COSPAS-SARSAT 406-MHz MEOSAR SYSTEM DEMONSTRATION AND EVALUATION PHASE II REPORT

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COSPAS SARSAT

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HISTORY

Issue	Revision	Date	Comments
1	-	February 2018	Approved by the Cospas-Sarsat Council (CSC-59)

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DOCUMENT SUMMARY

This document provides the report of Phase II of the Cospas-Sarsat MEOSAR Demonstration and Evaluation (D&E), tests which were conducted from April 2014 to June 2015.

Section 1 provides background on the MEOSAR system and reference material.

Section 2 reviews the planning and conduct of the tests, noting the list of participants, MEOSAR space and ground assets configuration used during the tests and information of interest on the coordination of the tests.

Section 3 details, for each D&E technical test the key results and interpretations as provided by each test participant that contributed to this Report (Canada, France, Russia, Turkey and USA). The underlying sub-sections were provided under the responsibility of these administrations and, therefore, were not reviewed nor commonly agreed by the Phase II technical test participants.

Section 4 details, for each D&E operational test the key results and interpretations as provided by each test participant that contributed to this Report: France, Italy, Norway, Japan, Russia, Spain and USA. The underlying sub-sections were provided under the responsibility of these administrations and, therefore, were not reviewed nor commonly agreed by the Phase II operational test participants. Additionally, the following participants contributed with SAR Reports to the O-6 test: Argentina, Australia, Brazil, Italy, New Zealand and Norway.

Section 5 provides, for each test, the conclusions and recommendations agreed by the Phase II test participants, as well as general recommendations regarding the implementation of the MEOSAR system.

1. BACKGROUND

1.1 MEOSAR System Description

Figure 1 provides a graphical summary of the MEOSAR concept. This picture shows the relay of beacon signals, via multiple satellites, to the MEOLUT. Beacon data is processed by the MEOLUT to derive the beacon locations, and passed onto the MCC, which in turn notifies the RCC.

