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

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406 MHz PAYLOADS USED IN
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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 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.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 G.004 | Cospas-Sarsat Glossary |

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:

| <u>Spacecraft</u> | <u>Country/Organization</u> | <u>Status</u> |
|-------------------|-----------------------------|-----------------------------------------------------|
| Galileo | Europe | In Deployment |
| Glomass-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/Glomass 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. Glomass 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 have been identified in document C/S R.012 that impact MEOSAR interoperability are as follows:

- Modulation of the downlinks: frequency translation will be used by all constellations so there is no additional modulation of the downlink. This simplified MEOLUT design.
- Downlink frequency. MEOSAR satellite constellations need not have the exact same downlink frequencies to enable MEOLUTs to process their downlinks. GPS L-band and Glonass will operate within a 200 kHz band at 1544.9 MHz as the center frequency for the downlink while Galileo will operate within a 200 kHz band at 1544.1 MHz for the downlink center frequency. These frequencies were chosen to avoid the 1544.5 MHz downlink of the GEOSAR spacecraft. The 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 dBw for all MEOLUT-to-satellite elevation angles above 5 degrees.
- Downlink polarization: the design for 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 at LHCP for both the uplink and downlink.
- Repeater bandwidth: MEOSAR providers and Cospas-Sarsat have agreed that the 406 MHz 10 dB pass-band must be less than 100 kHz, centered at 406.05 MHz, and that the 1 dB pass-band must exceed 90 kHz. 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 or greater would enable the development of a fully interoperable MEOSAR system that satisfied the performance requirements for compatibility with Cospas-Sarsat.
- Repeater 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, and that the ratio of power from a relayed beacon to intermodulation products should be greater than 30 dB when the repeater is operating beyond its linear range.
- Repeater linearity: to be specified.
- 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 should be less than 10 μ s with a stability within that range of 500 nanoseconds.

In addition, uplink polarization is different. GPS L-band, SAR Galileo and SAR Glonass will all use RHCP as the uplink polarization while DASS S-band uses LHCP as the uplink polarization.

- 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: ± 0.022 Hz (1 part in 10^{11})
- Maximum Doppler shift: ± 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.

$$\text{Downlink frequency} = 2226.472340 \text{ MHz} + 406.05 \text{ MHz} - \text{UHF uplink frequency}$$

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 dB_W.

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.

