA	90	406.05	48.0	23.24	2880.01	-64989.38	3335656.48	38142285.25	162.05	N/A	3.63E-12	95.2	103.4	138.6	168.6	TBD
403	NA	50	406.043	68.2	62.97	3635.01	-530029.93	31797703.40	1009138906.53	162.05	N/A	3.63E-12	65.6	72.5	98.6	119.6	TBD
403	WF	90	406.05	48.0	23.24	2880.01	-64989.38	3335656.48	38142285.25	162.05	160.4	3.63E-12	95.2	103.4	138.6	168.6	TBD

403	NF	50	406.043	68.2	62.97	3635.01	-530029.93	31797703.40	1009138906.53	162.05	161.3	3.63E-12	65.6	72.5	98.6	119.6	TBD
404	WA	90	406.05	48.0	14.86	3838.03	24954.69	2513372.42	-24606664.53	162.05	N/A	3.94E-12	94.7	102.7	138.8	169.9	TBD
404	NA	50	406.043	68.6	20.09	6459.41	118227.78	28489483.22	-532436147.88	162.05	N/A	3.94E-12	64.8	72.1	97.6	118	TBD
404	WF	90	406.05	48.0	14.86	3838.03	24954.69	2513372.42	-24606664.53	162.05	160.2	3.94E-12	94.7	102.7	138.8	169.9	TBD
404	NF	50	406.043	68.6	20.09	6459.41	118227.78	28489483.22	-532436147.88	162.05	161.1	3.94E-12	64.8	72.1	97.6	118	TBD
405	WA	90	406.05	47.7	39.51	4162.74	-62437.57	2379140.29	20709798.88	162.05	N/A	3.76E-12	94.9	103.4	138.9	170	TBD
405	NA	50	406.043	68.3	54.54	9514.82	-472014.26	20342337.07	944580069.96	162.05	N/A	3.76E-12	64.8	71.6	97	116.8	TBD
405	WF	90	406.05	47.7	39.51	4162.74	-62437.57	2379140.29	20709798.88	162.05	159.8	3.76E-12	94.9	103.4	138.9	170	TBD
405	NF	50	406.043	68.3	54.54	9514.82	-472014.26	20342337.07	944580069.96	162.05	160.4	3.76E-12	64.8	71.6	97	116.8	TBD
407	WA	90	406.05	47.8	34.99	4038.20	-53293.25	2243121.35	24039805.77	162.05	N/A	3.28E-12	94.2	102.9	138.8	169.6	TBD
407	NA	50	406.043	68.3	-1.05	5653.79	-268588.07	28978284.29	622744852.95	162.05	N/A	3.28E-12	64.3	72.2	97.2	116.5	TBD
407	WF	90	406.05	47.8	34.99	4038.20	-53293.25	2243121.35	24039805.77	162.05	160.4	3.28E-12	94.2	102.9	138.8	169.6	TBD
407	NF	50	406.043	68.3	-1.05	5653.79	-268588.07	28978284.29	622744852.95	162.05	160.9	3.28E-12	64.3	72.2	97.2	116.5	TBD
408	WA	90	406.050	47.9	17.63	4567.37	-11820.94	1502957.99	16078752.33	162.05	N/A	3.76E-12	94.6	102.4	138.3	169.8	TBD
408	NA	50	406.043	68.4	22.65	10909.97	-182359.27	16438073.01	338446606.45	162.05	N/A	3.76E-12	66	71.3	97	117.6	TBD
408	WF	90	406.050	47.9	17.63	4567.37	-11820.94	1502957.99	16078752.33	162.05	160.5	3.76E-12	94.6	102.4	138.3	169.8	TBD
408	NF	50	406.043	68.4	22.65	10909.97	-182359.27	16438073.01	338446606.45	162.05	161.2	3.76E-12	66	71.3	97	117.6	TBD
409	WA	90	406.050	47.6	28.81	5445.42	-51976.34	1009253.58	44863450.91	162.05	N/A	3.69E-12	94.7	103.1	139.4	170.7	TBD
409	NA	50	406.043	68.2	81.25	5301.17	-447408.51	35319009.76	715172414.21	162.05	N/A	3.69E-12	66	71.5	97.6	117.9	TBD
409	WF	90	406.050	47.6	28.81	5445.42	-51976.34	1009253.58	44863450.91	162.05	160.6	3.69E-12	94.7	103.1	139.4	170.7	TBD
409	NF	50	406.043	68.2	81.25	5301.17	-447408.51	35319009.76	715172414.21	162.05	161.1	3.69E-12	66	71.5	97.6	117.9	TBD
414	WA	90	406.050	47.7	6.59	3466.64	12027.11	2828810.48	4101126.92	162.05	N/A	3.62E-12	95.8	103.8	141.5	176.5	TBD
414	NA	50	406.043	68.4	131.19	13004.25	-1140001.35	7921827.22	2291568800.26	162.05	N/A	3.62E-12	65	71.8	97.9	119.4	TBD
414	WF	90	406.050	47.7	6.59	3466.64	12027.11	2828810.48	4101126.92	162.05	161.1	3.62E-12	95.8	103.8	141.5	176.5	TBD
414	NF	50	406.043	68.4	131.19	13004.25	-1140001.35	7921827.22	2291568800.26	162.05	161.6	3.62E-12	65	71.8	97.9	119.4	TBD
418	WA	90	406.050	47.2	-1.72	5834.23	35626.94	139165.34	-21759101.89	162.05	N/A	3.62E-12	97	105.4	142.3	176.4	TBD
418	NA	50	406.043	67.6	9.43	18915.82	67044.67	-8434053.86	-297039976.14	162.05	N/A	3.62E-12	66	72.6	98.8	120.3	TBD
418	WF	90	406.050	47.2	-1.72	5834.23	35626.94	139165.34	-21759101.89	162.05	160.6	3.62E-12	97	105.4	142.3	176.4	TBD
418	NF	50	406.043	67.6	9.43	18915.82	67044.67	-8434053.86	-297039976.14	162.05	162.0	3.62E-12	66	72.6	98.8	120.3	TBD