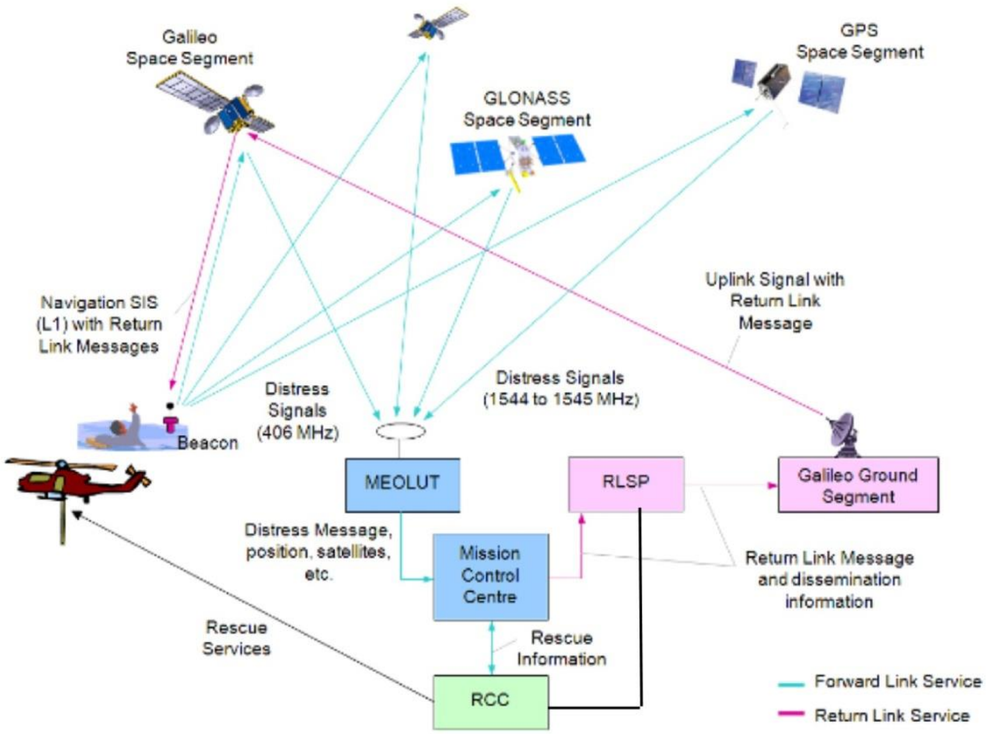


Figure 1: The MEOSAR System Concept

1.2 The Cospas-Sarsat MEOSAR Demonstration and Evaluation Plan

The Cospas-Sarsat Council (CSC) has directed that a demonstration and evaluation (D&E) be performed to confirm the expected capabilities and benefits of a satellite system in medium-altitude Earth orbit (MEO) that uses onboard repeater instruments to relay distress alert signals emanating from 406 MHz distress radiobeacons. The CSC further directed that the D&E should establish the technical and operational performance characteristics of the MEOSAR system.

The framework for the D&E of the MEOSAR system is provided in document C/S R.018 "Cospas-Sarsat Demonstration and Evaluation Plan for the 406 MHz MEOSAR System". In particular, documents provide guidelines for:

- conducting the D&E of the MEOSAR system in a standard manner among the participants,

- collecting a set of results from individual participants, using compatible formats, that can be consolidated into a final report for review by Cospas-Sarsat participants and other interested parties,
- analysing and translating the results into a set of recommendations for a decision by the Cospas-Sarsat Council to enter the Initial Operational Capability Phase.

Additional resources regarding the MEOSAR system (e.g., space segment information) are available in document C/S R.012 "Cospas-Sarsat 406 MHz MEOSAR Implementation Plan".

CSC-49 agreed to divide the MEOSAR D&E Phase into three phases:

- Phase I, during which the participants perform only technical tests,
- Phase II, during which the participants perform technical and operational tests,
- Phase III, during which the participants replicate the tests of the Phases I and II, when satellites with L-band downlinks are widely available.

1.3 The Phase II of the Cospas-Sarsat MEOSAR D&E

1.3.1 Objective of the D&E Phase II

In MEOSAR D&E Phase II, participants performed technical and operational tests (see the detailed definition in document C/S R.018) to characterise the technical and operational performance of the MEOSAR system. Due to the limited space segment available, some tests had to be coordinated and the processing be tuned accordingly, in particular capacity tests.

1.3.2 Report of the D&E Phase II

The D&E Phase II report was produced with inputs from the Phase II Test participants where some of the review and drafting work was achieved by a Correspondence Working Group with the support of the Secretariat, based on:

- the reports on the conduct of the technical and operational tests provided by the test coordinators (see Table 1 and Table 2),
- contributions from the technical test participants, which provided their interpretation of the test results (see section 3),
- contributions from the operational test participants, which provided their interpretation of the test results (see section 4),
- agreement among the participants on common conclusions and recommendation for the D&E Phase II (see section 5).

- END OF SECTION 1 -

2. CONDUCT OF PHASE II AND MEOSAR SYSTEM CONFIGURATION

2.1 Tests Conducted During the Phase II

Table 1 and Table 2 provides the list of technical and operational tests planned for the Phase II, respectively, their completeness status, the participants undertaking the role of test coordinator and the reference to the test reports written by the test coordinators. The detailed conduct of each test can be found in the test coordinator's reports. Figure 2 provides a Gantt chart of the D&E testing campaign.

Test	Definition	Run	Status	Test Coordinator
T-1	Processing Threshold and System Margin	1	Completed in February 2015	USA
T-2	Impact of Interference		Records available only for tests T-1, T-3 Run	Canada
T-3	Valid/Complete Message Acquisition	1	Completed in February and March 2015	France
T-4	Independent 2D Location Capability	1	Completed in March and April 2015	USA
T-5	Independent 2D Location Capability for Operational Beacons	-	Completed in March and April 2015	Turkey
T-6	MEOSAR System Capacity	1	Completed in June 2015	France
T-7	Networked MEOLUT Advantage	1	Completed in April and May 2015	USA
T-8	Combined MEO/GEO Operation Performance	-	Discarded	Turkey