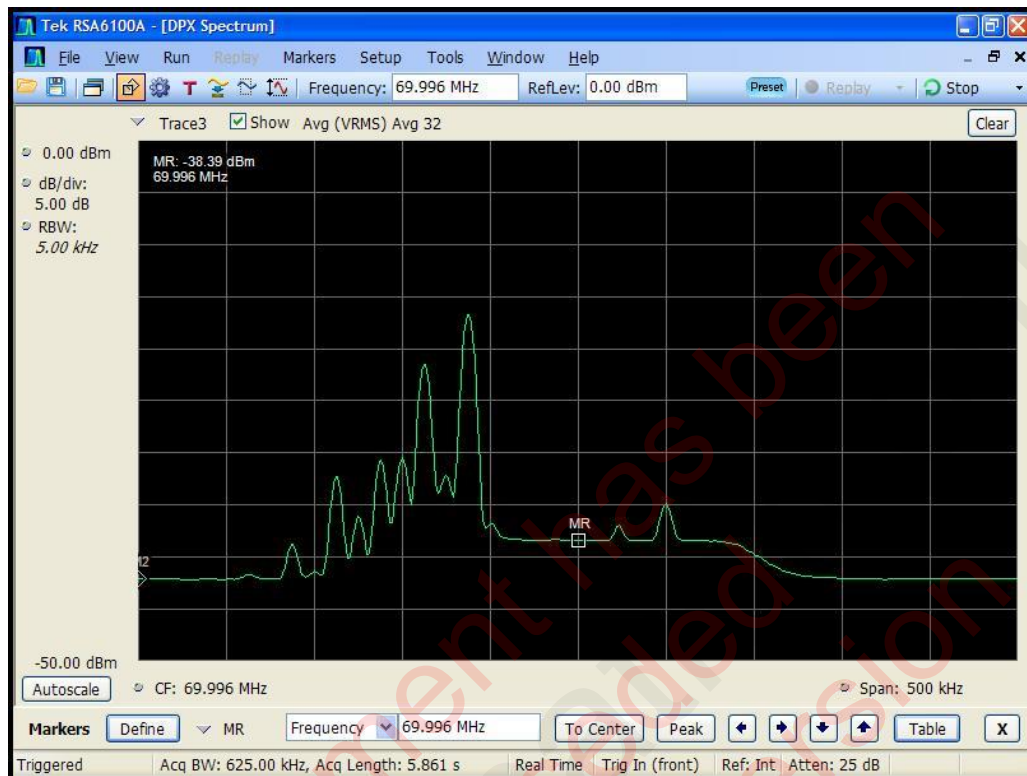


Figure 3.1: DASS S-Band Downlink Spectrum Averaged

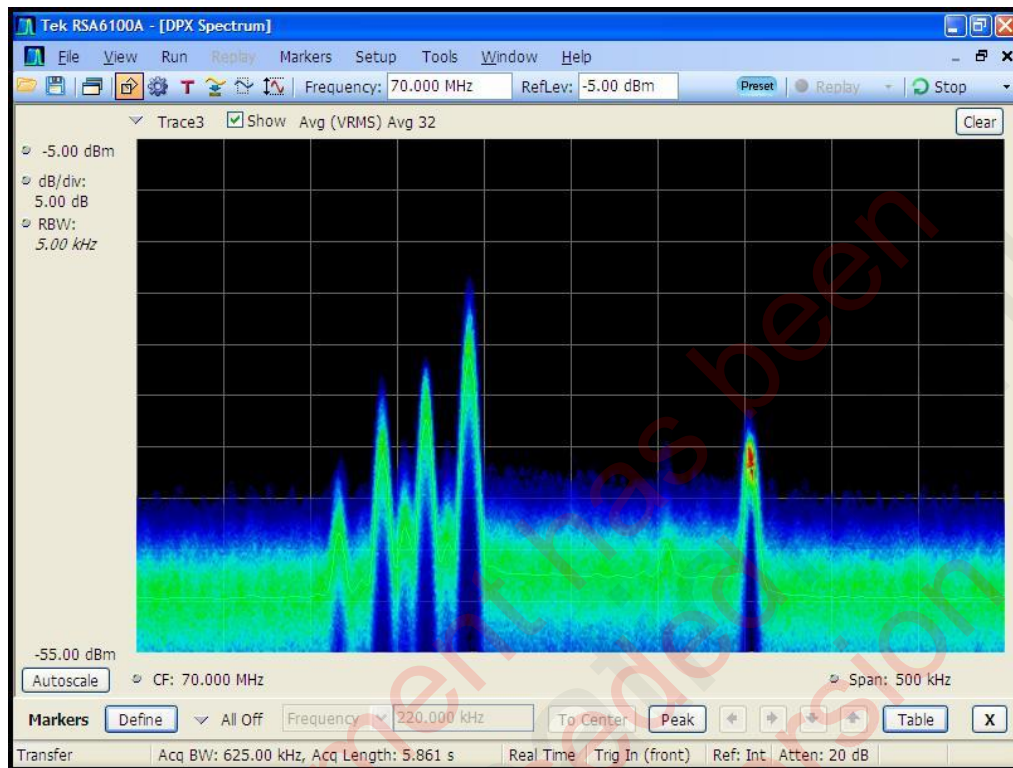


Figure 3.2: DASS S-Band Downlink Spectrum

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 |
| 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 |

| Parameter | Interoperability Requirement | DASS On Orbit Performance | Unit |
|--------------------------------------------------------------------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| 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**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

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

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 satellites² 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 CIRS³ (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).

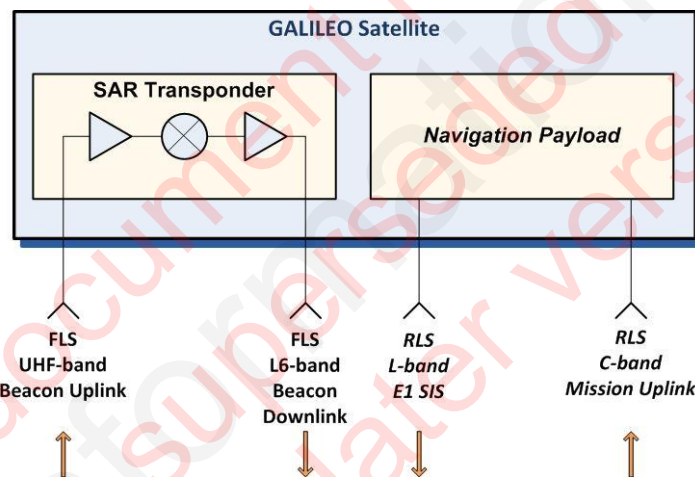


Figure 4.1: Implementation of SAR Functions on the Galileo Satellites

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 4.13). They are designed according to the space segment interoperability requirements⁴, 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 FGM⁵

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.

