COSPAS-SARSAT MEOSAR SPACE SEGMENT COMMISSIONING STANDARD

C/S T.017

Issue 2

October 2025

This document is provided as a complement to the final clean version of the document. In case of discrepancy between this marked-up version and the clean final version, the information in the clean final version shall prevail.

COSPAS-SARSAT MEOSAR SPACE SEGMENT COMMISSIONING STANDARD

HISTORY

Issue	Revision	Date	Comments
1	-	October 2013	Approved by the Cospas-Sarsat Council (CSC-51)
1	1	October 2014	Approved by the Cospas-Sarsat Council (CSC-53)
1	2	December 2015	Approved by the Cospas-Sarsat Council (CSC-55)
1	3	December 2016	Approved by the Cospas-Sarsat Council (CSC-57)
1	4	February 2018	Approved by the Cospas-Sarsat Council (CSC-59)
1	5	March 2021	Approved by the Cospas-Sarsat Council (CSC-64)
1	6	November 2022	Approved by the Cospas-Sarsat Council (CSC-67)
2	-	October 2025	Approved by the Cospas-Sarsat Council (CSC-73)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXES

1. INTRODUCTION

1.1 Purpose

This document ~~is aiming to~~ present*s* a proposal of recommended tests, technical measurement standards and high-level procedures for implementing on-orbit testing and commissioning of MEOSAR space segment payloads.

The commissioning authority (defined in section 2) will produce detailed test procedures and results.

1.2 Scope

The following two phases of MEOSAR space segment on-orbit testing are addressed: initial on-orbit testing *(IOT)* (commissioning) and routine monitoring. The basic responsibilities, specific tests *recommended* to be performed, and *suggested* test methodologies are defined by this document.

1.2.1 IOT – Commissioning

Initial on-orbit tests ~~(IOT)~~ are performed in order to establish that a MEOSAR payload can be placed in service to support SAR operations. The initial tests focus on establishing that the MEOSAR payload will properly operate and*,* therefore*,* will be able to interface with the beacon and the ground segment. It must be noted that MEOSAR payloads are non-inverting frequency translator instruments (repeaters) and*,* therefore*,* no on-board processing/demodulation of the signal is~~foreseen~~ *employed*.

If results of the initial on-orbit tests confirm that values for assessment indicators are within accepted ~~thresholds~~ *values*, the payload can be formally commissioned. The payload can then be used operationally and data exchanged as described in document C/S A.001.

A list of recommended tests and a description of each test is provided in section 3. The test descriptions provide sufficient detail to define the measurement method *including high level procedures*, but are not intended to be specific *detailed* test procedures. It is the responsibility of the commissioning authority to develop *detailed* test procedures that are traceable to the methods described in this document *for each recommended test conducted*.

1.2.2 Routine Monitoring

After initiation of MEOSAR *payload* operations, the space segment operator *will* conduct~~s~~ routine monitoring of the on-orbit payload performance using telemetry and other means as deemed necessary. Routine monitoring ~~will~~ *may* include *recommended* tests identified as routine monitoring tests in section *3*~~4~~*, Table 3.1*. *The detailed test procedure will be developed by space segment operators and may differ from the test procedures shown in section 3.*

MEOLUT and MCC operators can also detect significant changes (e.g., loss of channel, etc.). Abnormal conditions detected by MEOLUT and MCC operators are reported to the commissioning authority for further tests and corrective action as required. If deemed necessary, operational limitations may be placed on the use of the payload or it may be de-commissioned. The commissioning authority will advise *the* Cospas-Sarsat *Programme* of any detected abnormal conditions, and any required tests will be developed by the commissioning authority.

1.3 Reference Documents

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

C/S A.001	Cospas-Sarsat Data Distribution Plan
C/S T.013	Cospas-Sarsat GEOSAR Space Segment Commissioning Standard
C/S T.016	Description of the 406 MHz Payloads Used in the Cospas-Sarsat MEOSAR System
C/S R.012	Cospas-Sarsat 406 MHz MEOSAR Implementation Plan
C/S R.018	Cospas-Sarsat Demonstration and Evaluation Plan for the 406 MHz MEOSAR System
ITU-R P.676-6 15	Attenuation by atmospheric gases

1.4 Common System Units

The System International (SI) units of measurement will be used for exchange of interoperability parameters and test results.

Interpretation of technical terms in exchanged documentation will be in accordance with the latest edition of the "IEEE Standard Dictionary of Electrical and Electronic Terms".

- END OF SECTION 1 -

2. ON-ORBIT SPACE SEGMENT TESTING AND COMMISSIONING

2.1 Commissioning Authority Definition

Commissioning authorities are defined as follows:

MEOSAR Constellation	Space Segment Operator	Commissioning Authority
SAR/Galileo	European Commission	European Commission
SAR/GPS	USA	Canada and USA
SAR/Glonass	Russia	Russia
DASS S band (Note 1)	USA (USAF)	USA
SAR/BDS	China (P. R. of)	China (P. R. of)

Table 2.1: MEOSAR Commissioning Authorities Definition

Note 1: this constellation is not planned to be declared as operational, but its data may be used operationally.

2.2 Initial On-Orbit Tests

The payload parameters are defined in the following sections. On-orbit testing will provide a set of baseline values for the defined parameters, to be compared with ~~reference threshold~~ *compliance indicator* values defined in section 4, or optionally with pre-launch values obtained with on-ground testing.

It is the responsibility of each commissioning authority to develop the *detailed* procedures unique to the satellite and test facility for conducting tests on the*ir* MEOSAR payload. Such *detailed* procedures ~~shall~~ *should* be traceable to the ~~methods~~ *test objectives and high-level procedures* described in this document. Alternate *test* methods *and procedures* can be considered but must be described in detail ~~with the test result documentation provided with~~ *in* the commissioning report. In addition, other Participants may perform tests on the MEOSAR payload. ~~However,~~ *T*~~t~~hese tests *by other Participants* ~~shall~~ *may* conform to the ~~methods~~ *test objectives and high-level procedures* described herein*,* ~~and~~ *however,* the*ir detailed* test procedures *must* ~~shall~~ be provided to the responsible space segment operator beforehand to ensure the safety of the MEOSAR spacecraft. Furthermore, all Participants conducting tests shall conduct appropriate co-ordination within *the* Cospas-Sarsat *Programme* to ensure that there is no negative impact on Cospas-Sarsat operations.

The commissioning authority will analyse the initial on-orbit test data and prepare a post launch ~~test~~ *commissioning* report *as detailed in section 6*. ~~The report will include the results of the tests along with~~

~~a description of the test methods sufficient to allow interpretation of the data. The test report shall be provided to the Cospas-Sarsat Secretariat as an attachment to the commissioning report.~~

2.3 Commissioning Procedure

Commissioning is a formal declaration by the commissioning authority that the on-orbit MEOSAR payload *parameter* assessment indicators meet the required compliance levels and that the equipment is operational as part of the MEOSAR system. Commissioning may be declared with operational limitations if some compliance levels are not met and limited operation is deemed feasible. In such a case the status of the MEOSAR ~~instrument is~~*payload shall be* designated as being at "limited operational capability" (LOC).

Performing the initial on-orbit tests and preparing a report may be time consuming. During this time valid operational data will normally be available from the satellite payload that is under test. In view of this, an initial operational capability (IOC) status may be declared for the payload before the commissioning report is completed. This may be done at the option of the commissioning authority after sufficient tests have been conducted to establish confidence that use of the MEOSAR payload will not cause unnecessary expenditure of SAR resources.

Satellite payload IOC is declared with a SIT 605 message issued on behalf of the commissioning authority by the MCC associated with the commissioning *authority*. The information to be included in the SIT 605 IOC message is detailed ~~at~~*in* section 5. Once declared, IOC status shall remain in effect until commissioning is completed*, which shall normally be no more than 90 days after IOC status was declared*.

Commissioning an on-orbit MEOSAR instrument consists of confirming the basic health and safety of the payload and the measurement and analysis of post launch test data to verify compliance or non-compliance with the expected values of the *parameter* assessment indicators.

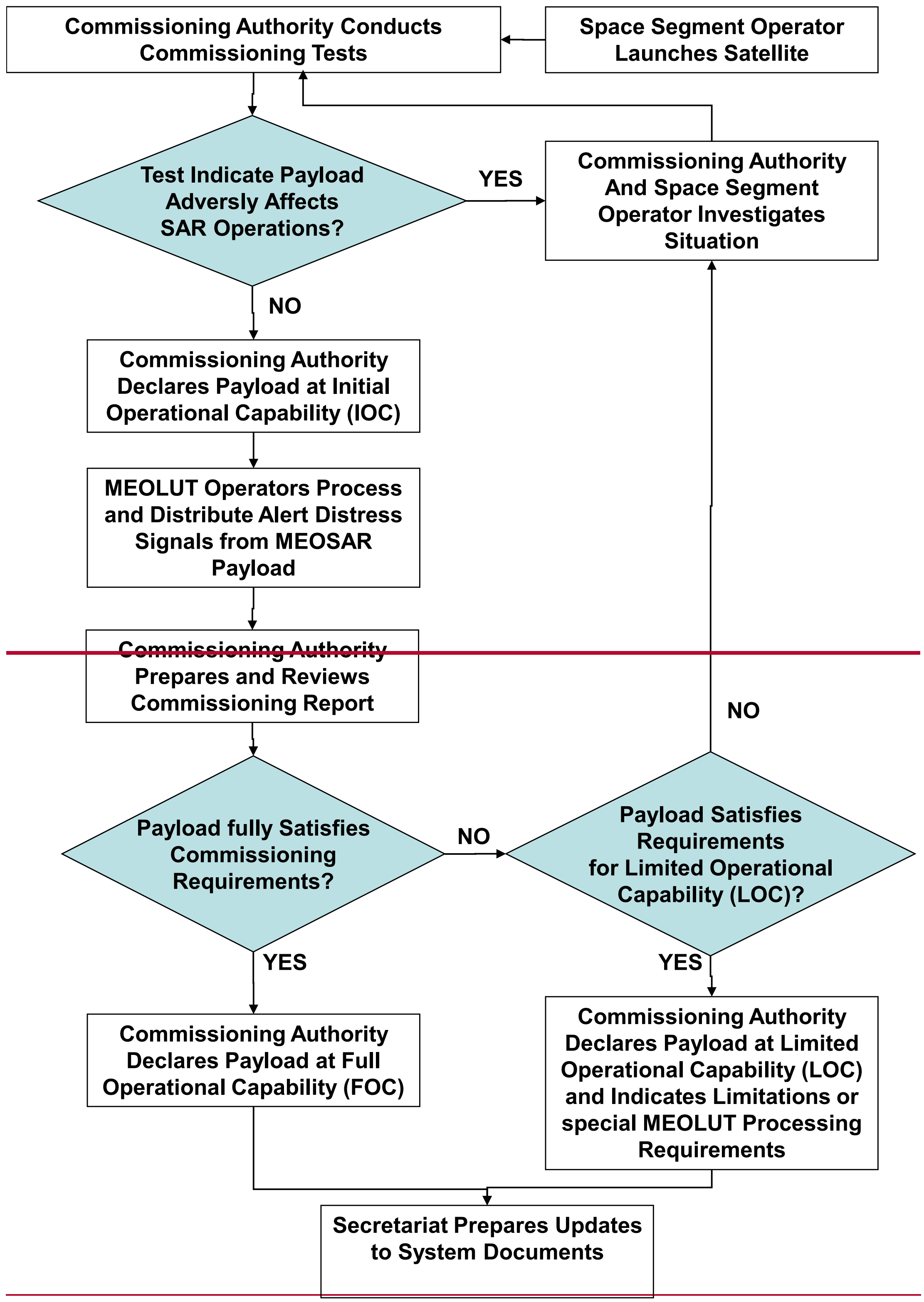
~~The commissioning report shall contain the test set-up used including beacon simulator transmit antenna (geographical position, gain and polarization), receiving antenna on ground (geographical position, G/T and polarization), and MEOLUT ID for test B.11.~~

