COSPAS-SARSAT MEOSAR SPACE SEGMENT COMMISSIONING STANDARD

C/S T.017

Issue 1 – Revision 2

December 2015

COSPAS-SARSAT MEOSAR SPACE SEGMENT COMMISSIONING STANDARD

HISTORY

Issue	Revision	Date	Comments
1	-	October 2013	Approved by the Cospas-Sarsat Council (CSC-51)
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1	2	December 2015	Approved by the Cospas-Sarsat Council (CSC-55)

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1. INTRODUCTION

1.1 Purpose

This document is aiming to present 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 (commissioning) and routine monitoring. The basic responsibilities, specific tests to be performed, and test methodologies are defined by this document.

1.2.1 IOT – Commissioning

Initial on-orbit tests 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.

If results of the initial on-orbit tests confirm that values for assessment indicators are within accepted thresholds, 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, but are not intended to be specific test procedures. It is the responsibility of the commissioning authority to develop test procedures that are traceable to the methods described in this document.

1.2.2 Routine Monitoring

After initiation of MEOSAR operations, the space segment operator conducts routine monitoring of the on-orbit payload performance using telemetry and other means as deemed necessary. Routine monitoring will include tests identified as routine monitoring tests in section 4. 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

Cospas-Sarsat 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

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 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 procedures unique to the satellite and test facility for conducting tests on the MEOSAR payload. Such procedures shall be traceable to the methods described in this document. Alternate methods can be considered but must be described in detail with the test result documentation provided with the commissioning report. In addition, other Participants may perform tests on the MEOSAR payload. However, these tests shall conform to the methods described herein and the test procedures 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 Cospas-Sarsat 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 report. 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 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 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. The information to be included in the SIT 605 IOC message is detailed at section 5. Once declared, IOC status shall remain in effect until commissioning is completed.

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 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 report shall be distributed by the MCC associated with the commissioning authority to all MCCs in the Cospas-Sarsat system using a SIT 605 message issued on behalf of the commissioning authority.

The commissioning authority shall submit the commissioning report to the Cospas-Sarsat Joint Committee for review and subsequent approval by the Cospas-Sarsat Council.

The commissioning authority shall provide a copy of the commissioning report to the Cospas-Sarsat Secretariat for permanent retention. The Secretariat will provide copies of the report to Cospas-Sarsat Participants upon request.