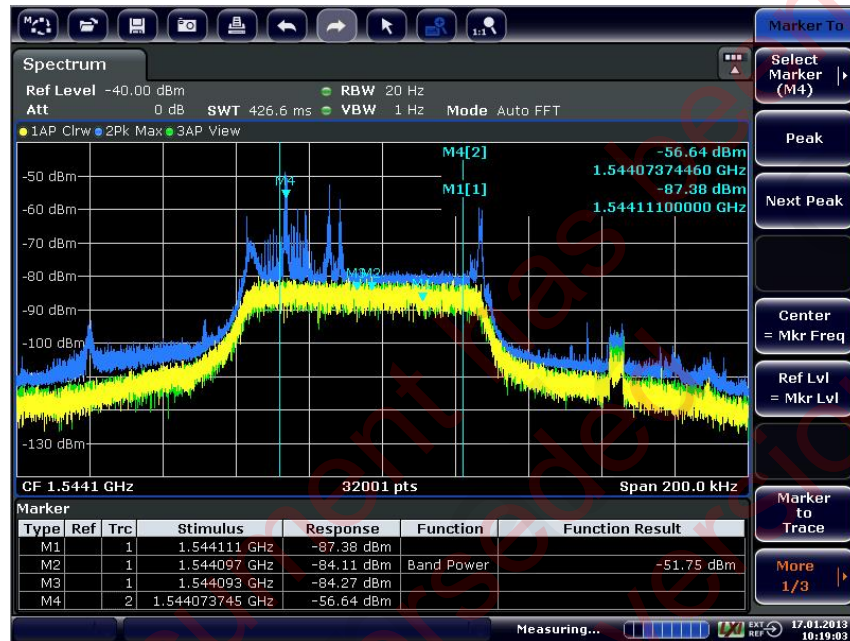


Figure 4.2: Galileo SAR Repeater L-Band Downlink Narrow-Band (50 kHz) Signal Spectrum

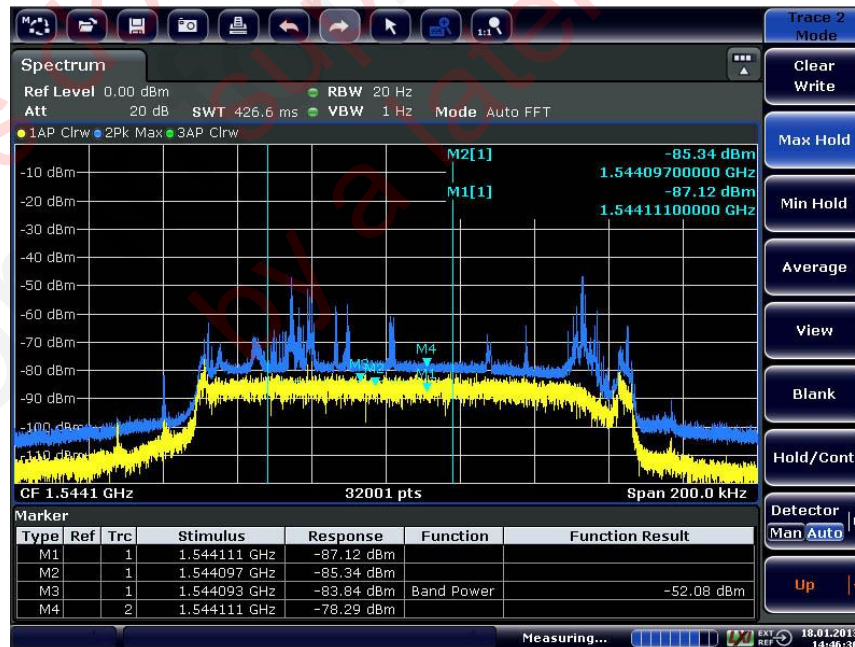


Figure 4.3: Galileo SAR Repeater L-Band Downlink Normal Band (90 kHz) Signal Spectrum

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 | 406.050 | 406.050 | | MHz |
| Narrowband mode | 406.043 | 406.043 | | |
| 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) | >-17.7 | > -14.9 | > -15.3 | dB/K |
| At centre of coverage | | > -12.6 | > -13.6 | |
| System noise temperature ^(c, d) | | 380 | 365 | K |
| 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) | > 80 kHz (10 dB) > 95 kHz (3 dB) < 110 kHz (10 dB) < 150 kHz (45 dB) < 200 kHz (70 dB) | > 80 kHz (1.0 dB) > 90 kHz (3 dB) < 110 kHz (10 dB) < 150 kHz (45 dB) < 180 kHz (70 dB) | |
| Narrowband mode | > 50 kHz (1.0 dB) < 75 kHz (10 dB) < 130 kHz (45 dB) < 160 kHz (70 dB) | > 50 kHz (1.0 dB) < 70 kHz (10 dB) < 100 kHz (45 dB) < 180kHz (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 | / | 28 | / | degree |
| Narrowband mode | / | 18 | / | |
| Group delay (turn-around time) ^(e) | | | | |
| Normal mode | / | 27 | 48 | µs |
| Narrowband mode | / | 38 | 68 | |
| 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 ⁽ⁱ⁾ (slope) | | | | |
| Normal mode | 10 | 5 | 2.5 | μs/4kHz |
| Narrowband mode | | 9 | 3.5 | |
| 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 | $\pm 2 \times 10^{-11}$ | $< \pm 2 \times 10^{-11}$ | $< \pm 1 \times 10^{-12}$ | |
| Short term stability (100ms) | 1×10^{-11} | 2×10^{-11} | 4×10^{-12} | (h) |
| Gain variation ^(g) | | 0.3 | | dB _{pk-pk} |
| Translation frequency stability | | RAFS: $< 1.0 \times 10^{-11}$ PHM: $< 1.0 \times 10^{-14}$ | | |
| Downlink frequency band | | 1,544.0 to 1,544.2 | | MHz |
| Downlink centre frequency | | | | |
| Normal mode | | 1,544.100 | | MHz |
| Narrowband mode | | 1,544.093 | | |
| Downlink antenna polarisation | | LHCP | | |
| Transmit antenna axial ratio | | < 1.7 | < 1.9 | dB |
| Downlink EIRP | 15 | > 18.7 ⁽ⁱ⁾ < 20.3 ⁽ⁱ⁾ | > 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 $T_a = 400$ 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.