Figure 2.1 shows the general commissioning procedure. Upon completion of all tests, the commissioning authority will evaluate the assessment indicators and prepare a commissioning report as shown in section 6. The commissioning report will designate the status of the MEOSAR instrument as ~~either~~ being either at full operational capability (FOC) or limited operational capability (LOC).

The commissioning authority submits the commissioning report for a review by the Joint Committee or other body as instructed by the Cospas-Sarsat Council. The experts will review the report and decide whether the report is complete and/or provide feedback to commissioning authority to update the report, as necessary. If the payload was deemed operational by the commissioning authority after the commissioning tests have been completed, the declaration of the operational status may be done by the commissioning authority before such a review.

The commissioning *test results as summarized in section 5* ~~report~~ shall be distributed by the MCC associated with the commissioning authority to all MCCs in the Cospas-Sarsat *S*~~s~~ystem using a SIT 605 message issued on behalf of the commissioning authority.

~~*The commissioning authority shall provide a copy of the commissioning report to the Cospas-Sarsat* Secretariat *for permanent retention.*~~*A copy of the finalized report is permanently retained by the Cospas-Sarsat Secretariat.* The Secretariat will provide copies of the report to Cospas-Sarsat Participants upon request.


Commissioning Authority Conducts Commissioning Tests
Space Segment Operator Launches Satellite
Test Indicate Payload Adversly Affects SAR Operations?
YES
Commissioning Authority And Space Segment Operator Investigates Situation
NO
Commissioning Authority Declares Payload at Initial Operational Capability (IOC)
MEOLUT Operators Process and Distribute Alert Distress Signals from MEOSAR Payload
Commissioning Authority Prepares and Reviews Commissioning Report
NO
Payload fully Satisfies Commissioning Requirements?
NO
Payload Satisfies Requirements for Limited Operational Capability (LOC)?
YES
YES
Commissioning Authority Declares Payload at Full Operational Capability (FOC)
Commissioning Authority Declares Payload at Limited Operational Capability (LOC) and Indicates Limitations or special MEOLUT Processing Requirements
Secretariat Prepares Updates to System Documents

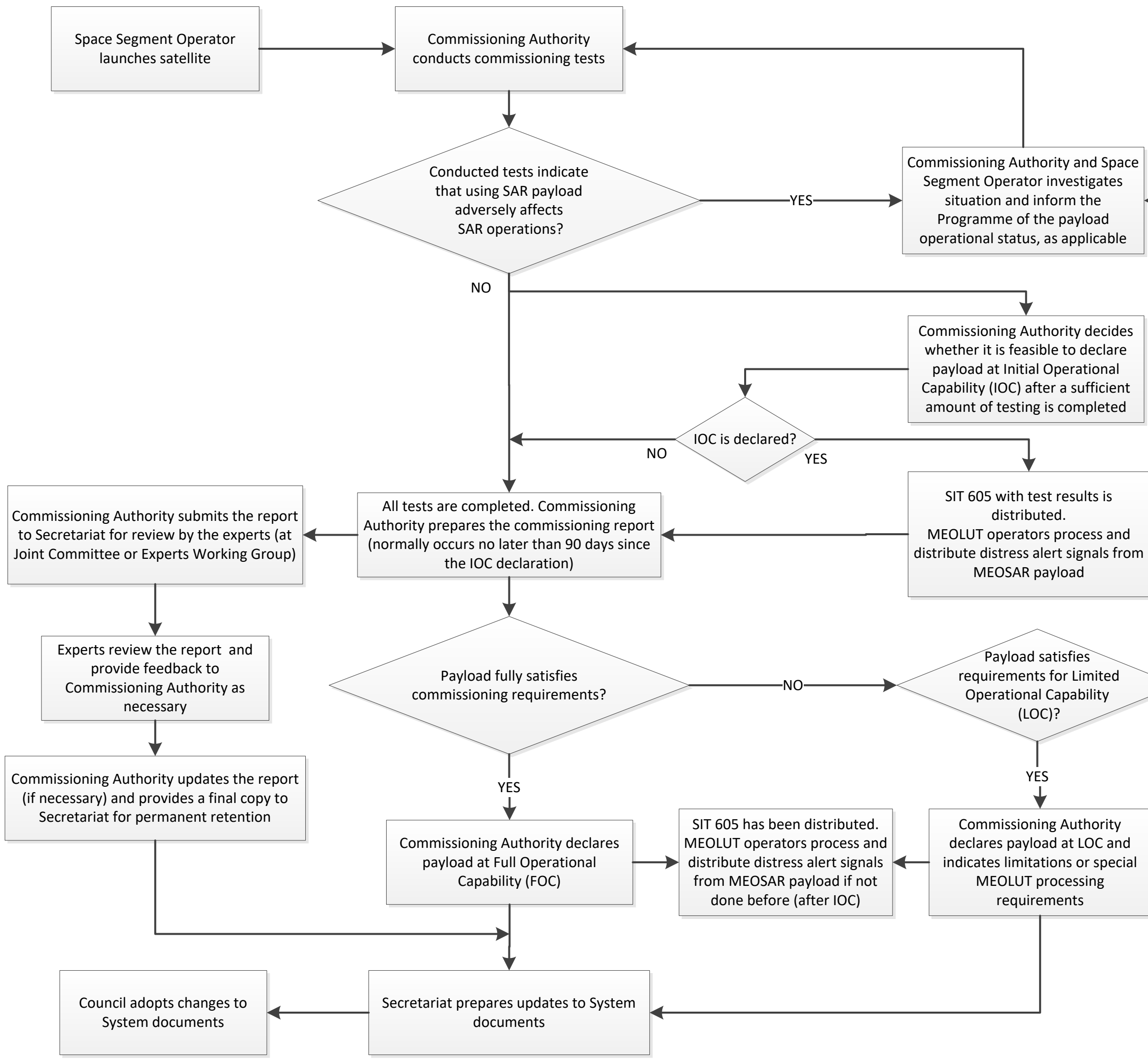


Figure 2.1: MEOSAR Payload Commissioning Procedure

Note: some paths may be taken in parallel

2.4 Satellite System Data

In order for *the* Cospas-Sarsat *Programme* to operate the MEOSAR ~~instruments~~ *payloads* at an IOC, LOC or FOC status, the MEOSAR space segment operator shall provide *the Programme with* ~~Cospas-Sarsat~~ the satellite/payload information necessary for conducting daily operations. Examples of such data are *Search and Rescue Repeater (*SARR*) payload* status on/off, gain control mode *(Automatic Gain Control (*AGC*) / Fixed Gain (*FG*))*, selected band mode Normal/Narrow band, *and* nominal downlink frequency. *Such data shall be contained in SIT 605 messages as per section 5 and in the payload commissioning report. The Programme and the Ground Segment Operators must be kept up to date of changes in such information and payload status.*

2.5 Routine Monitoring

The routine monitoring of the MEOSAR space segment is p~~P~~erformed by:

- space segment operator*s*, monitoring satellite telemetry *and conducting routine monitoring on orbit tests such as those listed in Table 3.1*,
- MEOLUT~~s~~ operators, monitoring satellite tracking performances and processing anomalies,
- MCC operators, comparing alerts produced by MEOSAR systems with information obtained from other sources.

Problems are to be reported to the commissioning authority, which *will* perform~~s~~ *further* tests in order to confirm health status of the payload.

2.6 Decommissioning Procedure

De-commissioning is a formal declaration by the MEOSAR commissioning authority that a MEOSAR payload is no longer a part of the MEOSAR system. A MEOSAR instrument that cannot meet the performance requirements for reliable Cospas-Sarsat service will be decommissioned.

An operational MEOSAR instrument may also be de-commissioned by the space segment operator due to general spacecraft health and safety issues. In this case, the spacecraft operator shall notify the commissioning authority that the SAR*R payload*~~instrument~~ should be de-commissioned. The commissioning authority would be responsible for distributing this information via the MCC network, and providing a copy to the Secretariat for permanent retention. A de-commissioned payload can later be re-commissioned, with or without limitations, based on an evaluation of current values of the assessment indicators and the need within *the* Cospas-Sarsat *Programme*.

2.7 Space Segment Problem Reporting and Investigation Procedures

Any space segment, MEOLUT or MCC operator that detects anomalies of a MEOSAR *payload* ~~instrument~~ during routine monitoring or system operation shall inform the relevant commissioning authority so that special tests can be conducted and possible corrective action (e.g., switch to backup payload, etc.) taken. MEOLUT and MCC operators will report problems to the responsible commissioning authority through the associated MCC in accordance with procedures given in document C/S A.001, and space segment operators shall report anomalies to the commissioning authority via the most effective means available. The procedure to be followed is shown in Figure 2.2.