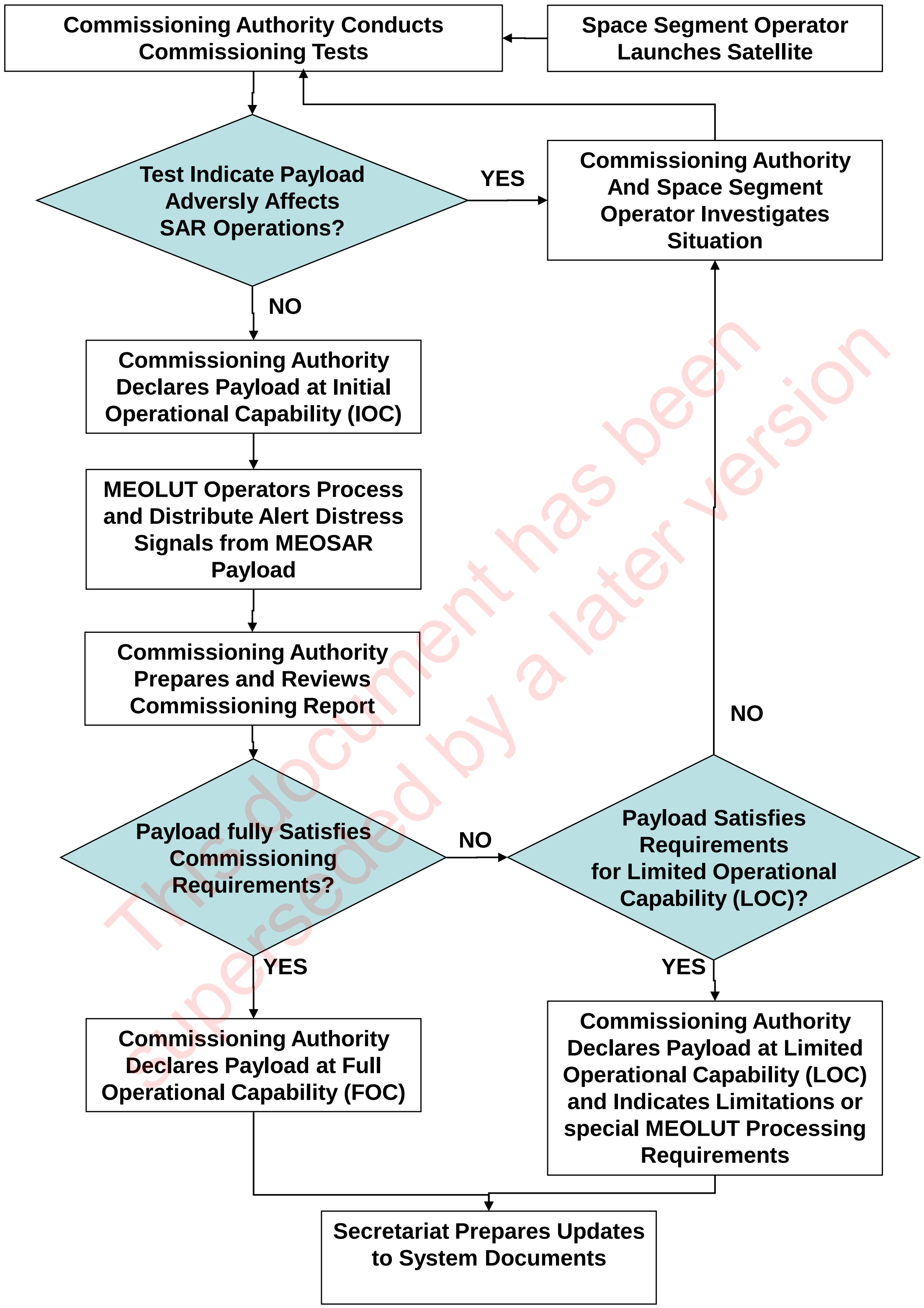

Figure 2.1: MEOSAR Payload Commissioning Procedure

2.4 Satellite System Data

In order for Cospas-Sarsat to operate the MEOSAR instruments at an IOC, LOC or FOC status, the MEOSAR space segment operator shall provide Cospas-Sarsat the satellite/payload information necessary for conducting daily operations. Examples of such data are SARR status on/off, gain control mode AGC/FG, selected band mode Normal/Narrow band, nominal downlink frequency.

2.5 Routine Monitoring

Performed by:

- space segment operator, monitoring satellite telemetry,
- MEOLUTs 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 performs 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 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 Cospas-Sarsat.

2.7 Space Segment Problem Reporting and Investigation Procedures

Any space segment, MEOLUT or MCC operator that detects anomalies of a MEOSAR 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.