Table 1: List of Technical Tests, Test Coordinators and Test Reports

Test	Definition	Test Coordinator	Test Report Reference
O-1	Potential Time Advantage	France	Section 4.3 of this report
O-2	Unique Detections by MEOSAR System as Compared to Existing System.	USA	Section 4.4 of this report
O-3	Volume of MEOSAR Distress Alert Traffic in the Cospas-Sarsat Ground Segment Network	Spain	JC-29/Inf 28
O-4	406 MHz Alert Data Distribution Procedures	USA	Section 4.6 of this report
O-5	SAR/Galileo Return Link Service	France (SGDSP)	Test O-5 has been postponed to Phase III
O-6	Evaluation of Direct and Indirect Benefits of the MEOSAR System	Australia	Section 4.8 of this report
O-7	MEOSAR Alert Data Distribution –Impact on Independent Location Accuracy	USA	Section 4.9 of this report

Table 2: List of Operational Tests, Test Coordinators and Test Reports

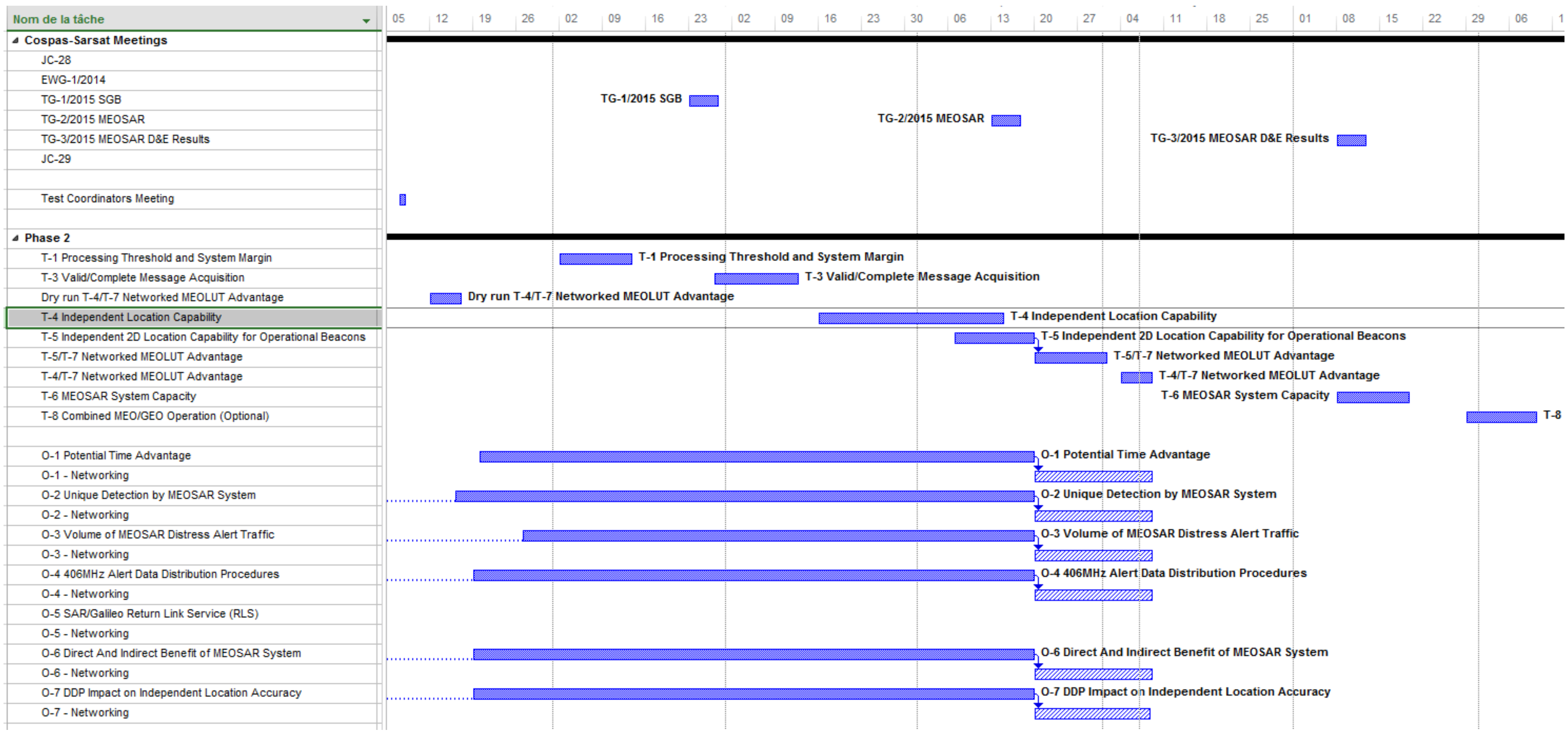


Figure 2: Phase II Test Planning (as Run)

2.2 Participants in the D&E Phase II

Table 3 provides the participants in each run of technical test, which provided at least raw data as per Table J.1 of document C/S R.018 or a technical test report. Some participants did not provide technical test results and/or technical test report. Table 3 also provides the test during which spectrum of the 406 MHz band was recorded. For test T-5, the participation in test T-5 is identified either in supplying test beacons or in involving MEOLUTs.

Test	Definition		Run	T-2: Impact of Interference (by Canada)	France	EC/France	Russia	Turkey	USA		
									Hawaii	Florida	Maryland
T-1	Processing Threshold and System Margin		1	X	X		X	X	X	X	X
T-3	Valid/Complete Message Acquisition		1	X	X		X	X	X	X	X
T-4	Independent 2D Location Capability		1		X		X	X	X	X	X
T-5	Independent 2D Location Capability for Operational Beacons	Test beacon	1		X			X	X	X	
		MEOLUT			X		X	X			X
T-6	MEOSAR System Capacity		1		X		X	X			X
T-4/T-7	Networked MEOLUT Advantage		1		X	X					X
T-5/T-7	Networked MEOLUT Advantage		1		X	X					X

Table 3: Participation in MEOSAR D&E Phase II Technical Tests