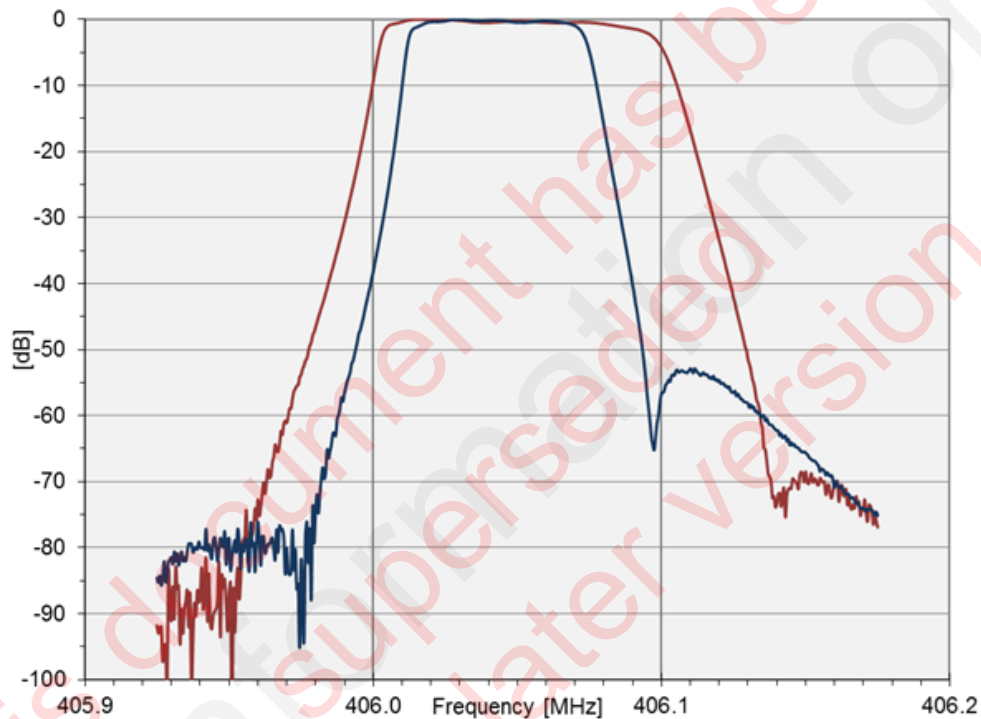


Figure 4.4: Galileo SAR Repeater Normal and Narrow Bandpass Filtering Performance

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.

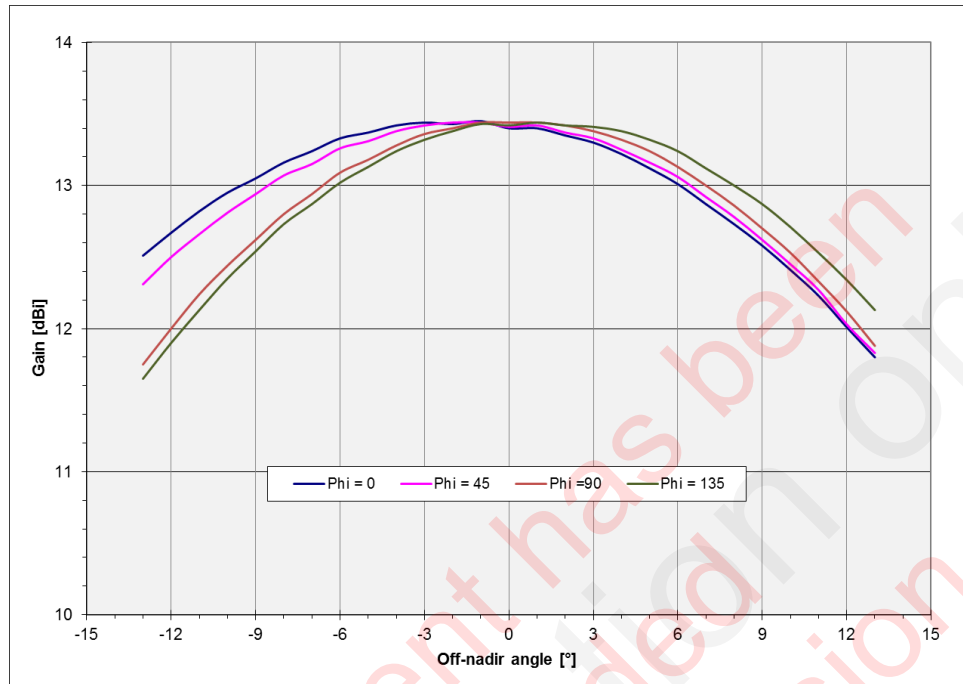


Figure 4.5: SAR Rx Antenna Gain on Galileo IOV 419 Satellite (Four Cross-Sections)