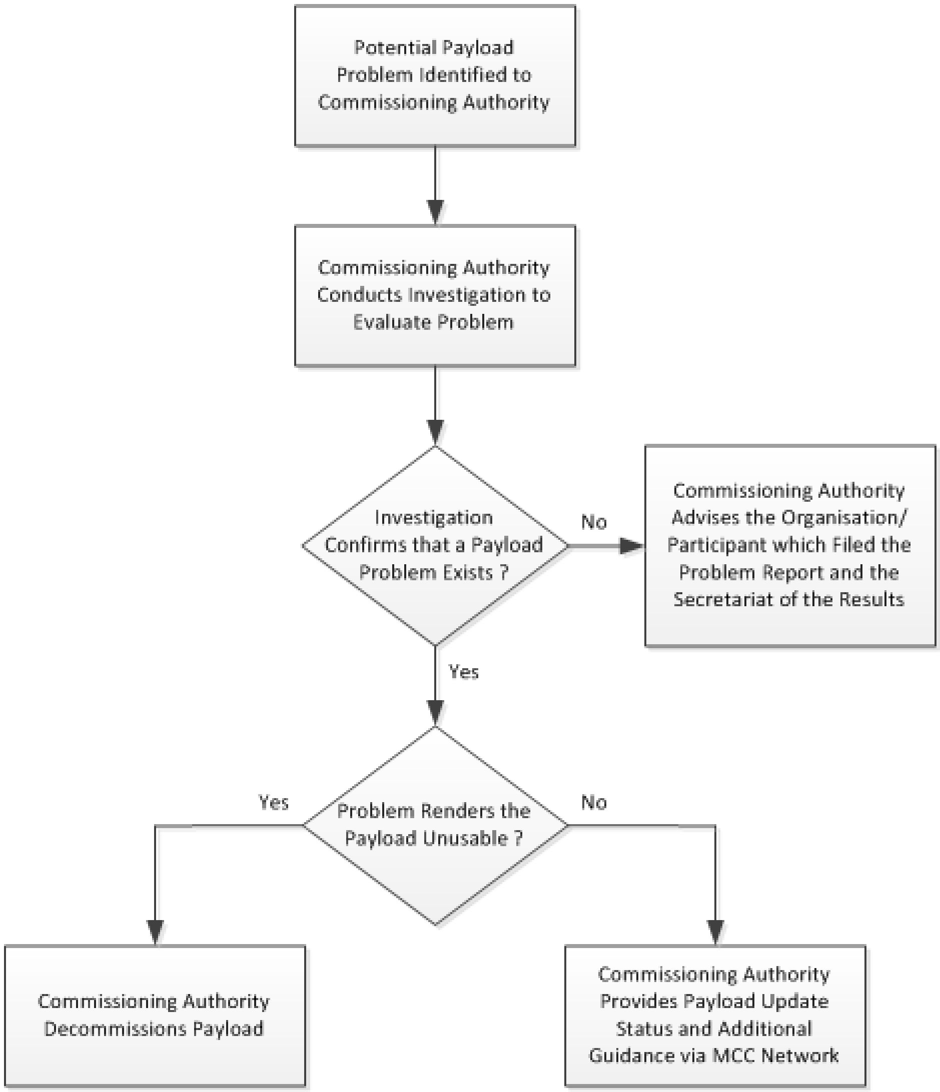


Figure 2.2: MEOSAR Problem Reporting and Investigation Procedures

Upon being made aware of a possible problem with the MEOSAR payload, the commissioning authority shall advise the space segment operator, and conduct an investigation to evaluate the status and performance of the instrument. Based on the results of the investigation, the commissioning authority shall take one of the courses of action described below:

a) should the investigation identify a serious problem with the payload which renders it unusable for SAR purposes, the commissioning authority shall decommission the payload in accordance with section 2.6; and

b) should the investigation identify a problem which confirms degraded payload performance, but indicates that the instrument is still useful for SAR purposes, the commissioning authority shall distribute an update of the payload status via the MCC network (using SIT 605), with a copy also provided to the Secretariat and to the space segment operator. The update shall specifically identify:

- the problem with the payload,
- the impact on MEOLUT processing,
- the impact on the quality of distress alerts produced,
- any special MEOLUT processing required.

Should the investigation not confirm the problem or conclude that there is a problem which does not impact on MEOSAR performance, the commissioning authority shall liaise with the organization which identified the problem to confirm that MEOSAR performance is not affected. A copy of the conclusions shall also be provided to the Secretariat for retention. There would be no requirement to advise other Cospas-Sarsat Participants of the results of the investigation in such a circumstance.

- END OF SECTION 2 -

3. MEOSAR SPACE SEGMENT TESTING

~~The recommended tests for MEOSAR commissioning are presented in this section.~~

Table 3.1 identifies the set of post launch tests recommended to be completed by the space segment operator in order to establish initial commissioning of a MEOSAR payload. Each space segment operator is also encouraged to conduct other tests that may more fully characterise payload performance.

Table 3.1 also lists recommended routine monitoring tests that should be periodically conducted by the space segment operator. The schedule of the routine monitoring tests shall be determined by the space segment operator.

Table* 3.1*: List of Post-Launch Tests

Parameter tested	*Recommended for commissioning (y/n)*	*Recommended routine monitoring test (y/n) (note 1)*
3.1 SAR Repeater Gain	*y*	*n*
3.2 Translation frequency	*y*	*y*
3.3 SARR G/T	*y*	*y*
3.4 Axial Ratio	*optional*	*n*
3.5 SARR Dynamic Range in AGC Mode	*y*	*n*
3.6 Channel Bandwidth and Amplitude Ripple	*y*	*y (operational mode only)*
3.7 Linearity/Third Order Intermodulation	*y*	*n*
3.8 SARR Downlink EIRP	*y*	*y*
3.9 Transponder Group Delay Variation as a Function of Frequency	*y*	*n*
3.10 Spurious Output Levels	*y*	*y*
3.11 Beacon Signal Processing	*y*	*y*

Note: 1. The schedule of these tests shall be determined by the space segment operator.

Consistent with section 2.2, it is the responsibility of each commissioning authority to develop the detailed procedures for conducting tests on their MEOSAR payload. Such detailed procedures should be traceable to the test objectives and high-level procedures described in this section below. Alternate methods can be used but must be described in detail in the commissioning report, including the test setup, with the test result documentation provided. An example of an alternate method would be if the commissioning authority elects to specify uplink transmit power into the antenna instead of EIRP.

3.1 SAR Repeater Gain

3.1.1 Objective

The objective of this test is to measure the SARR gain including *ultra-high frequency (*UHF*)* receiver antenna *gain*, SARR *payload* and L-band transmitting antenna *gain*.

3.1.2 Procedure

The SARR gain is to be expressed in boresight conditions for the satellite-onboard receive and transmit antennas.

The SARR can be stimulated, in any operational mode, with a *continuous wave (*CW*) frequency (*UHF*)* signal generated by a signal generator. Then the satellite gain can be *calculated based upon* ~~computed measuring~~:

- *uplink* transmitted EIRP ~~(measured with a RF power meter)~~,
- power received from the satellite *downlink* (measured on ground ~~with a spectrum analyser~~).

The procedure steps are the following:

a) compute $EIRP_{DL}$ (*SARR* ~~satellite~~ EIRP) *in the direction of the ground station* as:

$$EIRP_{DL}|_{dB} = P_{SA}|_{dB} - G_{DL}|_{dB} - G_{PROP}|_{dB} - G_{ATM}^{DL}|_{dB} - G_{ASPECT}^{DL}|_{dB} - G_{POL}^{DL}|_{dB}$$

$$EIRP_{DL}|_{dB_m} = P_{SA}|_{dB_m} - G_{DL}|_{dB} - G_{FSL}|_{dB} - G_{ATM}^{DL}|_{dB} - G_{POL}^{DL}|_{dB}$$

where:

- P_{SA} is the measured power level at the *ground station* spectrum analyser (SA),
- G_{DL} is the gain *in the direction of the satellite* of the *ground station* receiver chain path *(i.e.,* from the receiver antenna (including antenna gain) to the *spectrum analyser (*SA*))* (the test setup must ensure the stability of this term during the test),
- ~~G_{PROP}~~ G_{FSL} is the ~~propagation gain~~ *free space loss in dB*:

$$G_{PROP} = 20\, log\left(\frac{\lambda}{4\pi R}\right) G_{FSL} = 20\, log\left(\frac{\lambda}{4\pi R}\right)$$

  where R is the *downlink* range and λ is the downlink wavelength,
- G_{ATM}^{DL} is the atmospheric loss expressed as a negative gain for the downlink path, as defined in Annex B,
- ~~G_{ASPECT}^{DL} is the gain correction to take into account the actual satellite on-board antenna gain in the MEOLUT direction. G_{ASPECT}^{DL} is expressed as a gain relative to the in-axis gain of the on-board antenna. It can be derived from the knowledge of the radiation pattern of~~

~~the antenna on-board the satellite (measured during ground tests), the satellite pointing direction and the satellite-to-MEOLUT geometry at the time of the test.~~

- $G_{POL}^{DL}|_{dB}$– downlink polarization losses[1] expressed as a negative gain.

Compute the satellite EIRP downlink in boresight conditions, if possible.[2]

b) compute $EIRP_{UL}$ (uplink EIRP) *in the direction of the satellite* as:

$$EIRP_{UL}|_{dB} = P_{PM}|_{dB} + G_{UL}|_{dB}$$

where:

- P_{PM} is the *uplink transmitter* ~~measured~~ power ~~level at the power meter~~,
- G_{UL} is the gain of the *uplink* transmitting chain path from the *output of the transmitter* ~~power meter~~ to the output of the transmitting antenna (including coupler losses) *in the direction of the satellite*~~,~~*. This could be found from the radiation pattern of the uplink antenna, if known.*

c) compute the Input Power Flux Density Uplink ($IPFD_{UL}$) at the satellite as:

~~$$IPFD_{UL}|_{dB} = EIRP_{UL}|_{dB} - SF|_{dB} + G_{ATM}^{UL}|_{dB} + G_{ASPECT}^{UL}|_{dB} + G_{POL}^{UL}|_{dB}$$~~

$$IPFD_{UL}|_{dB_m/m^2} = EIRP_{UL}|_{dB_m} - SF|_{dB/m^2} + G_{ATM}^{UL}|_{dB}$$

where:

- $EIRP_{UL}$ is computed above,
- SF is the signal spreading factor:

$$SF = 10log\left(\frac{1}{4\pi R^2}\right)$$

- G_{ATM}^{UL} is the atmospheric loss expressed as a negative gain for the uplink path, as defined in Annex B,
- ~~G_{ASPECT}^{UL} is the gain correction to take into account the actual satellite on-board antenna gain in the beacon direction. G_{ASPECT}^{DL} is expressed as a gain relative to the in-axis gain of the on-board antenna. It can be derived from the knowledge of the radiation pattern of the *receiver* antenna on-board the satellite (measured during ground tests), the satellite pointing direction and the beacon-to-satellite geometry at the time of the test,~~
- ~~$G_{POL}^{UL}|_{dB}$ uplink polarization losses[1] expressed as a negative gain.~~

d) compute ~~GS~~ G_S *satellite* repeater gain as:

~~$$G_S|_{dB} = EIRP_{DL}|_{dB} - IPFD_{UL}|_{dB} - XS_I|_{dB}$$~~

$$G_S|_{dB} = EIRP_{DL}|_{dB_m} - P_{in}|_{dB_m}$$

---

[1] Note that if *the* UHF ground transmitting antenna and the L-band ground receiving antenna match satellite antennas polarization this parameter can be neglected.