1	2	3	4	5	6a	6b	6c	6d	6e	7	8	9	10a	10b	10c	10d	11
SAT_ID	MODE _ID	BW (kHz)	Centre Frequency (MHz)	Group Delay @ Centre Frequency Coeff. a0 (µs)	Group Delay Data Curve Fit Coeff.					Group Delay Uncertainty (ns)	FG Setting (dB)	Short Term Stability	Pre-Filter Characteristics				Historical
					a1	a2	a3	a4	a5				3 dB BW (kHz)	10 dB BW (kHz)	45 dB BW (kHz)	BWn (kHz)	
419	WA	90	406.050	26.9	-54.85	4583.28	162823.18	838747.67	-141170213.84	100	N/A	1.30E-11	95	106	145	85	TBD
419	NA	50	406.043	38.6	1.21	1111.39	-45298.19	16934072.10	-88037351.72	100	N/A	1.30E-11	62	68	94	58	TBD
419	WF	90	406.050	26.9	-54.85	4583.28	162823.18	838747.67	-141170213.84	100	155	1.30E-11	95	106	145	85	TBD
419	NF	50	406.043	38.6	1.21	1111.39	-45298.19	16934072.10	-88037351.72	100	155	1.30E-11	62	68	94	58	TBD
420	WA	90	406.050	27.2	34.03	5168.09	63330.85	167315.61	-53564418.98	100	N/A	1.10E-11	95	106	146	87	TBD
420	NA	50	406.043	38.5	-128.71	12624.37	441313.62	18817793.16	-589936952.92	150	N/A	1.10E-11	61	68	95	57	TBD
420	WF	90	406.050	27.2	34.03	5168.09	63330.85	167315.61	-53564418.98	100	156	1.10E-11	94	106	146	87	TBD
420	NF	50	406.043	38.5	-128.71	12624.37	441313.62	18817793.16	-589936952.92	150	156	1.10E-11	61	68	95	57	TBD
421	WA	90	406.050	47.66	70.36	2403.63	-176927.66	3960618.46	99163342.85	162.05	N/A	3.25E-12	95.7	103.4	138.8	168.5	TBD
421	NA	50	406.043	68.5	170.66	10702.21	416368.66	4560128.75	1031883165.67	162.05	N/A	3.25E-12	55.9	72.9	99	119.9	TBD
421	WF	90	406.050	47.66	70.36	2403.63	-176927.66	3960618.46	99163342.85	162.05	160.8	3.25E-12	95.7	103.4	138.8	168.5	TBD
421	NF	50	406.043	68.5	170.66	10702.21	416368.66	4560128.75	1031883165.67	162.05	160.8	3.25E-12	55.9	72.9	99	119.9	TBD
422	WA	90	406.050	47.7	29.09	3452.21	-74370.29	2730423.75	60566565.15	162.05	N/A	4.23E-12	95.5	103.7	139.4	170.4	TBD
422	NA	50	406.043	68.0	120.77	14433.52	-900822.91	11401488.41	1592840169.02	162.05	N/A	4.23E-12	66	71.1	97.8	119.2	TBD
422	WF	90	406.050	47.7	29.09	3452.21	-74370.29	2730423.75	60566565.15	162.05	161.2	4.23E-12	95.5	103.7	139.4	170.4	TBD
422	NF	50	406.043	68.0	120.77	14433.52	-900822.91	11401488.41	1592840169.02	162.05	161.8	4.23E-12	66	71.1	97.8	119.2	TBD
424	WA	90	406.050	47.8	30.42	4972.63	-75558.93	956143.35	63142668.11	162.05	N/A	3.16E-12	95.5	100.4	138.9	169.7	TBD
424	NA	50	406.043	67.6	-53.82	17709.29	165094.19	-5016270.90	5948836.10	162.05	N/A	3.16E-12	65	73.5	99.3	141.4	TBD
424	WF	90	406.050	47.8	30.42	4972.63	-75558.93	956143.35	63142668.11	162.05	160.7	3.16E-12	95.5	100.4	138.9	169.7	TBD
424	NF	50	406.043	67.6	-53.82	17709.29	165094.19	-5016270.90	5948836.10	162.05	161.1	3.16E-12	65	73.5	99.3	141.4	TBD
425	WA	90	406.050	47.39	28.82	6116.77	-24797.47	-213476.54	-902615.31	162.05	N/A	3.35E-12	95.4	103.5	140.4	174.4	TBD
425	NA	50	406.043	68.13	223.03	30926.22	407879.45	-55816309.65	-1951356588.89	162.05	N/A	3.35E-12	55.3	72.3	98	118.3	TBD
425	WF	90	406.050	47.39	28.82	6116.77	-24797.47	-213476.54	-902615.31	162.05	160.8	3.35E-12	95.4	103.5	140.4	174.4	TBD
425	NF	50	406.043	68.13	223.03	30926.22	407879.45	-55816309.65	-1951356588.89	162.05	160.8	3.35E-12	55.3	72.3	98	118.3	TBD
426	WA	90	406.050	47.8	17.49	5070.48	863.85	1033927.09	898721.42	162.05	N/A	3.96E-12	94.1	102.2	138.3	169.1	TBD