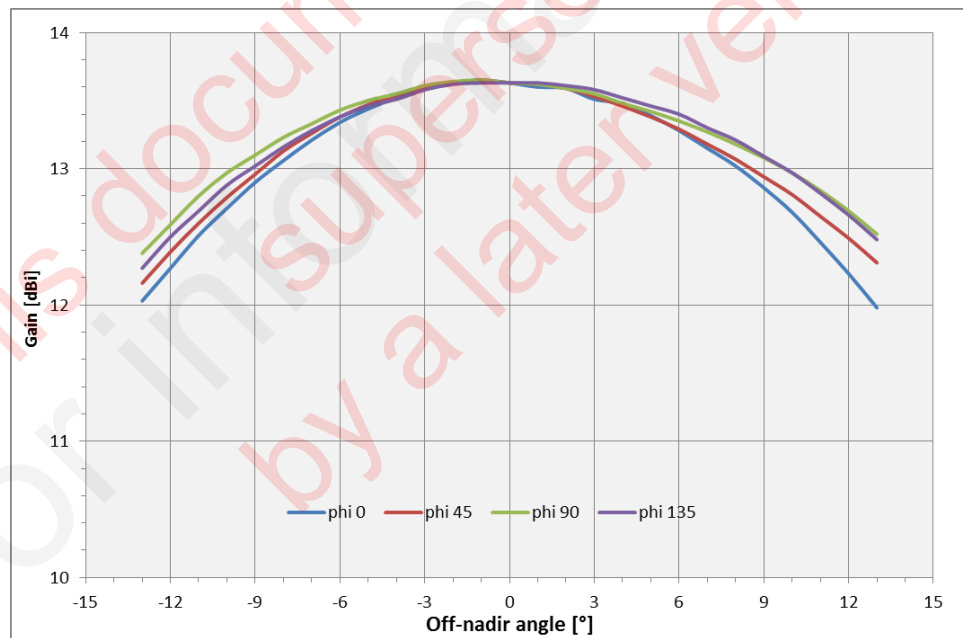


Figure 4.6: SAR Tx Antenna Gain on Galileo IOV 419 Satellite (Four Cross-Sections)

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.

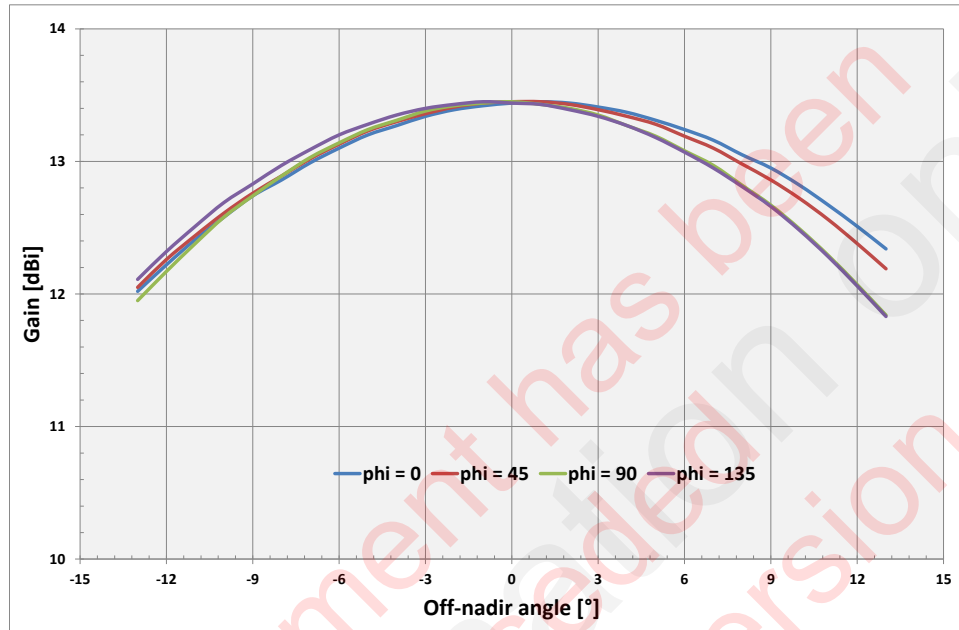


Figure 4.7: SAR Rx Antenna Gain on Galileo FOC 426 Satellite (Four Cross-Sections)