[2] *Satellite maximum EIRP (boresight) can be derived from the EIRP in the direction of the ground station calculated above and the knowledge of the space-to--ground antenna geometry to compensate for the variations in antenna gains.*

~~where XS_I is the isotropic cross section at the uplink frequency, which converts incident flux to received power level:~~
where:

- P_{in} *is the power into the satellite receiver antenna (in boresight conditions)*[3]*:*

$$P_{in} = IPFD_{UL}|_{dB_m/m^2} + Ae + G_{POL}^{UL}|_{dB}$$

- $EIRP_{DL}|_{dBm}$ *is the satellite downlink EIRP (in boresight conditions*[4]*):*

$$G_S|_{dB} = EIRP_{DL}|_{dB_m} - IPFD_{UL}|_{dB_m/m^2} - A_e - G_{POL}^{UP}|_{dB}$$

where:

  - A_e *is effective aperture:*

$$A_e = XS_I + G_r$$

  with:

    - XS_I *is the isotropic cross section at the uplink frequency:*

$$XS_I = 10\,log\left(\frac{\lambda^2}{4\pi}\right)$$

    where λ is the uplink wavelength *(at satellite UHF antenna),*

    - G_r *is the gain of the satellite onboard receiver antenna in the direction of the uplink transmitter which can be determined from the radiation pattern of the antenna*[5]*,*

  - $G_{POL}^{UL}\big|_{dB}$ *is uplink polarization losses expressed as a negative gain.*

3.2 Translation ~~*and Downlink Tramsitter*~~ Frequency

3.2.1 Objective

The objective of this test ~~The test~~ is ~~aimed~~ to measure the *frequency translation between uplink and downlink frequencies* ~~downlink frequency at which an uplink 406 MHz SAR distress signal is translated by SART local oscillators~~ *implemented by the SARR payload.* The values measured will be compared with the requirements reported in the payload description.

3.2.2 Procedure

The measurement system transmits a CW test carrier signal to the satellite and then measures the return carrier to earth station. The frequency of the downlink carrier is measured by a SA ~~in gated frequency counter mode. The frequency measurement result is time tagged as accurately as possible to the centre~~

[3] *If P_{in} is not available in boresight conditions, satellite-to-ground station geometry should be provided.*
[4] *If the downlink EIRP is not available in boresight conditions, satellite-to-ground station geometry should be provided.*
[5] *If the gain is not available in in the direction of the uplink transmitter, satellite-to-ground station geometry should be provided.*

~~of the gate time~~. Translation frequency is the difference between uplink and downlink frequencies. According to satellite ephemeris, uplink and downlink frequencies have to be corrected for Doppler shift.

3.3 SARR G/T

3.3.1 Objective

~~This test aims to measure the SARR gain-to-noise temperature ratio. The results are to be compared with the requirement in payload description.~~*The objective of this test is to measure the 406 MHz SARR receiver antenna gain-to-noise temperature ratio (G/T). The measured value will be compared with the level specified in document C/S T.016.*

3.3.2 Procedure

~~The measurement equipment transmits a CW test carrier to the satellite and then measures the return carrier at earth station. The carrier power is measured with a*n* SA and then the system noise temperature is measured, still on the SA, and corrected for system background noise.~~
~~The procedure is the following:~~

~~a) measure N_{0SYS} system background noise with *an* SA (e.g., pointing receiver antenna away from MEOSAR *satellite under test* being sure not to have stellar sources in the field of view),~~

~~b) measure C carrier *CW test carrier* power received with *an* SA in spectrum mode,~~

~~c) measure *N_{0SYS} (receiving system noise) and* N_{0TOT} total noise power *density* measured in a 1 Hz reference bandwidth,~~

~~d) compute N_{0SAT} as:~~

$$N_{0SAT} = N_{0TOT} + N_{0SYS}$$

~~e) compute uplink power incident on the satellite as $IPFD_{UL}$ + *Ae*XS_I, as described in section 3.1.2,~~

~~f) compute G/T as:~~

$$\left.\frac{G}{T}\right|_{dB} = \left.\frac{C}{N_{0SAT}}\right|_{dB} + k|_{dB} - PinIPFD_{UL}|_{dB} - XS_I|_{dB}$$

~~where k is Boltzmann's constant (-228.6 dB_W/K/Hz).~~

The on-orbit G/T in dB/K can be derived by using the following equation:

$$\frac{G}{T} = \frac{C}{N_0}(up) - EIRP(up)\Big|_{dB_m} - G_{FSL}|_{dB} - G_{ATM}^{UP}|_{dB} - G_{POL}^{UP}|_{dB} + k$$

where:

- $\frac{C}{N_0}(up)$ *is the carrier to noise density ratio in the SAR repeater (dBHz),*
- *EIRP(up) is the known up-link EIRP (dB_m),*
- *G_{FSL} is the uplink free space path loss (dB),*
- $G_{ATM}^{UP}|_{dB}$ *is the uplink negative valued atmospheric gain,*

- *G_{POL}^{UP} is the polarisation mismatch negative valued gain between the uplink antenna and the satellite receive antenna (dB),*
- *k is the Boltzmann's constant (-198.6 dB_m/Hz-K).*

$C/N_0(up)$ is calculated from the overall $C/N_0(total)$ measured at the ground test facility by subtracting out the ground station receiver noise. The N_0 (total) observed at the ground station consists of two parts: $N_0(total) = N_0(up) + N_0(gs)$ where $N_0(gs)$ is the ground station receiver noise. $N_0(gs)$ can be measured by pointing the ground station antenna away from the MEOSAR spacecraft but not in the beam width of stellar sources emitting high radio frequency energy levels.

The general procedure is as follows:

a) *Uplink a known CW EIRP (≥ 40 dB_m) in a non operational channel of the 406 MHz band.*
b) *Monitor the received signal using a spectrum analyser. This can be done after demodulation and/or filtering to baseband. Adjust ground station antenna azimuth and elevation to maximise the received level. Set analyser resolution bandwidth such that C/N(total) ≥ 20 dB. Measure values of $C/N_0(total)$, C, and $N_0(total)$. The noise spectral density values can be measured directly using the spectrum analyser if it has an automatic noise density measuring feature. If not, the noise power, N(total) measured in the analyser resolution bandwidth can be converted to $N_o(total)$ by applying the bandwidth correction plus any other correction factors specified for the analyser.*
c) *Adjust the ground station antenna pointing such that it points away from the MEOSAR satellite under test by at least 15° but not in the field of view (FOV) of stellar sources emitting high radio frequency energy levels. Measure the clear sky ground station receiver noise, $N_0(gs)$.*
d) *Compute $N_0(up) = N_0(total) - N_0(gs)$ and use the value to determine $C/N_0(up)$ (convert as needed between numerics and dB).*
e) *Derive G/T with the equation above.*

3.4 Axial Ratio (Optional)

3.4.1 Objective

The objective of this test is to measure the axial ratio of the satellite L-band transmit antenna, by means of a rotatory linearly polarized L-band receiving antenna at *the* measurement station.

3.4.2 Procedure

A CW carrier in the 406 MHz band of suitable EIRP is uplinked to the satellite and the satellite downlink EIRP is computed as described in section 3.1.2. Next, the receiving antenna is rotated through a predetermined angle (e.g., a 10° step) and the satellite EIRP is measured again. These measurement steps are repeated until the receiving antenna has been turned by 180° or preferably 360°.

The axial ratio is derived by reconstructing the EIRP ellipse and finding its major and minor axes (i.e., maximum and minimum EIRP) *using interpolation or curve fitting between data points as required* ~~by approximating portions of the ellipse by a parabola determined via a linear system solver~~. The axial ratio is then determined as the difference (ratio) between the maximum and minimum computed EIRP.

3.5 ~~Amplitude Transfer Function in ALC Mode~~ *SARR Dynamic Range in AGC Mode*

3.5.1 Objective

The *objective of this* test ~~goal~~is to determine the SAR*R*~~payload gain transfer function~~ *dynamic range in AGC mode*.

3.5.2 Procedure

~~The procedure is the following:~~

a) ~~set the transmitting power so that IPFD is equal to the minimum value foreseen for the satellite,~~

b) ~~compute $IPFD_{UL}$ at satellite as described in section 3.1.2,~~

c) ~~from $IPFD_{UL}$ compute P_{IN} power at SART input as:~~

$$P_{IN}|_{dB} = IPFD_{UL}|_{dB} + 10\log\left(\frac{\lambda^2}{4\pi}\right) + G_{RX}|_{dB} - L_{RX}|_{dB}$$

~~where:~~

- ~~λ is the UHF signal wavelength (at satellite UHF antenna),~~
- ~~G_{RX} is the UHF receiving antenna gain at line of sight,~~
- ~~L_{RX} are the cable losses between the receiving antenna and the SAR transponder,~~

d) ~~compute $EIRP_{DL}$ (satellite EIRP) as described in section 3.1.2,~~

e) ~~from $EIRP_{DL}$ compute P_{OUT} power at SART output as:~~

$$P_{OUT}|_{dB} = EIRP_{DL}|_{dB} - G_{TX}|_{dB} + L_{TX}|_{dB}$$

~~where:~~

- ~~G_{TX} is the L-band transmitting antenna gain at line of sight,~~
- ~~L_{TX} are the cable losses between the SAR transponder and the transmitting antenna,~~

f) ~~repeat bullets 1 to 3 for increasing transmitting power until IPFD is equal to the maximum value foreseen for the satellite.~~

~~The plot of P_{OUT} vs. P_{IN} is the SAR payload gain curve.~~
The dynamic range is a measure of the transponder output power versus transponder input power. This procedure uses unmodulated carrier signals only. The uplink signal EIRP is varied in level over the dynamic range of the SAR receiver, from near input noise to the maximum signal into the transponder at the threshold of triggering the AGC function. The resulting downlink carrier level, C_d,

is measured using a spectrum analyzer. In a plot of transponder output power versus input power, the dynamic range is the linear part of the curve before the AGC is triggered.

