
COSPAS-SARSAT MEOSAR SPACE SEGMENT COMMISSIONING STANDARD

C/S T-017

Issue 1

October 2013



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COSPAS-SARSAT MEOSAR SPACE SEGMENT
COMMISSIONING STANDARD

HISTORY

<u>Issue</u>	<u>Revision</u>	<u>Date</u>	<u>Comments</u>
1	-	October 2013	Approved by the Cospas-Sarsat Council (CSC-51)

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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. 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

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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	USA
SAR/Glonass	Russia	Russia

Table 2.1: MEOSAR Commissioning Authorities Definition

2.2 Initial On-Orbit Tests

The payload parameters are defined in the following sections: IOT will provide set of baseline values for the defined parameters, to be compared with pre-launch values to determine if in orbit operation is nominal at launch.

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.

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 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.

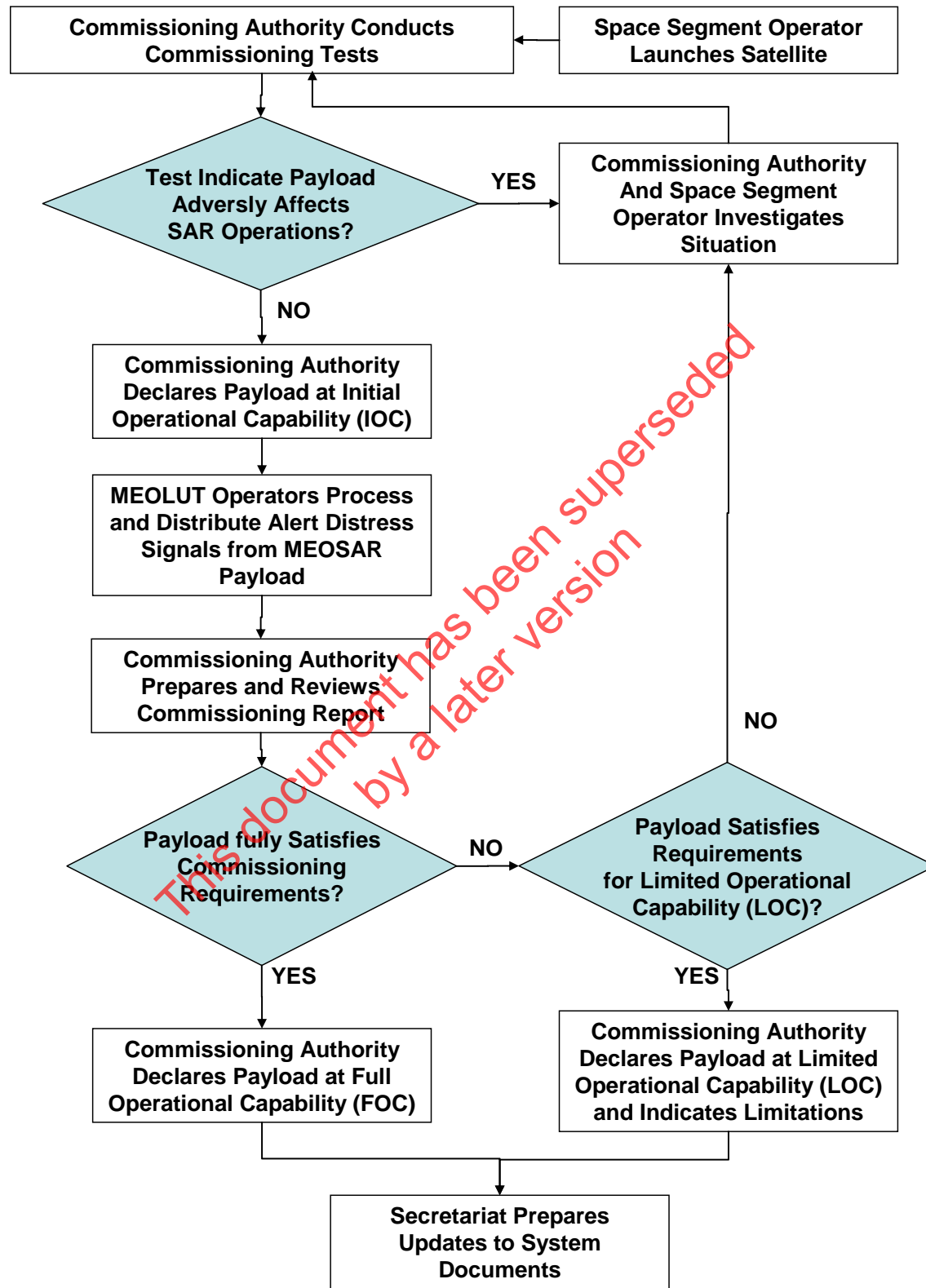


Figure 2.1: MEOSAR Payload Commissioning Procedure

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.

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 -

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3. MEOSAR SPACE SEGMENT TESTING

The recommended tests for MEOSAR commissioning are presented in this section. Please note that, in order to consider as negligible the polarization losses, both UHF ground transmitting antenna and the L-Band ground receiving antenna will be circularly polarized in order to match satellite antennas polarization.