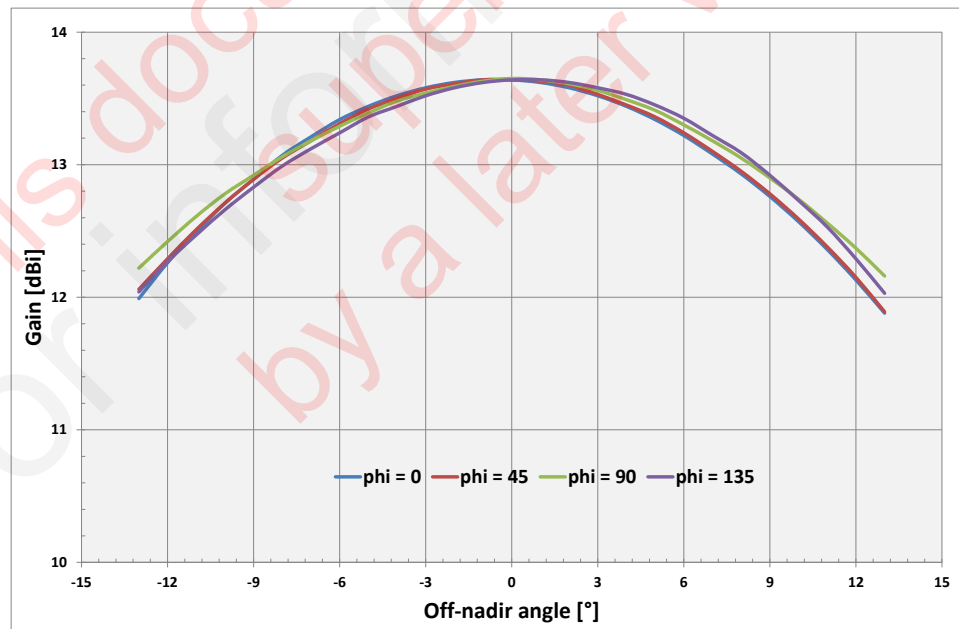


Figure 4.8: SAR Tx Antenna Gain on Galileo FOC 426 Satellite (Four Cross-Sections)

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" | |
| <p>* 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)</p> <p>** 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).</p> | | | | | | | | | |

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.

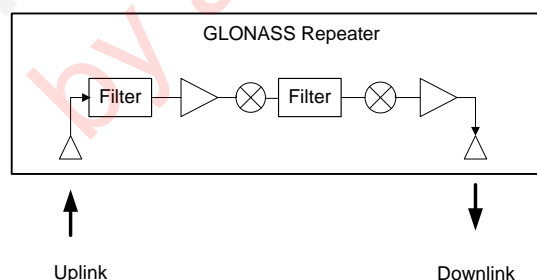


Figure 5.1: Implementation of SAR Functions on the Glonass-K Satellites

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.