Table 4 provides the participants in each run of operational tests, which provided raw data using the O-test spreadsheet described in section 5 of document C/S R.018, or have provided reports to be included in the O-6 section.

Test	Definition	Period	Argentina	Australia	Brazil	France	Italy	Japan	New Zealand	Norway	Spain	USA
O-1	Potential Time Advantage	1										X
		2				X	X	X		X	X	X
O-2	Unique Detections by MEOSAR System as Compared to Existing System	1										X
		2				X	X	X		X	X	X
O-3	Volume of MEOSAR Distress Alert Traffic in the Cospas-Sarsat Ground Segment Network	1										X
		2				X	X	X		X	X	X
O-4	406 MHz Alert Data Distribution Procedures	1										X
		2				X	X					
O-5	SAR/Galileo Return Link Service	1										
		2										
O-6	Evaluation of Direct and Indirect Benefits of the MEOSAR System	1										
		2	X	X	X		X		X	X		
O-7	MEOSAR Alert Data Distribution – Impact on Independent Location Accuracy	1										X
		2				X						X

Table 4: Participation in MEOSAR D&E Phase II Operational Tests

2.3 Configuration of the D&E Phase II

2.3.1 Experimental Space Segment

Table 5 provides the list of experimental MEOSAR satellites available for testing during MEOSAR D&E Phase II.

MEOSAR Constellation	Satellite (C/S ID)	Satellite availability status for Phase I or launch date
DASS (GPS-II)	318	Available
	316	Available
	319	Available
	323	Available
	302	Available
	317	Available
	312	Available
	315	Available
	329	Available
	301	Available
	324	Available subsequent to launch on 4 October 2012
	327	Available subsequent to launch on 15 May 2013
	330	Available subsequent to launch on 21 February 2014
	306	Available subsequent to launch on 15 May 2014
	309	Available subsequent to launch on 2 August 2014
	303	Available subsequent to launch on 29 October 2014
Galileo	418	Available for testing from January 2015 (without ephemeris)
	419	Available for testing from March 2013
	420	Available for testing from March 2013 (without ephemeris)
Glonass	501	Available with limitations (no ephemeris data available)
	502	Available with limitations (no ephemeris data available)