3.1 SAR Repeater Gain

3.1.1 Objective

The objective of this test is to measure the SARR gain including UHF receiver antenna, SART 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 satellite gain can be computed measuring:

- transmitted EIRP (measured with a RF power meter),
- power received by satellite (measured with a spectrum analyser).

The procedure steps are the following:

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

$$EIRP_{DL} = P_{SA} - G_{DL} - G_{PROP} - G_{ATM} - G_{ASPECT}$$

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 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} is the atmospheric loss expressed as a negative gain,
- G_{ASPECT} is the antenna pattern aspect correction to boresight to reference pattern,

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

$$EIRP_{UL} = P_{PM} + G_{UL}$$

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:

$$IPFD_{UL} = EIRP_{UL} - SF + G_{ATM} + G_{ASPECT}$$

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} is the atmospheric loss expressed as a negative gain,
- G_{ASPECT} is the antenna pattern aspect correction to boresight to reference pattern,

d) compute GS repeater gain as:

$$G_S = EIRP_{DE} - IPFD_{UL} - XS_I$$

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 center 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 $IPFD_{UL} + XS_1$, as described in section 3.2.1,
- f) compute G/T as:

$$\frac{G}{T} = \frac{C}{N_{0SAT}} + k - IPFD_{UL} + XS_1$$

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

3.4 Axial Ratio (Optional)

3.4.1 Objective

This test is aimed to measure the satellite transmit antenna axial ratio, by mean of a linearly polarized rotatory horn L-band antenna at measurement station.

3.4.2 Procedure

A CW carrier is uplinked and the satellite EIRP is computed (as described in section 3.2.1) continuously while rotating the horn antenna. The difference between the maximum and minimum computed EIRP is the axial ratio.

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 3.2.1,
- c) from $IPFD_{UL}$ compute P_{IN} power at SART input as:

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

where:

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

- d) compute $EIRP_{DL}$ (satellite EIRP) as described in section 3.2.1,
- e) from $EIRP_{DL}$ compute P_{OUT} power at SART output as:

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

where:

- G_{TX} is the L-Band transmitting antenna gain,
- 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.

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. Measurement is performed for transit power level response, downlink gain response and end-to end response. Satellite frequency response is then computed correcting the end-to-end response for the uplink and downlink chains responses. 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

The signal synthesizer has to generate two carriers matched in level; 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.

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 for a full satellite pass.

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 UHF to L-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:

$$RoundTripDelay = 2 \frac{R}{c} + IonosphereCorrUHF + IonosphereCorrLband + 2TropospherCorr$$

$$RoundTripDelayPhaseShift = 360 \frac{RoundTripDelay}{Fm}$$

$$TransponderPhaseShiftRaw = - \left(MeasuredPhaseShift - \right. \\ \left. - LoopbackPhaseShift - RoundTripDelayPhaseShift \right)$$

$$TransponderPhaseShift = MOD(TransponderPhaseShiftRaw, 360) \text{ (in the range 0-360 degrees)}$$

$$TransponderrDelay = \frac{TransponderPhaseShift}{360} \frac{1}{Fm} + DealyCorrection$$

where:

- R is satellite range,
- 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.

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.

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 spuri are highlighted, the spectrum will be recorded for further power level assessments.

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 EIRP. Test procedure is derived from the similar T-1 (for single channel processing) test already foreseen for the MEOSAR D&E phase and described in document C/S R.018:

- ensure the beacon simulator 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 bursts at least five second intervals with an EIRP of 37 dBm (at least 1,400 TBC bursts have to be transmitted),
- for each transmitted burst, collect all received bursts at the MEOLUT and capture the C/No value 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.

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4. MEOSAR SPACE SEGMENT ASSESSMENT INDICATORS / COMPLIANCE LEVELS

Assessment Indicator	Compliance Level Reference
Translation Frequency	C/S R.012, Annex F
Translation Frequency stability (if available)	C/S R.012, Annex F
G/T	C/S R.012, Annex F
Axial Ratio (optional)	C/S R.012, Annex F
Amplitude Transfer Function in AGC mode	C/S R.012, Annex F
1 dB bandwidth in Narrowband Mode	C/S R.012, Annex F
1 dB bandwidth in Normal band Mode	C/S R.012, Annex F
Third Order Intermodulation Level	C/S R.012, Annex F
EIRP	C/S R.012, Annex F
Forward Group Delay Slope	C/S R.012, Annex F
SAR Transmit Emission Mask	C/S R.012, Annex F
Single channel valid message detection probability	C/S R.012, Annex E

Figure 4.1: MEOSAR Space Segment Assessment Indicators / Compliance Levels

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5. MEOSAR 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:

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6. MEOSAR 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:

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Cospas-Sarsat Secretariat
700 de la Gauchetière West, Suite 2450, Montreal (Quebec) H3B 5M2 Canada
Telephone: +1 514 954 6761 Fax: +1 514 954 6750
Email: mail@cospas-sarsat.int
Website: <http://www.cospas-sarsat.org>