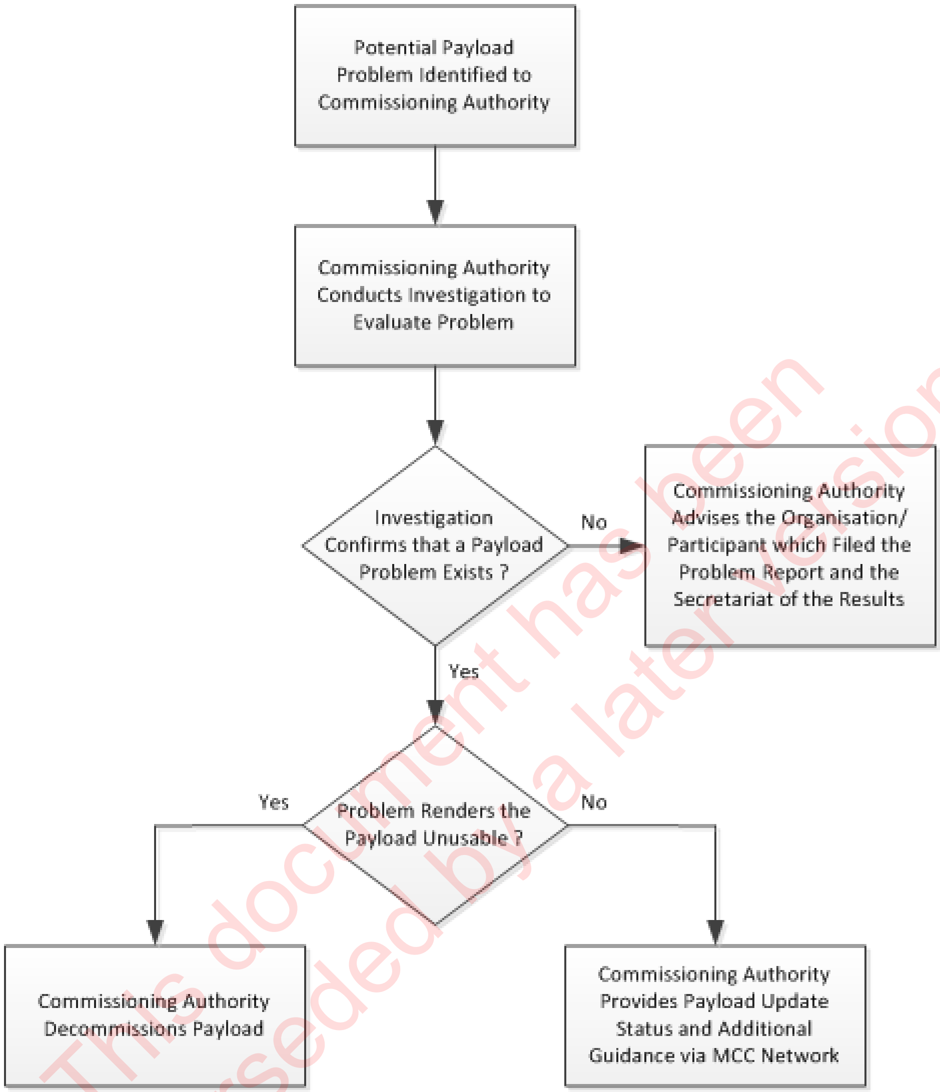

Figure 2.2: MEOSAR Problem Reporting and Investigation Procedures

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.

3.1 SAR Repeater Gain

3.1.1 Objective

The objective of this test is to measure the SARR gain including UHF receiver antenna, SARR and L-band transmitting antenna.

3.1.2 Procedure

The SARR can be stimulated, in any operational mode, with a CW UHF signal generated by a signal generator. Then the satellite gain can be computed measuring:

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

The procedure steps are the following:

a) compute $EIRP_{DL}$ (satellite EIRP) as:

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

where:

- P_{SA} is the measured power level at the spectrum analyser (SA),
- G_{DL} is the gain of the receiver chain path from the receiver antenna (including antenna gain) to the SA (the test setup must ensure the stability of this term during the test),
- G_{PROP} is the propagation gain:

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

  where R is the 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.

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

b) compute $EIRP_{UL}$ (uplink EIRP) as:

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

where:

- P_{PM} is the measured power level at the power meter,
- G_{UL} is the gain of the transmitting chain path from the power meter to the output of the transmitting antenna (including coupler losses),

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

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

where:

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

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

- 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 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,
- $G_{POL}^{UL}\big|_{dB}$ - uplink polarization losses[1] expressed as a negative gain.

d) compute GS repeater gain as:

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

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

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

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

where λ is the uplink wavelength.

3.2 Translation Frequency

3.2.1 Objective

The test is aimed to measure the downlink frequency at which an uplink 406 MHz SAR distress signal is translated by SART local oscillators. 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 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.

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 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 SA (e.g., pointing receiver antenna away from MEOSAR being sure not to have stellar sources in the field of view),

b) measure C carrier power received with SA in spectrum mode,

c) measure N_{0TOT} total noise power 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 $IPFD_{UL}$ + XS_I, as described in section 3.1.2,

f) compute G/T as:

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

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

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 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) 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

3.5.1 Objective

The test goal is to determine the SAR payload gain transfer function.