426	NA	50	406.043	68.5	37.61	11461.86	-178849.41	14563268.13	375805778.54	162.05	N/A	3.96E-12	64	71.3	97.3	118.1	TBD
426	WF	90	406.050	47.8	17.49	5070.48	863.85	1033927.09	898721.42	162.05	160.7	3.96E-12	94.1	102.2	138.3	169.1	TBD
426	NF	50	406.043	68.5	37.61	11461.86	-178849.41	14563268.13	375805778.54	162.05	161.4	3.96E-12	64	71.3	97.3	118.1	TBD
427	WA	90	406.050	47.7	63.81	2418.48	-163382.25	3674684.59	98270394.87	162.05	N/A	3.43E-12	96	103.6	138.9	168.5	TBD
427	NA	50	406.043	68.11	322.08	26580.24	-492985.71	-54928537.49	-911936554.78	162.05	N/A	3.43E-12	55.6	72.6	98.5	118.3	TBD
427	WF	90	406.050	47.7	63.81	2418.48	-163382.25	3674684.59	98270394.87	162.05	160.8	3.43E-12	96	103.6	138.9	168.5	TBD
427	NF	50	406.043	68.11	322.08	26580.24	-492985.71	-54928537.49	-911936554.78	162.05	160.8	3.43E-12	55.6	72.6	98.5	118.3	TBD
430	WA	90	406.050	48.2	52.94	2084.12	-144403.95	4214079.01	105437134.06	162.05	N/A	4.15E-12	94.5	102.4	138.1	168.7	TBD
430	NA	50	406.043	67.7	-28.25	13916.93	65711.23	9174097.03	-543561.81	162.05	N/A	4.15E-12	66	72.6	97.3	116.7	TBD
430	WF	90	406.050	48.2	52.94	2084.12	-144403.95	4214079.01	105437134.06	162.05	160.5	4.15E-12	94.5	102.4	138.1	168.7	TBD
430	NF	50	406.043	67.7	-28.25	13916.93	65711.23	9174097.03	-543561.81	162.05	161.2	4.15E-12	66	72.6	97.3	116.7	TBD
431	WA	90	406.050	47.88	87.98	3694.947	-230069.01	2297982.24	154844882.60	162.05	N/A	3.35E-12	94.3	102.6	138.3	167.8	TBD
431	NA	50	406.043	68.45	118.68	16381.45	1001285.15	32442380.73	3819726.22	162.05	N/A	3.35E-12	55.6	71.8	97.7	117.3	TBD
431	WF	90	406.050	47.88	87.98	3694.947	-230069.01	2297982.24	154844882.60	162.05	160.8	3.35E-12	94.3	102.6	138.3	167.8	TBD
431	NF	50	406.043	68.45	118.68	16381.45	1001285.15	32442380.73	3819726.22	162.05	160.8	3.35E-12	55.6	71.8	97.7	117.3	TBD