The general procedure is as follows:

a) *Begin with no uplink. Monitor the downlink to ensure that no active beacons or interference signals are present.*

b) *Establish a CW uplink signal at a frequency near mid-band and an EIRP of 5 Watts. Observe this signal on the downlink using the spectrum analyzer. Increase the uplink signal level to the point where the observed downlink signal, C_d, does not continue to increase, i.e., the AGC is operating at the upper limit of the dynamic range. Record the uplink EIRP, the value of the measured downlink signal and the SAR receiver N_0 (measured a few kHz away from C_d using the spectrum analyzer). The downlink should be free of interference when making these measurements.*

c) *Decrement the CW uplink signal in 1 dB steps; monitor the downlink to ensure that there is no interference present and record the measured values of C_d, N_0 and the uplink EIRP. Continue to reduce the uplink signal by 1 dB and make the measurements until C_d approaches the receiver noise level.*

d) *The range of uplink EIRP from where the AGC starts to operate down to where C_d approaches the receiver noise level is the SARR transponder dynamic range in AGC mode. This can be confirmed if required by calculating transponder input power and output power pairs based on transmitted EIRP and received C_d, plotting those power pairs in numeric form, and confirming a linear plot. This test should be done rapidly to minimize change in satellite-to-ground geometry*.

3.6 ~~Frequency Response~~*Channel Bandwidth and Amplitude Ripple*

3.6.1 Objective

~~This test is aimed to compute SAR payload frequency response (both in-band and out-of-band); this will also allow to measure the effective SART bandwidth, as well as in-band ripple.~~*The objective of this test is to measure the downlink channel bandwidth and amplitude ripple in the MEOSAR repeater channel. The test must be performed for each channel bandwidth mode of operation intended for service (narrowband/wideband, fixed gain mode and AGC mode).*

3.6.2 Procedure

~~The test signal synthesizer has to produce CW signals for different frequencies; start/stop frequency and frequency step are under operator control. From end-to-end response, and from the uplink and downlink response, the payload response can be derived. SA measurements of satellite signal are delayed by the round trip transmit time with respect to the transmit frequency step timing.~~

~~Test has to be performed when SARR is set both in normal bandwidth and narrow bandwidth, if applicable.~~*This test can be conducted as a passive test without uplink signal (preferrable if possible) or as an active test with uplink CW signals.*

In the passive case, the level of 406 MHz beacon signals received at the spacecraft is sufficiently small such that under normal situations a band of white noise generated by the payload LNA is transmitted on the channel. The amplitude ripple of the channel can be estimated by observing this band of noise power using the ground test facility equipment. The observation should be done during a "quiet" period, i.e., no interference or the appearance of large test signals.

The procedure steps are the following:

a) *With the spacecraft in the narrowband fixed gain mode if applicable, monitor the downlink signal in the ground station receiver IF ahead of any filtering that would corrupt the channel measurement. The analyser centre frequency, resolution bandwidth and span should be adjusted to appropriately display the channel data.*

b) *Take a spectrum plot during a quiet period.*

c) *Estimate the amplitude ripple from the plot.*

d) *Use the spectrum analyser offset markers to identify the 3-dB bandwidth. Record the measurement for the test report.*

e) *Repeat steps a through d for the other possible modes as applicable narrowband AGC, wideband fixed gain, wideband AGC.*

If finding a "quiet period" is problematic, as an alternative, an active uplink swept frequency test can be used. In this active case, repeatedly uplink to the payload a CW signal at constant EIRP (e.g., 37 dB_m EIRP) and capture the resulting downlink baseband spectral plot noting the CW C/N_0. Start the uplink CW near the lower end of the 406 MHz SAR band, and increment the frequency of each repeated CW signal toward the upper end of the 406 MHz SAR band. Merge the spectral plots resulting from each uplinked CW signal into a single spectral plot. From the merged spectral plot, estimate the amplitude ripple from the envelope of baseband CW magnitude, and determine the 3-dB channel bandwidth of the repeater. This test should be done rapidly to minimize change in satellite-to-ground geometry.

3.7 Linearity/Third Order Intermodulation

3.7.1 Objective

~~This test aims to compute the payload C/I3. Obtained values have to be compared with the ones in the payload description.~~*The objective of this test is to detect and measure intermodulation products that might be produced by two large in-band test signals in the 406 MHz SARR frequency band.*

3.7.2 Procedure

~~Two matched level test signals (CW carriers) at 1 kHz separation shall be applied at the transponder input. Each test signal, S_{in}, must be 7 dB above total receiver noise level for modes with ALC ON. In order to ensure uplink linearity, the first and third order uplink intermodulation products resulting from the two signals are measured.~~

~~The downlink signal, containing both uplink and satellite generated intermodulation products, is measured with SA.~~

~~The measurements are made at increasing power levels; at the end downlink measured, C/I_3 is corrected for uplink C/I_3 in order to have satellite C/I_3 range. This range is small as long as the measurement station uplink chain is operating linearly when satellite approaches saturation.~~

~~This test is performed with the SAR repeater in ALC gain mode.~~
For testing in-band intermodulation products, two strong uplink carriers are simultaneously transmitted from the test ground station to the 406 MHz SARR receiver. All tests are performed with the receivers in the AGC mode, using a nominal channel frequency of 406.050 MHz. The in-band uplink frequencies are as follows:

- f_1 *= nominal channel frequency - 1 kHz,*
- f_2 *= nominal channel frequency + 1 kHz.*

When intermodulation products are generated, the third order intermodulation products are generally the strongest and occur at $2f_1$-f_2 *and* $2f_2$-f_1. *If* f_1 *equals nominal frequency minus 1 kHz and* f_2 *equals nominal frequency plus 1 kHz, then the third order intermodulation products would be at the nominal frequency -3 kHz and at the nominal frequency +3 kHz. Therefore, for a receive system with a 70 MHz IF frequency the (IF) frequencies to search in order to detect any third order intermodulation products are as follows:*

	Nominal Channel	*Lower intermodulation product*	*Upper intermodulation product*
Channel	*Frequency (MHz)*	*Frequency (MHz)*	*Frequency (MHz)*
406.05 MHz	*70*	*69.997*	*70.003*

The uplink EIRP for each test signal should be strong enough to produce intermodulation products in the satellite receiver, but not too strong to cause any damage to the satellite receive system. One way to do this is to transmit each test signal at an EIRP of $7dB_W$, *and then increase the uplink EIRP until intermodulation products are seen on the downlink spectrum. Increments in the uplink EIRP can be made as long as the combined uplink signal power into the satellite receiver payload remains 6 dB below the receiver input power upper limit.*

In order to avoid intermodulation products from the test ground station test system itself, separate transmitter chains are used for the two uplink signals.

As a consequence of running this test, harmonic products may also be detected in the 406 MHz SARR frequency band and reported.

3.8 SARR *Downlink* EIRP

3.8.1 Objective

~~This~~ *The objective of this* test *is* ~~aims~~ to compute SARR maximum/minimum *downlink* EIRP, and to compare results with payload description.

3.8.2 Procedure

~~The satellite EIRP can be computed following the procedure described in section 3.1.2.~~ *This test should be conducted as a passive test without uplink test signal, for each operational mode of the satellite payload.*

Choose a high elevation satellite pass (e.g., 60 degrees or more), and monitor the satellite downlink signal using a spectrum analyser. Set the resolution bandwidth (RBW) value of the analyser to the satellite payload downlink 3 dB bandwidth frequency range (f_R) (e.g., 100 kHz) as per document C/S T.016. Consider (f_C) the centre frequency of the satellite downlink band. Set the analyser frequency measurement span at least from f_C - 1.5f_R to f_C + 1.5f_R, such that the analyser will sweep completely across the downlink frequency range.

From time of start of test to end of test, capture at least 50 spectral plot snapshots equally spaced in time. The test should last long enough to capture the minimum and maximum EIRP values over a pass.

For each spectral plot snapshot:

a) *Measure the peak power (P_{SA}) captured by the spectrum analyser which should occur approximately at the downlink centre frequency (possibly plus or minus small Doppler shift).*

b) *Calculate the downlink EIRP using the equation provided in section 3.1.2 (a).*

c) *If the radiation pattern of the satellite downlink antenna is known, adjust the calculated downlink EIRP to the value that would be transmitted if the satellite was passing directly over the test facility ground station.*

Plot all downlink EIRP values (indicating whether they have been adjusted as above or not) on a graph. Report the graph, and maximum and minimum EIRP values from the graph. Report the geometry of the pass (e.g., elevation angles at the beginning and end of the measurement period, and at maximum).

Alternate procedures may be possible (such as to use fixed tune mode with zero span for the spectrum analyzer), and some experimentation with detailed procedures and analyser settings by the tester may be required.

3.9 Transponder Group Delay Variation *as a Function of* ~~in~~ Frequency

3.9.1 Objective

~~This~~ *The objective of this* test *is* ~~aims~~ to compute transponder group delay variation *as a function of* ~~in~~ frequency.

3.9.2 Procedure

The forward group delay of SAR*R payload* ~~transponder~~ is measured using the modulation envelope delay model. The frequency modulated uplink signal is generated by a signal synthesizer. The earth station group delay is calibrated out at the time of the measurement by switching between satellite signal and signal loopback through the Test Loop Translation, that upconverts the signal from the 406-MHz band to L-band (or S-band). Both over-the-satellite and loopback calibration measurement are performed with the same SA signal captured in IQ sampling mode.

Measured modulation data points are converted to a delay given the range to the satellite at the time of each data minus the one-way trip delay to the satellite (i.e., where the satellite was for the corresponding signal when it arrived at the SA).

Transponder delay is computed as follows:

$$RoundTripDelay = \frac{R_{BEACON}}{c} + \frac{R_{MEOLUT}}{c} + IonosphereCorrUHF + IonosphereCorrLSband + 2TroposphereCorr$$

$$RoundTripDelayPhaseShift = 360RoundTripDelay * F_m$$

$$TransponderPhaseShiftRaw = -\left(MeasuredPhaseShift - LoopbackPhaseShift - RoundtripdelayPhaseshift\right)$$

$$TransponderPhaseShift = MOD(TransponderPhaseShiftRaw, 360)$$ (in the range 0-360 degrees)

$$TransponderDelay = \frac{TransponderPhaseShift}{360}\frac{1}{Fm} + DelayCorrection$$

where:

- R_{BEACON} and R_{MEOLUT} are satellite ranges w.r.t. the beacon and the MEOLUT, respectively,
- F_m is modulation frequency,
- MeasuredPhaseShift is the signal phase measured for the downlink signal,
- LoopbackPhaseShift is the signal phase measured for the loopback path,

- DelayCorrection is a correction due to the slight difference in path between the loopback and the RF signal paths,
- $IonosphereCorrUHF$ and $IonosphereCorrLSband$ are ionospheric delays correction that have to be computed and taken into account. The measurement of ionospheric delay requires a double frequency GNSS receiver tracking the satellite under test: the computation of ionospheric delay is as follows:

$$IonosphereCorr(f_t) = \frac{f_1^2 f_2^2 (\rho_2 - \rho_1)}{(f_1^2 - f_2^2) f_t^2}$$

where:

- ρ_1 and ρ_2 are the ranging measurement provided by the receiver from frequency f_1 and f_2 respectively,
- f_1 and f_2 are the two frequencies of the two ranging signals,
- f_t is the frequency for which the ionospheric correction is calculated.