Table 5: List of Experimental MEOSAR Satellites Used During the MEOSAR D&E Phase II

2.3.2 Experimental Ground Segment

The ground segment equipment in place for the Phase II of the MEOSAR D&E consisted of experimental MEOLUTs located in Brazil, Cyprus, Canada, France, Norway, Russia, Spain, Turkey, the UK and the USA. Table 6 provides the MEOLUTs available for testing, their number of antennas, their software configuration and their availability (note that some participants may have experienced unexpected down periods for some channels, thus limiting their participation in particular tests; see the Test Coordinators reports for more detail).

Country/ Organisation	Location	Number of Antennas	Configuration	Available for D&E testing since
Brazil	Brasilia	4	[to be completed]	February 2013
Canada	Ottawa	4	HGT MEOLUT 600 Spectrum Monitoring Only	February 2013
Cyprus	Larnaca	4	HGT MEOLUT600 LP v2.0 / SP v2.0 / FP v2.0	May 2015
France	Toulouse	4	HGT MEOLUT600 LP v1.7b / SP v1.5 / FP v1.5	February 2013
Norway	Svalbard	4	HGT MEOLUT600 LP v2.0 / SP v2.0 / FP v2.0	May 2015
Russia	Moscow	4	4 antennas (for more information see relevant sections of test reports)	February 2013
Spain	Maspalomas	4	HGT MEOLUT600 LP v2.0 / SP v2.0 / FP v2.0	May 2015
Turkey	Ankara	6	6-channel (1-2-4-5-6-7) HGT MEOLUT600 LP v1.8 / SP v1.8 / FP v1.8	October 2013
USA	Florida	6	McMurdo MEOLUT v1.0	February 2013
	Hawaii	6	McMurdo MEOLUT v1.0	February 2013
	Maryland	4	McMurdo MEOLUT v1.0	February 2013