Table B.4: Galileo Filter Settings

The up-to-date version of this table is available on the Cospas-Sarsat website www.cospas-sarsat.int.

1	2	3	4	5	6a	6b	6c	6d	6e	7	8	9	10a	10b	10c	10d	11
SAT_ID	MODE_ID	BW (kHz)	Centre Frequency (MHz)	Group Delay @ Centre Frequency Coeff. a0 (µs)	Group Delay Data Curve Fit Coeff.					Group Delay Uncertainty (ns)	FG Setting (dB)	Short Term Stability	Pre-Filter Characteristics				Historical
					a1	a2	a3	a4	a5				3 dB BW (kHz)	10 dB BW (kHz)	45 dB BW (kHz)	BWn (kHz)	

Table B.5: GPS L-Band Filter Settings (To Be Completed)

The up-to-date version of this table is available on the Cospas-Sarsat website www.cospas-sarsat.int.

1	2	3	4	5	6a	6b	6c	6d	6e	7	8	9	10a	10b	10c	10d	11
SAT_ID	MODE_ID	BW (kHz)	Centre Frequency (MHz)	Group Delay @ Centre Frequency Coeff. a0 (µs)	Group Delay Data Curve Fit Coeff					Group Delay Uncertainty (ns)	FG Setting (dB)	Short Term Stability	Pre-Filter Characteristics				Historical
					a1	a2	a3	a4	a5				3 dB BW (kHz)	10 dB BW (kHz)	45 dB BW (kHz)	BWn (kHz)	
501		60	406.043														

501		100	406.050														
502		60	406.043														
502		100	406.050														

Table B.6: Glonass L-Band Filter Settings (To Be Completed)

The up-to-date version of this table is available on the Cospas-Sarsat website www.cospas-sarsat.int.

Additional information on the columns:

1 SAT_ID is the unique identifier format that is the same as defined for MEOSAR satellite identification. There are a maximum of four modes per satellite but only one will be in selected at any time. Therefore, any satellite ID will have data populated in rows equal to the number of satellite modes as defined by column 3.

2 MODE_ID is a single unique identifier defining the specific single satellite mode. All data contained in the row are the space segment parameter values for the unique combination of SAT_ID and MODE_ID. The four unique identifiers are:

- WA = Wideband filter and ALC,
- NA = Narrowband filter and ALC,
- WF = Wideband filter and Fixed Gain,
- NF = Narrowband filter and Fixed Gain.

3 BW is the bandwidth associated with the MODE_ID.

4 Centre frequency associated with the MODE_ID.

5 Group delay is a single value that defines the actual group delay at 406.05 MHz for wideband filter and 406.43 MHz for narrowband. The format is xx.y in microseconds. This value is coefficient a0 derived from the group curve fit data defined in column 5 at the associated downlink frequency (see Table B.4) for wideband and narrowband filters.

6 The group delay curve fit data defines the coefficients of the group delay variation curve as a function of frequency over the respective filter's 1 dB bandwidth. This data represents a single best fit curve of the filter's group delay performance as a function of a variety of environmental conditions. Coefficient a0 is the group delay at the associated downlink frequency (see Table B.4) for wideband and narrowband filters. Note this value is populated in column 4.

7 Group delay uncertainty is single value defining the maximum error of the actual group delay due to any satellite environmental condition from the best fit curve (columns 5 and 6) and quantifies the uncertainty of the delay through the satellite at any time. The format is a single integer number in nanoseconds.

8 The FG gain setting is a single value that sets the gain of the transponder/repeater for the nominal output power. This value only applies to MODE_ID WF and NF. Format is xx.

9 Short term frequency stability is a value quantifying the actual performance of the satellite for any 100 ms per document C/S R.012 ($< 1 \times 10^{-11}$). The method to assess the short term frequency stability is still to be confirmed.