Measurement of the group delay variation *as a function of* ~~in~~ frequency can be performed repeating the previous procedure at different uplink frequencies (within the 406-406.1 MHz UHF band) or comparing the 406.05 MHz group delay with the one at the other frequencies.

The commissioning authority will provide data on measurement accuracy in the commissioning report.

3.10 Spurious Output Levels

3.10.1 Objective

~~This test is aimed to measure the spurious levels in the MEOSAR selected band.~~*The objective of this test is to determine the frequency and level of any in band spurious signals within the SARR bandwidth.*

3.10.2 Procedure

~~The test is performed qualitatively monitoring the SAR spectrum with SA: if significant spurii are highlighted, the spectrum will be recorded for further power level assessments. In order to determine the -1 dB, -3 dB and -20 dB bandwidths, the following [TBC 100 kHz, 300 kHz, 1 MHz and 10 GHz] span, [TBD] averaging and [TBD] resolution bandwidth shall be used.~~

~~This test should be performed with SAR payload powered OFF (allows to measure N_0 down) and then SAR payload ON (allows to measure N_{tot}).~~*This test must be performed for all operational modes of the satellite payload.*

This test is passive without an uplink signal. Spurious signals within the repeater bandwidth can be monitored in the baseband spectrum using a spectrum analyser. These measurements should be made as accurately as possible; therefore, they should be made with as small a resolution bandwidth as practical (e.g., 100 Hz).

Care must be exercised in identifying spurious signals generated by on-board equipment. To that end, if possible, monitor the spectrum prior to turning on the SARR payload. The spurious signals originating on board will in general not vary much in frequency due to the slow motion of the MEOSAR satellite (e.g., ± 1300 Hz). However, terrestrially emitted spurious signals in the 406 MHz band may also appear and will need to be disregarded.

It may be necessary to take several spectrum plots over a number of days to identify on-board spurious signals from terrestrial emitters. The test personnel can also ask for assistance from MEOLUT operators in identifying terrestrial emitters. The MEOSAR spacecraft can be used to identify these terrestrial spurious signals due to their Doppler shift at the MEOSAR spacecraft.

The frequency and magnitude of any in-band spurious signal can be read using the spectrum analyser. The magnitude of the onboard spurious signal can be referred back to the payload using a link budget calculation.

Finally, a comparison between spectra received from the spacecraft with reference spectra from the ground receiving system should be used to discriminate between suspected spacecraft generated onboard spurious signals and locally generated signals by the test receiver system on the ground. The receiving system reference spectrum must be taken with the ground station antenna not pointing at any spacecraft.

3.11 Beacon Signal Processing

3.11.1 Objective

The *objective*~~purpose~~ of this test is to demonstrate that 406 MHz beacon signals relayed through the MEOSAR *satellite* repeater can be properly *incorporated into the processing of*~~processed by~~ a MEOLUT with sufficient reliability for distribution within the Cospas-Sarsat network. *This test is also useful for trend analysis overtime and does not have a pass/fail criterion.*

This test is intended to be performed using FGB signals. In addition, testing may also be performed using SGB signals.

3.11.2 Procedure

Beacon *simulator* output signals at specific *transmitter power* levels*, or EIRP levels if a directional antenna is used,* will be transmitted to the MEOSAR satellite and relayed to a MEOLUT *tracking the payload* for reception and processing. *The results are compiled based on the MEOLUT processing of a single channel corresponding to the payload under test.* ~~The test requires therefore a MEOLUT operator located in the coverage area and a beacon simulator or a reference beacon with a nominal transmit power level.~~

The following procedures should be used:

- ~~ensure the beacon(s)is located within the coverage area of the MEOLUT used for the test,~~*ensure that the beacon simulator to be used for the test is located within the satellite footprint of the satellite as it is being tracked by the MEOLUT used for the test.*
- *for the first generation beacon case,* select a frequency channel to avoid as much as possible interference with operational channels.~~,~~
- ~~transmit a minimum of 200 bursts at a minimum of five second intervals at four transmit power levels into the antenna (nominally 37, 32, 27 and 22 dBm, with an accuracy of ± [1] dB). The antenna pattern, the start and stop time of the test, and the transmitter location information shall be provided. If a directional antenna is used, the transmit EIRP levels shall be 37, 32, 27 and 22 dBm, with an accuracy of ± [1] dB.~~
- *transmit a minimum of 100 bursts at each of four transmitter power levels into the antenna (nominally 39, 37, 32, and 27 dBm, with an accuracy of ± [1] dB). If a directional antenna is used, the transmit EIRP levels should be 39, 37, 32, and 27 dBm, with an accuracy of ± [1] dB based on the antenna vendor radiation pattern specification. The bursts at each power level should be repeated at intervals of every 20 seconds and the bursts between power levels should be interleaved with a 5-second interval, from highest to lowest power level. This script will produce a total of 400 bursts. The antenna pattern (e.g., as published by the vendor, or measured in an anechoic chamber), the start and stop time of the test, and the transmitter location information shall be provided. For the purpose of trend analysis each execution of this procedure should be done during the same portion of the satellite pass used in previous tests (to the best extent possible).*
- ~~determine the overall C/N_0 distribution,~~
- for each transmitted burst, collect ~~all~~ *the* received burst~~s~~ at the MEOLUT *from the satellite under test* and capture the *associated* C/~~No~~ *N_0* value~~ and report the transmitted power level into the antenna or EIRP of each received burst~~.

For each transmitted power level *(or EIRP level)*:

- determine *and plot in a histogram and/or a cumulative distribution of* the *received burst* C/N_0 ~~distribution~~*values*,
- compile the lists of all messages produced and determine the number of valid~~/incomplete~~ messages (NV~~I~~M) and*, optionally, the number of* complete messages (NCM),
- determine the number of transmitted bursts (NTB) that should have been received.

Compute the single satellite channel throughput (~~(~~NV~~I~~M~~+NCM~~)/NTB) and the average C/N*$_0$*~~o~~ *for each transmit power level or EIRP* and compare the results with ~~expected~~ *typical* values.

Optionally, compute the single satellite channel throughput for complete messages (NCM/NTB) and the average C/N_0 for each transmit power level or EIRP.

If this test is with SGB signals, the test procedure should be the same using the same transmit power levels (or EIRP levels), but only valid messages should be considering, as the complete/incomplete message category do not apply for SGBs.

- END OF SECTION 3 -

4. MEOSAR SPACE SEGMENT *PARAMETER* ASSESEMENT COMPLIANCE INDICATORS ~~*AND RECOMMENDAED ROUTINE MONITORING TESTS*~~

Assessment Indicator		Compliance Level Reference			
		GPS (S-band / L-band)	GALILEO	GLONASS	BDS
Translation Frequency		S-band: C/S T.016, Table 3.1 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
Translation Frequency stability (if available)		S-band: C/S T.016 Table 3.1 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
G/T		S-band: C/S T.016, Table 3.1 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
Axial Ratio (optional)		L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
Amplitude Transfer Function in AGC mode		S-band: C/S T.016, Table 3.1 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
1 dB bandwidth in Narrowband Mode		(2)	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
1 dB bandwidth in Normal Band Mode		S-band: C/S T.016, Table 3.1 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
Third Order Intermodulation Level		S-band: C/S T.016, Table 3.2 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
EIRP		S-band: C/S T.016, Table 3.2 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
Forward Group Delay Slope		S-band: C/S T.016, Table 3.1 L-band: TBD	C/S T.016, Table 4.3[1]	C/S T.016, Table 5.2	C/S T.016, Table 6.2
Repeater Transmit Emission Mask		TBD	TBD	TBD	TBD
Beacon Signal Processing[3]	Single channel valid message detection probability	No compliance level reference applicable			
	Average C/N_0	No compliance level reference applicable			

Table 4.1: MEOSAR Space Segment Assessment Indicators / Compliance Levels

Notes:

(1) Refer to the "Interoperability Requirement" column of C/S T.016, Table 4.3
(2) S-band satellites do not have a narrow band mode; availability of L-band narrow mode TBD
(3) See document C/S T.017, section 3.11
TBD: To Be Defined

	Recommended Routine Monitoring Tests **Assessment Indicator**	**Compliance Level Reference**
1	Routine monitoring of alert message detection from system and test beacons	Test 3.11
2	Routine monitoring of localisation of system and test beacons and determining errors	[TBD]
3	Routine monitoring of downlink for signal strength	[TBD]
4	Routine monitoring of downlink for spectral occupancy and spurs	[TBD]
5	Determine G/T of satellite (requires uplink signal-done yearly)	[TBD]
6	Determine translation frequency (requires uplink signal-done yearly)	[TBD]

Table 4.2: MEOSAR Space Segment Routine Monitoring

- END OF SECTION 4 -

5. MEOSAR SATELLITE ~~IOC~~ STATUS COMMUNICATION

~~Should the test results confirm that the payload satisfies IOC requirements, the commissioning authority shall distribute the information identified below throughout the Cospas-Sarsat system using a SIT 605 message. Items not tested must be so noted as comments in the SIT 605 message.~~

~~[Example of SIT 605 message to be sent to inform MCCs of MEOSAR satellite IOC status~~

```
FROM FMCC
TO ALL MCC
SUBJ: COSPAS/SARSAT MEOSAR-EQUIPPED SATELLITE COMMISSIONING

A.  OBJECTIVE: SATELLITE XXX COMMISSIONING
B.  COMMISSIONING AUTHORITY: EC/GSA

C.  SATELLITE DETAILS:
        - COSPAS/SARSAT SATELLITE ID: 419
        - SATELLITE NAME: GSAT0103
        - SATELLITE ORBIT: MEO
        - LAUNCH DATE (day/month/year): DD/MM/YYYY

D.  STATUS: PAYLOAD COMMISSIONED AT [IOC/FOC/LOC] STATUS

E.  SINCE (day/month/year): DD/MM/YYYY

F.  SAR PAYLOAD STATUS AT COMMISSIONING:
            - SART STATUS: ON
            - SART MODE: ALC
            - SART BW: 90 KHZ
            - OPERATIONAL LIMITATIONS (IF ANY OR NONE):

G.  ADDITIONAL INFORMATION:
    - AVAILABLE AT WWW.COSPAS-SARSAT.INT
    - THIS SATELLITE SUPPORTS THE SAR/GALILEO RETURN LINK SERVICE
    - …

H.  REMARKS:  NONE
```

~~]~~

~~1. IOC Mode~~

~~The spacecraft will be operated in the following IOC mode:~~

~~Channel Bandwidth:~~	~~WB or NB (where applicable)~~
~~Gain Mode:~~	~~ALC or FGM (where applicable)~~
~~Operational Limitations:~~	
~~Commissioning Authority:~~	~~Date:~~

5.1 MEOSAR Satellite Status Communication

Once the commissioning tests are conducted, the commissioning authority shall communicate the MEOSAR satellite operational status for it to be used for operation by the Ground Segment Operators as per Figure 2.1. After the communication of the satellite commissioning status defined in this section, changes in MEOSAR payload status shall be notified to all Ground Segment Operators as defined in document C/S A.001.