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:

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

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.

3.6 Frequency Response

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.

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.

3.7 Linearity/Third Order Intermodulation

3.7.1 Objective

This test aims to compute the payload C/I_3. Obtained values have to be compared with the ones in the payload description.

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.

3.8 SARR EIRP

3.8.1 Objective

This test aims to compute SARR maximum/minimum 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.

3.9 Transponder Group Delay Variation in Frequency

3.9.1 Objective

This test aims to compute transponder group delay variation in frequency.

3.9.2 Procedure

The forward group delay of SAR 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:

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

$$RoundTripDelayPhaseShift = 360RoundTripDelay * Fm$$

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

$$TransponderPhaseShift = MOD(TransponderPhaseShiftRaw, 360)$$ (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,
- Fm 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 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.

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}).

3.11 Beacon Signal Processing

3.11.1 Objective

The purpose of this test is to demonstrate that 406 MHz beacon signals relayed through the MEOSAR repeater can be properly processed by a MEOLUT with sufficient reliability for distribution within the Cospas-Sarsat network.

3.11.2 Procedure

Beacon output signals at specific levels will be transmitted to the MEOSAR and relayed to a MEOLUT for reception and processing. 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 operational radius of the MEOLUT used for the test,
- 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). If a

directional antenna is used, the transmit power levels shall be in terms of EIRP (at the same four levels).

- determine the threshold to an accuracy of ± [2] dB
- for each transmitted burst, collect all received bursts at the MEOLUT and capture the C/No value and report the transmitted power level into the antenna and EIRP of each received burst,
- compile the lists of all messages produced and determine the number of valid/incomplete messages (NVIM) and complete messages (NCM),
- determine the number of transmitted bursts (NTB) that should have been received.

Compute the single satellite channel throughput ((NVIM+NCM)/NTB) and the average C/No and compare the results with expected values.

- END OF SECTION 3 -

4. MEOSAR SPACE SEGMENT ASSESMENT COMPLIANCE INDICATORS

Assessment Indicator	Compliance Level Reference
Translation Frequency	C/S T.016, Annex B
Translation Frequency stability (if available)	C/S T.016, Annex B
G/T	C/S T.016, Annex B
Axial Ratio (optional)	C/S T.016, Annex B
Amplitude Transfer Function in AGC mode	C/S T.016, Annex B
1 dB bandwidth in Narrowband Mode	C/S T.016, Annex B
1 dB bandwidth in Normal band Mode	C/S T.016, Annex B
Third Order Intermodulation Level	C/S T.016, Annex B
EIRP	C/S T.016, Annex B
Forward Group Delay Slope	C/S T.016, Annex B
SAR Transmit Emission Mask	C/S T.016, Annex B
Single channel valid message detection probability	C/S T.016, Annex A

Table 4.1: MEOSAR Space Segment Assessment Indicators / Compliance Levels

Assessment Indicator	Compliance Level Reference
Routine monitoring of alert message detection from system and test beacons	Test 3.11
Routine monitoring of localisation of system and test beacons and determining errors	[TBD]
Routine monitoring of downlink for signal strength	[TBD]
Routine monitoring of downlink for spectral occupancy and spurs	[TBD]
Determine G/T of satellite (requires uplink signal-done yearly)	[TBD]
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.

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.

2. 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:

- 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.

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:

- END OF SECTION 6 -

ANNEXES 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/No	carrier-to-noise density ratio
CW	continuous wave
dB	decibel
dBHz	decibel relative to one Hertz
dBm	decibel above one milliwatt
dBW	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
GS	repeater gain
G/T	gain-to-noise temperature
IOC	initial operational capability
IPFD	input power flux density
IQ	in-phase and quadrature
fc	carrier frequency
Fm	frequency modulation
FOC	full operational capability
L	loss
LOC	local 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 message
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

ATMOSPHERIC ATTENUATION COMPUTATION

In this annex 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 inputs required are:

- 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.

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.

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

7.

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

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.

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

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 -

- END OF DOCUMENT -

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