10 Pre-Filter Characteristics provides the BW range in kHz (yyy) for 3 dB, 10 dB, 45 dB rejection points, and noise bandwidth. MEOSAR payload providers should provide within future technical documents rejection characteristics of any repeater filtering. The bandwidth at rejection points of 3 dB, 10 dB, and 45 dB should be provided at a minimum within this Annex. Final rejection values (i.e., 60 dB or 70 dB) and its respective BW should be provided in future technical documents. In addition, to quantify the impacts of the general background interfering noise signals, the knowledge of the equivalent Gaussian noise bandwidth, BWn in kHz (xxxxx) of any repeater input filtering if used would be beneficial for definition of ITU protection requirement and should be provided in future technical documents . This is fourth sub-column (10d).

11 Column 11 is intended to provide a means whereby historical data can be accessed. For the current mode selected, the start date and UTC time of when this current mode was in use is provided at the top of its cell (i.e., since 1 September 2011). The date should be specified in the format dd/mm/yyyy, where dd is the day of the month, mm is the month (as a number), and yyyy is the year. The time should be specified as hh:mm:ss, where hh is hour, mm is minutes, and ss is seconds.

- END OF ANNEX B –

ANNEX C

MEOSAR ORBITAL DATA DESCRIPTION

C.1 Introduction

Precise satellite position vectors and velocity vectors are essential for location processing as they directly impact the achievable accuracy of beacon locations (satellite position and velocity vector errors are part of the location error budget). These vectors can be computed from the ephemeris broadcasted in the navigation message by GNSS satellites. However the ephemeris data may not be available for the following reasons:

- if the navigation signal is not available (e.g., no navigation signal broadcasted by the satellite, navigation signal not processed by the GNSS receiver, etc.), or
- if the station GNSS receiver has failed.

A MEOLUT may acquire satellite position vectors and velocity vectors by other means, such as from an on-line source.

C.2 Summary of available MEOSAR Satellite Orbital Data and Associated Accuracy Performance

The following table represents values of the parameters that the service providers are intending to provide (url to be specified later for ground server).

MEOSAR Constellation	Orbital Data Type	Duration of Data Validity (days)	Update Rate (hours)	Latency (hours)	Position Accuracy (meters)	Data Source
Galileo	Sp3	7	12v	< 2	50	Ground server
	Rinex 3.0	7 [8]	1	< 2	50	Ground server
	Ephemerids	0.167 (4 hours)	1	< 2	50	Ground server
	Almanac	TBD	24	< 2	TBD	Ground server
	Broadcasted ephemerids	100 min	TBC	0 (real time)	< 1	Satellite
	Broadcasted almanac	TBC	TBC	TBC	TBC	Satellite
GPS-DASS	Sp3	7	24	< 2	< 1	Ground server

[8] Each file contains several blocks of data. The whole file covers 7 days prediction, each block is valid for 4 hours.

	Rinex 2.1	0.083 (2 hours)	1	< 1	< 1	Ground server
	Broadcasted ephemerids	0.167 (4 hours)	2	0 (real time)	< 1	Satellite
	Broadcasted almanac	30	24	0 (real time)	< 1,000	Satellite
GPS–L Band	Sp3	7	24	< 2	< 1	Ground server
	Rinex 2.1	0.083 (2 hours)	1	< 1	< 1	Ground server
	Broadcasted ephemerids	0.167 (4 hours)	2	0 (real time)	< 1	Satellite
	Broadcasted almanac	30	24	0 (real time)	< 1,000	Satellite
Glonass	Rinex	0.021 (30 min)	1	< 1	< 1 over 30 min < 15 over 1 hour	Ground server
	Sp3 – ultra rapid	1	6	< 4	< 2	Ground server
	SP3 - rapid	2	24	< 15	< 4	Ground server
	Broadcasted ephemerids	0.021 (30 min)	0.5	0 (real time)	< 1	Satellite
	Broadcasted almanac	1	24	0 (real time)	< 1,000	Satellite

Note: Characteristics regarding broadcasted almanacs are provided for information only.

Galileo notes:

GSC (Galileo Service Center) data are linked to GST (Galileo System Time). In order to use Galileo orbital data the following information are needed:

- the clock corrections,
- the GST-UTC differences.

Furthermore GST-GPS time differences may also be helpful. This information is contained in Rinex 3.0 only (SP3 do not contain it).