5.1.1 MEOSAR Satellite IOC Communication

Should the results of the commissioning tests conducted by the commissioning authority confirm that the payload performance does not adversely affects the SAR operations, the commissioning authority may inform Ground Segment Operators that the payload could now be used for initial operation by declaring its IOC status. Table 5.3 should provide sufficient results to offer assurance that the payload could be used safely.

To communicate the IOC status of the payload, the commissioning authority shall distribute the information identified in sections 5.2.1 *and* 5.2.2*, as available, throughout the System using a SIT 605 message. This will allow the early operational use of the satellite and will inform MEOLUT operators that their MEOLUT(s) can now process and distribute distress signal alerts relayed from the MEOSAR payload while the commissioning report is in preparation. Items not tested during the commissioning tests must be so noted as comments in the SIT 605 message. An example of a SIT 605 message declaring a MEOSAR satellite IOC status is provided at section* 5.3*.*

5.1.2 MEOSAR Satellite FOC Communication

Should the commissioning test results allow the commissioning authority to declare the FOC status of the MEOSAR satellite, the commissioning authority shall distribute the information contained in the commissioning report as identified in sections 5.2.1 *and* 5.2.2 *throughout the C/S System using a SIT 605 message to allow the full operational use of the satellite by MEOLUT operators and MCCs. An example of a SIT 605 message declaring a MEOSAR satellite FOC status is provided at section* 5.3*.*

5.1.3 MEOSAR Satellite LOC Communication

Should the MEOSAR payload be declared with a LOC status (see section 2.3), the commissioning authority shall distribute the information contained in the commissioning report as identified in sections 5.2.1 *and* 5.2.2*, including the limitations identified, throughout the System using a SIT 605 message to allow the operational use of the satellite by MEOLUT operators and MCCs. An example of a SIT 605 message declaring a MEOSAR satellite LOC status is provided at section* 5.3.

5.2 MEOSAR Satellite Information

5.2.1 Satellite Status and Mode Information

Table 5.1 *provides the satellite status information to be provided throughout the System.*

Payload Status:	*IOC, FOC or LOC*
Initial operational configuration	
Channel Bandwidth:	*WB or NB (where applicable)*
Gain Mode:	*AGC or FGM (where applicable)*
Operational Limitations:	
Other Remarks:	
Commissioning Authority:	*Date:*

Table* 5.1*: Satellite Status Information

Table 5.2 *provides the information regarding the commissioned payload modes to be provided throughout the System (only applicable to satellite FOC or LOC status communication).*

Spacecraft ID:	*Date:*	
Mode	*Commissioning Status (FOC, LOC, Not Operational)*	*Comments (e.g., initial operation mode)*
NB/FGM		
NB/AGC		
WB/FGM		
WB/AGC		

Table* 5.2*: Commissioned Payload Modes

5.2.2 Commissioning Test Results Summary

Table 5.3 *provides the technical information to be provided to MEOLUT operators throughout the System.*

Spacecraft ID:		Date:	
Test	Results	Pass/fail	Comments
3.1 SAR Repeater Gain			
3.2 Translation frequency			
3.3 SARR G/T			
3.4 Axial ratio (optional)			
3.5 SARR Dynamic Range in AGC Mode			
3.6 Channel Bandwidth and Amplitude Ripple			
3.7 Linearity/Third Order Intermodulation			
3.8 SARR Downlink EIRP			
3.9 Transponder Group Delay Variation as a Function of Frequency			
3.10 Spurious Output Levels			
3.11 Beacon Signal Processing		n/a	

Table 5.3: Commissioning Test Results Summary

5.3 Example of SIT 605 Communication for MEOSAR Satellite Commissioning Status

An example of SIT 605 message to be sent to inform MCCs of MEOSAR satellite IOC, FOC or LOC status is provided in Table 5.4.

FROM FMCC
TO ALL MCC
SUBJ: COSPAS-SARSAT MEOSAR-EQUIPPED SATELLITE COMMISSIONING

A. OBJECTIVE: SATELLITE GALILEO 436 COMMISSIONING

B. COMMISSIONING AUTHORITY: EC/GSA

C. SATELLITE DETAILS:
- COSPAS/SARSAT SATELLITE ID: 436
- SATELLITE NAME: GSAT0219
- SATELLITE ORBIT: MEO
- LAUNCH DATE (DD/MM/YYYY): 25/07/2018

D. STATUS: PAYLOAD COMMISSIONED AT [IOC/FOC/LOC] STATUS

E. SINCE (DD/MM/YYYY): DD/MM/YYYY

F. CURRENT SAR PAYLOAD MODE:
- SART STATUS: ON

- SARR~~T~~ BW: 90 KHZ
- SARR~~T~~ MODE: AGC ~~ALC~~
- OPERATIONAL LIMITATIONS (IF ANY OR NONE): NONE

G. COMMISSIONED MODES [FOR FOC OR LOC COMMUNICATION, AS APPLICABLE]

CONFIGURATION	PASS/FAIL	STATUS	COMMENTS
NB/FGM	PASS	OPERATIONAL	
NB/AGC	PASS	OPERATIONAL	INITIAL OPERATION MODE
WB/FGM	PASS	OPERATIONAL	
WB/AGC	PASS	OPERATIONAL	

H. REMARKS
[E.G., LOC LIMITATIONS IF ANY]

I. TEST RESULTS

TEST	RESULT	PASS/FAIL	COMMENTS
3.1 SARR GAIN	174.65 DB	PASS	
3.2 TRANSLATION FREQUENCY	1138.049998 MHZ	PASS	
3.3 SARR G/T	-11.71 DB/K	PASS	AT CENTER OF COVERAGE
3.4 AXIAL RATIO (OPTIONAL)	0.71 DB	PASS	IOT TEST
3.5 SARR DYNAMIC RANGE IN AGC MODE		PASS	
3.6 CHANNEL BANDWIDTH AND AMPLITUDE RIPPLE		PASS	
3.7 LINEARITY/THIRD ORDER INTERMODULATION	> 29.32 DBC	PASS	
3.8 SARR EIRP	19.5 DBW	PASS	AT CENTER OF COVERAGE
3.9 TRANSPONDER GROUP DELAY VARIATION AS A FUNCTION OF FREQUENCY	< 10 µs/4kHz	PASS	
3.10 SPURIOUS OUTPUT LEVEL	NONE	PASS	
3.11 BEACON SIGNAL PROCESSING	>95%	N/A	AT 37 DBM OF BEACON POWER

J. ADDITIONAL INFORMATION:
- AVAILABLE AT WWW.COSPAS-SARSAT.INT
- THIS SATELLITE SUPPORTS THE SAR/GALILEO RETURN LINK SERVICE
- ...

Table 5.4: Example of SIT 605 Message for Initial Status Communication of MEOSAR Satellite

- END OF SECTION 5 -

6. MEOSAR SATELLITE COMMISSIONING REPORT

~~Should the test results confirm that the MEOSAR payload satisfies commissioning requirements, the commissioning authority shall distribute the information contained in the commissioning report as identified below throughout the Cospas-Sarsat system using a SIT 605 message.~~

~~1. Test Results~~

~~Spacecraft ID:~~		~~Date:~~	
~~Test~~	~~Results~~	~~Pass/fail~~	~~Comments~~
~~3.1 SARR Gain~~			
~~3.2 Translation Frequency~~			
~~3.3 SARR G/T~~			
~~3.4 Axial ratio (optional)~~			
~~3.5 Amplitude Transfer Function in ALC mode~~			
~~3.6 Frequency Response~~			
~~3.7 Linearity/Third Order Intermodulation~~			
~~3.8 SARR EIRP~~			
~~3.9 Forward Group Delay variation in frequency~~			
~~3.10 Spurious Output Level~~			
~~3.11 Beacon Signal Processing~~			

~~Note: Graphics and supplementary data may be provided as attachments to this report and provided to the Cospas-Sarsat Secretariat for permanent retention.~~

~~Spacecraft ID:~~		~~Date:~~	
~~Configuration~~	~~Pass/Fail~~	~~Operational, Not Operational, Limited Operation~~	~~Comments~~
~~NB/FGM~~			~~Gain setting:~~
~~NB/ALC~~			
~~WB/FGM~~			~~Gain setting:~~
~~WB/ALC~~			

~~Payload Status:~~ ~~FOC or LOC~~

~~Initial operational configuration~~

~~The spacecraft will initially be operated in the following mode:~~

~~Channel Bandwidth:~~ ~~WB or NB (where applicable)~~

~~Gain Mode:~~ ~~ALC or FGM (where applicable)~~

~~Operational Limitations:~~

~~Other Remarks:~~

~~Commissioning Authority:~~ ~~Date:~~

As mentioned in previous sections, upon completion of all tests, the commissioning authority will evaluate the assessment indicators and prepare a commissioning report. Such a report shall include the results of the tests along with a description of the test objectives and procedures for each test conducted sufficient to allow interpretation of the data.

Although there is no required structure for a commissioning report, it is recommended that the report include:

a) a description with schematic diagram of the test set-up equipment used including signal generators, uplink and/or beacon simulator transmitter antenna(s) (geographical position, gain and polarization), ground station receiving antenna (geographical position, G/T and polarization), signal analysers, and MEOLUT ID, as appropriate.

b) a summary table that consolidates the results and indicates whether each particular result is consistent with the expectations of space segment provider.

c) a detailed description of test results and conclusions made by the commissioning authority with charts, spectrograms, formulas etc, as necessary (it is expected that each test result interpretation will be described to such extent that its clearly understood how the conclusion was drawn by the commissioning authority).