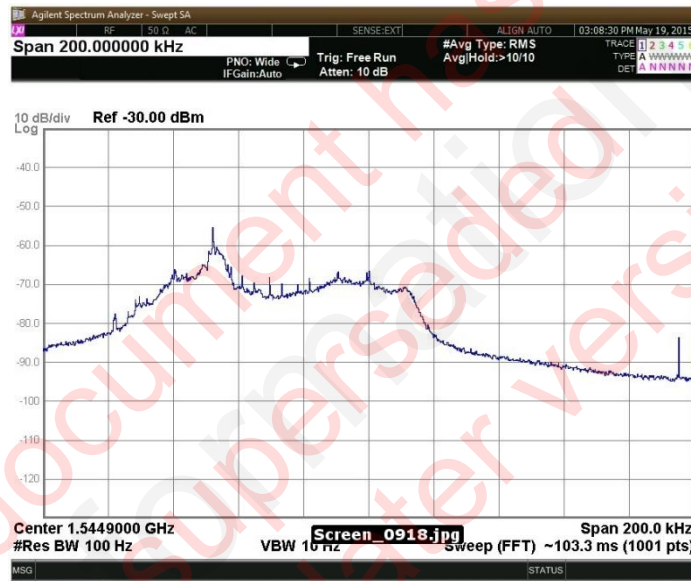


Figure 5.2: Glonass-K SAR Repeater L-Band Downlink Narrow Band Signal Spectrum

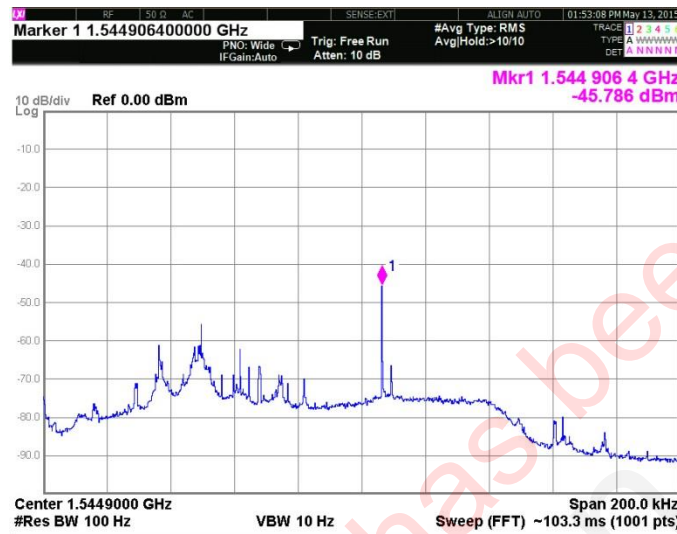


Figure 5.3: Glonass-K SAR Repeater L-Band Downlink Wide Band Signal Spectrum

5.5 Glonass Repeater Coverage Area

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

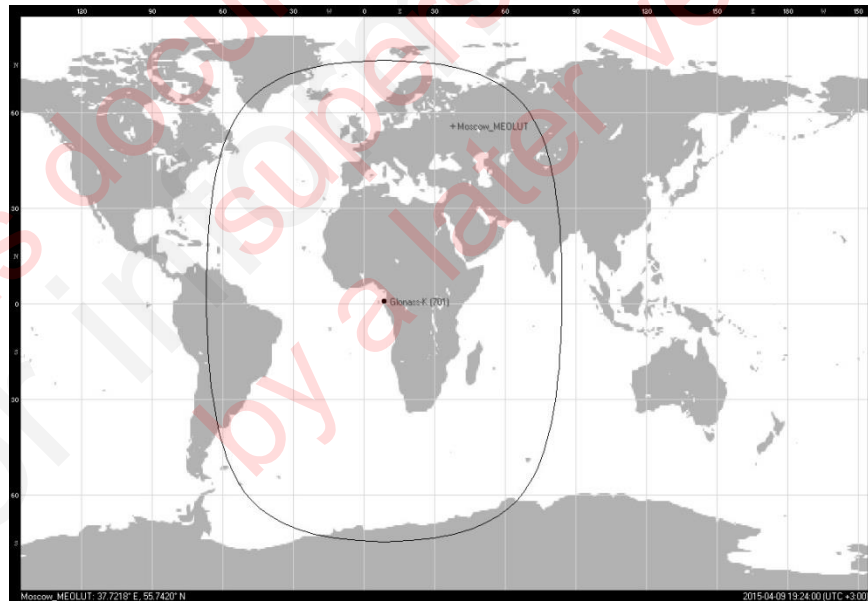


Figure 5.4: Glonass-K 0° Elevation Coverage Area
(an example of coverage area taken near the equator)

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 | MHz | |
| Normal mode | | 406.050 |
| Narrowband mode | | 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 | dB/K | |
| At edge of coverage | | -16.3 |
| At centre of coverage | | -14.3 |
| System noise temperature | K | 490 |
| Bandpass characteristics | | |
| Normal mode | | > 120 kHz (3 dB) < 150 kHz (10 dB) < 340 kHz (30 dB) < 450 kHz (40 dB) |
| Narrowband mode | | > 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) | µs/4kHz | In uplink frequency range |
| Normal mode | | < 10 |
| Narrowband mode | | < 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 | Hz | 1.53 |
| Short term stability (100 ms) | | ± 5 x 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 | MHz | 1544.900 |
| Normal mode | | 1544.893 |
| Narrowband mode | | |
| Downlink antenna polarisation | | LHCP |
| Downlink EIRP (at edge of coverage) | dBw | 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.