GPS DASS notes: to be supplied

GPS L-band notes: to be supplied

Glonass notes: applies to commissioned Glonass-M series only, will include Glonass-K when commissioned into the Glonass system.

C.3 Definitions

Orbit data product

Set of satellite orbit data information allowing to determine future satellite locations and/or velocity vectors. Orbit data products can be provided in different formats (SP3, Rinex, ephemerids, almanac, xml, etc.)

Standard Product 3 (SP3) format
The Standard Product #3 (SP3) format is used to exchange orbital information in the form of tabular ephemerides of satellite positions every 15 min expressed. Associated consistent estimates for the satellite clocks are also provided at 15-min intervals.

Ephemeris Data
Ephemeris data is a set of parameters that can be used to accurately calculate the location of a GNSS satellite at a particular point in time. It describes the path that the satellite is following as it orbits Earth. Ephemeris data are valid for a certain period of time, typically 4 hours for GPS and Galileo.

Almanac Data
The GPS almanac is a set of data that every GNSS satellite transmits, and it includes information about the state (health) of the entire GPS satellite constellation, and coarse data on every satellite's orbit. When a GNSS receiver has *current* almanac data in memory, it can acquire satellite signals and determine initial position more quickly.

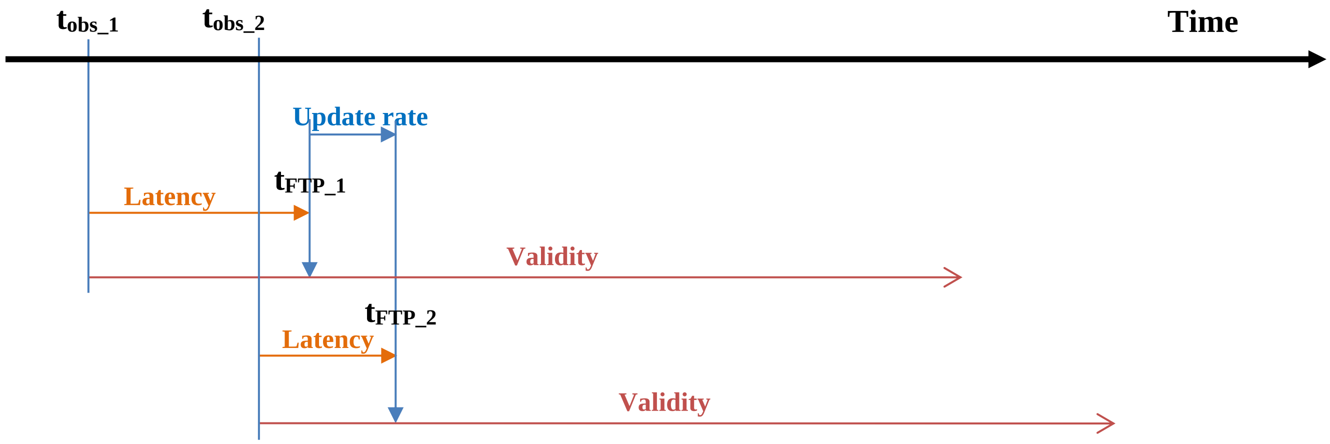
RINEX
Receiver Independent Exchange Format (RINEX) is a data interchange format for raw satellite navigation system data. This allows the user to post-process the received data to produce a more accurate result. RINEX is the standard format that allows the management and disposal of the measures generated by a receiver, as well as their off-line processing by a multitude of applications. The RINEX format is designed to evolve over time, adapting to new types of measurements and new satellite navigation systems.
There is basically two types of RINEX data:

- Observation Data which contains receiver measurements (pseudoranges, Doppler, C/N_0, etc…)
- Navigation Data which contain the ephemeris parameters as read by the receiver from the navigation message

Definitions related to the timeline for making orbit data products available through ground servers:

- t_{obs}: observation time, i.e., time at which satellite orbits are ultimately observed to produce the orbit data products
- t_{FTP}: time at which the orbit data product are made available to users on the FTP server
- latency: duration required to produce the orbit data products (i.e., time elapsed between t_{obs} and the time when the data are made available to users on the FTP server). Latency may vary based on conditions.
- validity: duration during which the orbit data product are valid (i.e., duration for which the orbit data products are within accuracy values guaranteed by the space segment provider)
- update rate (expressed in hours): duration between two successive orbital data products be made available on the FTP server (i.e., refresh rate of the files on the FTP server).

Latency and validity timeline
An illustration of the definitions above is provided in the schematic below (latency and update rate may vary based on conditions).



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