To support the use of the commissioned MEOSAR satellite by the System, the following information should be provided in the report:

a) reference to a website providing orbital elements for the satellite, for use in case navigation data ephemerids are not available to MEOLUTs,

b) confirmation of the availability of SIT217 messages to the Ground Segment.

- END OF SECTION 6 -

ANNEX~~S~~ TO DOCUMENT C/S T.017

COSPAS-SARSAT MEOSAR SPACE SEGMENT COMMISSIONING STANDARD

~~ANNEX A~~

~~LIST OF ACRONYMS~~

~~AGC~~	~~automatic gain control~~
~~ALC~~	~~automatic level control~~
~~BW~~	~~bandwidth~~
~~C/I~~	~~carrier-to-interference~~
~~C/N~~	~~carrier-to-noise power ratio~~
~~C/N_0~~	~~carrier-to-noise density ratio~~
~~CW~~	~~continuous wave~~
~~dB~~	~~decibel~~
~~dBHz~~	~~decibel relative to one Hertz~~
~~dBm~~	~~decibel above one milliwatt~~
~~dB_W~~	~~decibel above one Watt~~
~~EIRP~~	~~equivalent isotropically radiated power~~
~~EOC~~	~~edge of coverage~~
~~FG/FGM~~	~~fixed gain/fixed gain mode~~
~~FOC~~	~~full operational capability~~
~~G~~	~~gain~~
~~GEOSAR~~	~~geostationary earth orbit satellite system for search and rescue~~
~~G_S~~	~~*satellite* repeater gain~~
~~G/T~~	~~gain-to-noise temperature~~
~~IOC~~	~~initial operational capability~~
~~IPFD~~	~~input power flux density~~
~~IQ~~	~~in-phase and quadrature~~
~~f_c~~	~~carrier *centre* frequency~~
~~F_m~~	~~frequency modulation~~
~~FOC~~	~~full operational capability~~
~~L~~	~~loss~~
~~LOC~~	~~local *limited* operational capability~~

~~MCC~~	~~mission coordination centre~~
~~MEOLUT~~	~~LUT in a MEOSAR system~~
~~MEOSAR~~	~~medium earth orbit satellite system for search and rescue~~
~~NB~~	~~narrowband~~
~~NVIM~~	~~number of valid incomplete messages~~
~~NCM~~	~~number of complete messages~~
~~NTB~~	~~number of transmitted bursts~~
~~P~~	~~power~~
~~R~~	~~range~~
~~RF~~	~~radiofrequency~~
~~SF~~	~~signal spreading factor~~
~~SA~~	~~spectrum analyzer~~
~~SAR~~	~~search and rescue~~
~~SARR~~	~~SAR repeater~~
~~SARTUHF~~	~~SAR Transponder UHF~~
~~WB~~	~~wideband~~
~~XS~~	~~cross section~~

~~- END OF ANNEX A -~~

~~ANNEX B~~*ANNEX A*

ATMOSPHERIC ATTENUATION COMPUTATION

In this annex*, an atmospheric attenuation algorithm is presented which comes from data presented in ITU-R P.676-11.*~~the atmospheric attenuation computation algorithm is presented; this is the same as presented in ITU-R P.676-6 15, therefore only the equations will be presented.~~

The algorithm is considered valid for satellite elevation between 5° and 90°.

The total zenith values in dB/km includes both dry air attenuation and water vapor attenuation which are as follows for standard atmosphere conditions:

Standard atmospheric conditions for ground level (sea level) water vapor pressure are P_0- 7.5 g/m^{3,} for temperature T=300.4222 K, and total atmospheric pressure is 1013.25 hPa.

From ITU-R P.676-11, Figure 5, the specific attenuation in dB/km is:

- *406 MHz: dry air =0.004, water vapor =0.000008, total L_{zenith} is 0.004008,*
- *L band: dry air=0.006, water vapor = 0.000017, total L_{zenith} is 0.00617,*
- *S band: dry air = 0.007, water vapor = 0.00005, total L_{zenith} is 0.00705.*

The inputs required *for sea level heights and standard atmospheric conditions* are:

- *The satellite w.r.t reference beacon elevation E_r (measure in radians),*
- The satellite w.r.t. station elevation E_a (measured in radians)*,*~~;~~
- ~~The signal frequency f_a [GHz]~~
- ~~The atmospheric temperature t_a [°C], to be measured with weather station;~~
- ~~The atmospheric pressure p_a [hPa], to be measured with weather station;~~
- ~~The water-vapour density pressure V_a [kg/m^2], to be measured with weather station.~~
- *H_{tropo} is the height of the troposphere, which ITU assumes to be 10 km from sea level.*

The uplink and downlink atmospheric attenuation values are then:

- *$G^{UL}{}_{ATM}=L_{zenith} * H_{tropo} * cosecant(E_r)$,*
- *$G^{DL}{}_{ATM}={}^{Lzenith} * H_{tropo} * cosecant(E_a)$.*

For non-standard atmospheric conditions or reference beacons or MEOLUT stations not located at sea level, need to compute T and water vapor pressure (from ITU-R P.835) as a function of heights of the reference beacon and MEOLUT station.

~~Equations to compute the atmospheric attenuation A are given in sequence:~~

~~1.~~

$$r_p(p) = \frac{p}{1013}$$

~~2.~~

$$r_t(t) = \frac{288}{273 + t}$$

~~3.~~

$$t_1(p,f) = \frac{4.64}{1 + 0.066 r_p(p)^{-2.3}} exp\left[-\left(\frac{f - 59.7}{2.87 + 12.4 exp\left(-7.9 r_p(p)\right)}\right)^2\right]$$

~~4.~~

$$t_2(p,f) = \frac{4.640.14 exp\left(2.12 r_p(p)\right)}{(f - 118.75)^2 + 0.031 exp\left(2.2 r_p(p)\right)}$$

~~5.~~

$$t_3(p,f) = \frac{0.0114}{1 + 0.14 r_p(p)^{-2.6}} f \frac{-0.0247 + 0.0001 f + 1.61 f^2 10^{-6}}{1 - 0.0169 f + 4.1 f^2 10^{-5} + 3.2 f^3 10^{-7}}$$

~~6.~~

$$h_o(p,f) = \frac{6.1}{1 + 0.17 r_p^{-1.1}}\left[1 + t_1(p,f) + t_2(p,f) + t_3(p,f)\right]$$

~~7.~~

$$\varphi\left(r_p, r_t, a, b, c, d\right) = r_p^a r_t^b exp\left[c\left(1 - r_p\right) + d\left(1 - r_t\right)\right]$$

~~8.~~

$$\xi_1(p,t) = \varphi\left(r_p(p), r_t(t), 0.0717, -1.8132, 0.0156, -1.6515\right)$$

~~9.~~

$$\xi_2(p,t) = \varphi\left(r_p(p), r_t(t), 0.5146, -4.6368, -0.1921, -5.7416\right)$$

~~10.~~

$$\xi_3(p,t) = \varphi\left(r_p(p), r_t(t), 0.2705, -2.7192, -0.3016, -4.1033\right)$$

~~11.~~

$$\gamma_o(p,t,f) = \left[\frac{7.2 r_t(t)^{2.8}}{f^2 + 0.34 r_p(p)^2 r_t(t)^{1.6}} + \frac{0.62 \xi_3(p,t)}{(54 - f)^{1.1 \xi_1(p,t)} + 0.83 \xi_2(p,t)}\right] f^2 r_p(p)^2 10^{-3}$$

~~12.~~

$$A_O(p,t,f) = h_o(p,f)\gamma_o(p,t,f)$$

13.

$$g(f,f_i) = 1 + \left(\frac{f - f_i}{f + f_i}\right)^2$$

14.

$$\eta_1(p,t,\rho) = 0.955 r_p(p) r_t(t)^{0.68} + 0.006\rho$$

15.

$$\eta_2(p,t,\rho) = 0.735 r_p(p) r_t(t)^{0.5} + 0.0353 r_t(t)^4 \rho$$

16.

$$\gamma_w(p,t,\rho,f) = \left\{\frac{3.98\eta_1(p,t,\rho)exp\left[2.23\left(1 - r_t(t)\right)\right]}{(f-22.235)^2 + 9.42\eta_1(p,t,\rho)^2} g(f,22) + \frac{11.96\eta_1(p,t,\rho)exp\left[0.7\left(1 - r_t(t)\right)\right]}{(f-183.31)^2 + 11.14\eta_1(p,t,\rho)^2} + \frac{0.081\eta_1(p,t,\rho)exp\left[6.44\left(1 - r_t(t)\right)\right]}{(f-321.226)^2 + 6.29\eta_1(p,t,\rho)^2} + \frac{3.66\eta_1(p,t,\rho)exp\left[1.6\left(1 - r_t(t)\right)\right]}{(f-325.153)^2 + 9.22\eta_1(p,t,\rho)^2} + \frac{25.37\eta_1(p,t,\rho)exp\left[1.09\left(1 - r_t(t)\right)\right]}{(f-380)^2} + \frac{17.4\eta_1(p,t,\rho)exp\left[1.46\left(1 - r_t(t)\right)\right]}{(f-448)^2} + \frac{844.6\eta_1(p,t,\rho)exp\left[0.17\left(1 - r_t(t)\right)\right]}{(f-557)^2} g(f,557) + \frac{290\eta_1(p,t,\rho)exp\left[0.41\left(1 - r_t(t)\right)\right]}{(f-752)^2} g(f,752) + \frac{8.3328\eta_2(p,t,\rho)exp\left[0.99\left(1 - r_t(t)\right)\right]10^4}{(f-1780)^2} g(f,1780)\right\} f^2 r_t(t)^{2.5} \rho 10^{-4}$$

17.

$$t_{ref}(V) = 14 ln\left(\frac{0.22V}{4}\right) + 3$$

18.

$$\rho_{ref}(V) = \frac{V}{4}$$

19.

$$A_W(V,E,f) = \frac{0.0173V}{sin(E)} \frac{\gamma_w\left(780, t_{ref}(V), \rho_{ref}(V), f\right)}{\gamma_w\left(780, t_{ref}(V), \rho_{ref}(V), 20.6\right)}$$

~~Atmospheric Attenuation *A* [dB] is given by:~~

$$A = \frac{A_O(p_a, t_a, f_a) + A_W(V_a, E_a, f_a)}{sin(E_a)}$$

- END OF ANNEX ~~B~~*A* -

- END OF DOCUMENT -

Cospas-Sarsat Secretariat
1250 Boul. René-Lévesque West, Suite 4215, Montreal (Quebec) H3B 4W8 Canada
Telephone: +1 514 500 7999 / Fax: +1 514 500 7996
Email: mail@cospas-sarsat.int
Website: www.cospas-sarsat.int