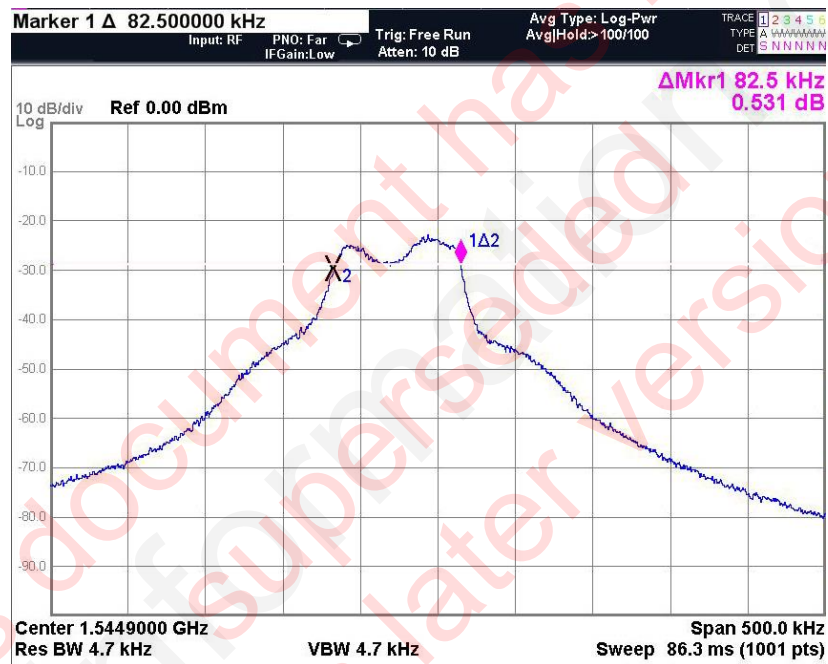


Figure 5.5: Glonass-K SAR Repeater Narrow Bandpass Filtering Performance

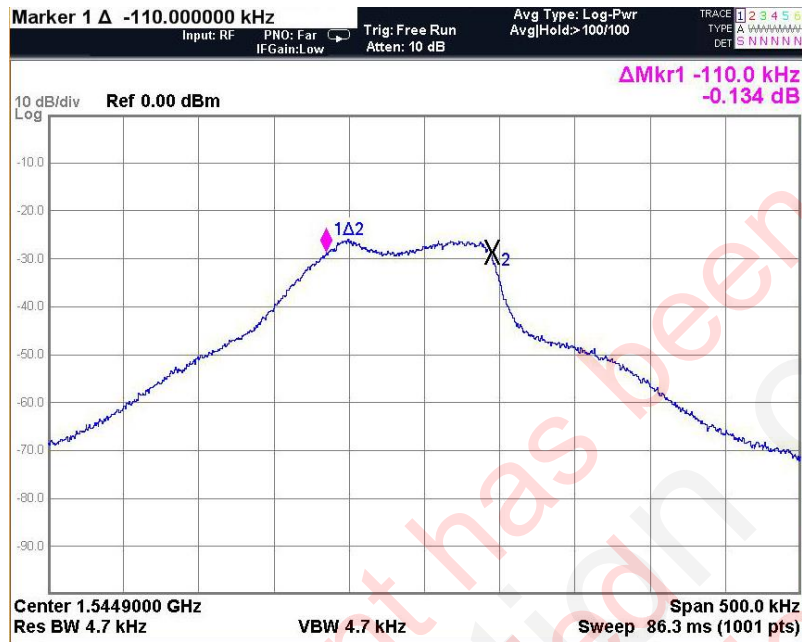


Figure 5.6: Glonass SAR Repeater Normal Bandpass Filtering Performance

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.

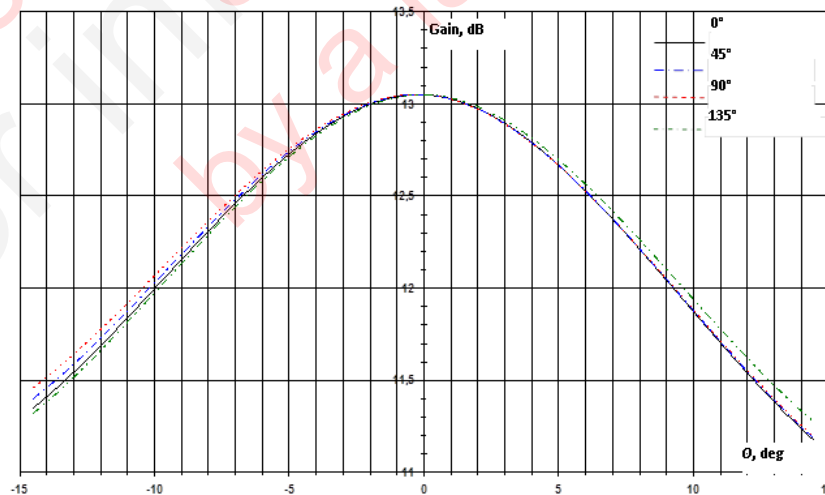


Figure 5.7: Glonass-K SAR Repeater Receiving Antenna Gain (Four Cross-Sections)



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 | Danielè | | 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 $[\pm 100 \text{ Hz}]$. 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 | 155N/A | 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 |

Table B.4: Galileo Filter Settings

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

| Group Delay Data Curve Fit Coeff | | | | | Group Delay | R |
|----------------------------------|--|--|--|--|-------------|---|
| | | | | | | |
| | | | | | | |

[illegible]

| | | | | | | | | | | | | | | | | | |
|-----|--|-----|---------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| 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:

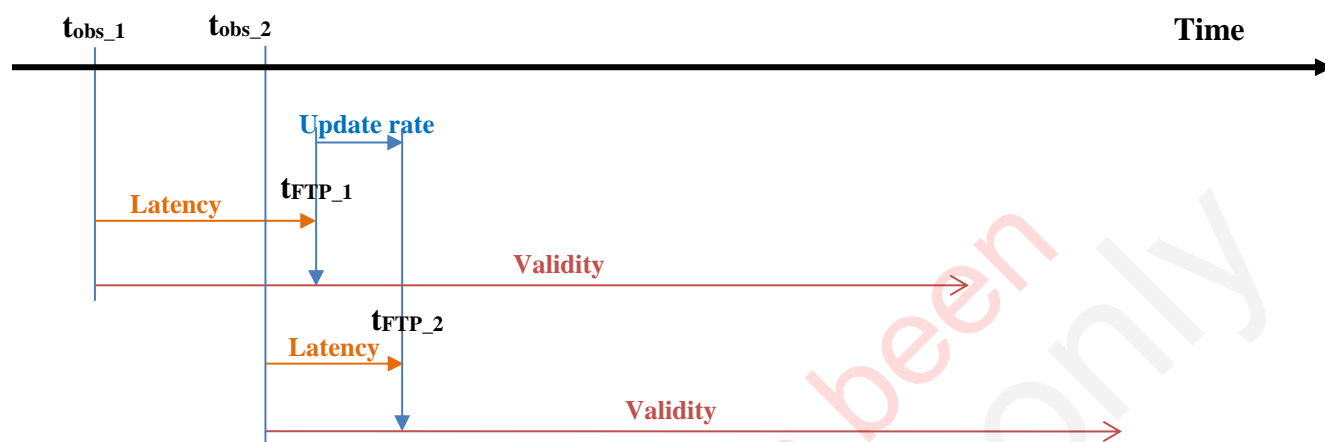
- Observation Data which contains receiver measurements (pseudoranges, Doppler, C/N₀, etc...)
- Navigation Data which contain the ephemeris parameters as read by the receiver from the navigation message

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).



- END OF ANNEX C -

- END OF DOCUMENT -

This document has been
For information only
superseded by a later version

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