Table 6: MEOLUTs Participating in MEOSAR D&E Phase II Tests

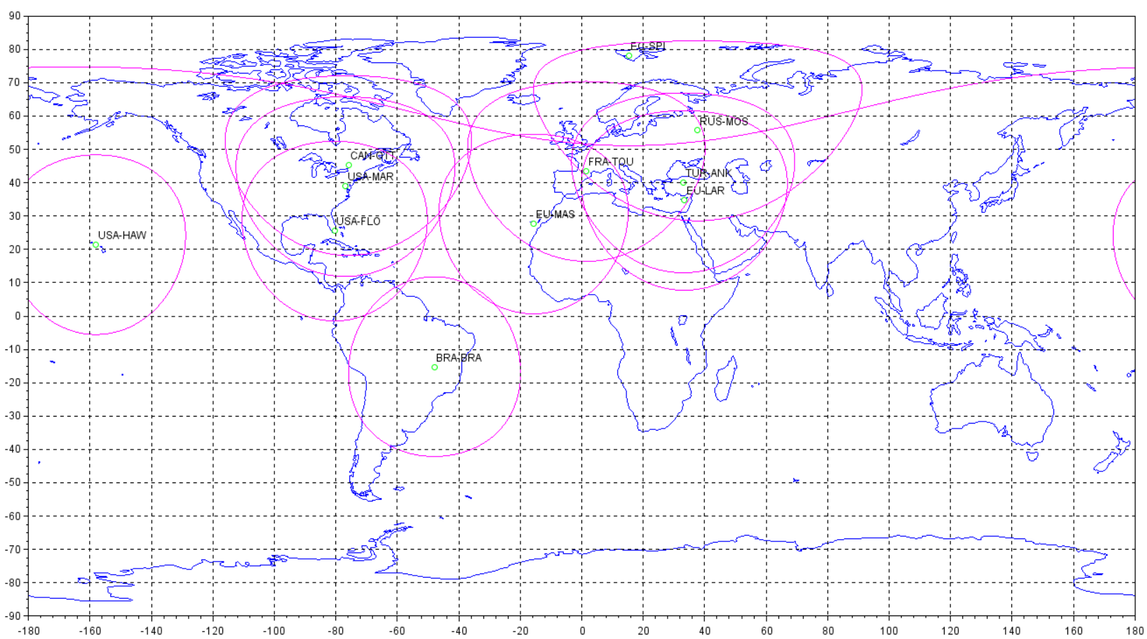


Figure 3: MEOLUTs Involved in Phase II Technical Testing with 3,000 km Radius Circles

2.3.3 Beacon Simulators and Test Beacons

Four beacon simulators were used during the Phase II testing, located in Florida, Hawaii and Maryland, USA and Toulouse, France. After each test, the beacon log files were provided by each administration providing beacon simulators.

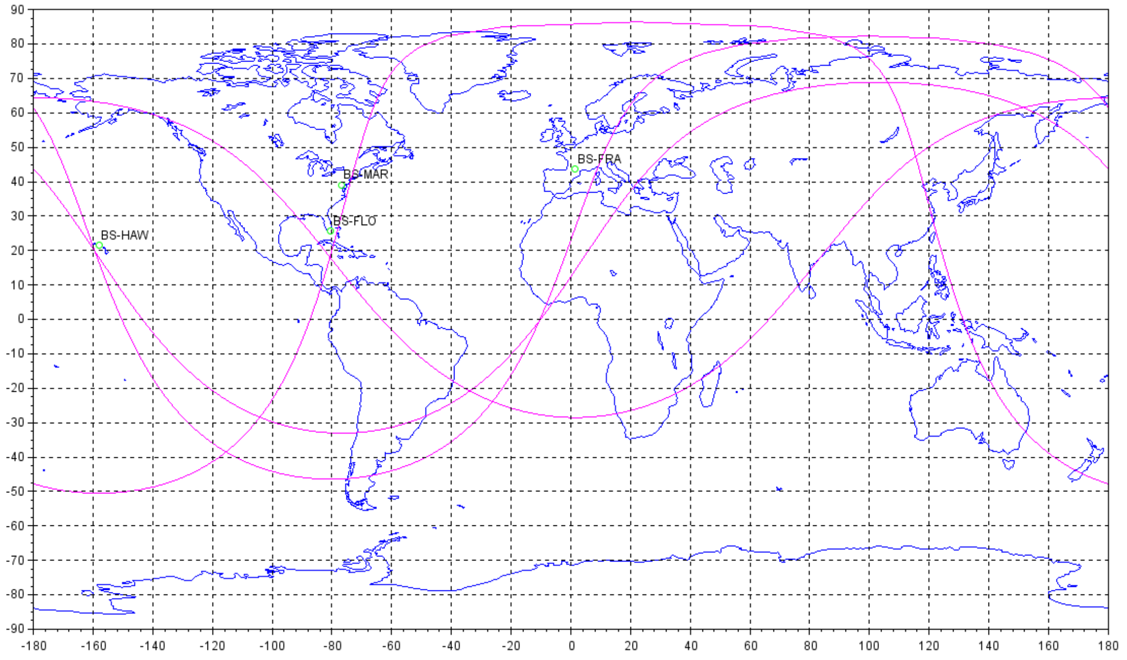


Figure 4: Beacon Simulators Used in the MEOSAR D&E Phase II (MEOSAR Visibility Circles at Five Degree Elevation)

2.4 Test Coordination

A smooth progression of the D&E planning and tests has been observed thanks to the active participation of the Test Coordinators and Test Participants. No formal D&E test had to be postponed or re-scheduled due to a coordination issue.

However, a dry-run test encountered some difficulty because of the work simultaneously being performed by the Galileo Programme. In addition to this particular case, other tests had been planned by Test Participants at times similar to those of SAR/Galileo commissioning tests, requiring an active coordination between France and EC/ESA in order to avoid the simultaneous transmission of beacon signals.

2.5 Operational Issues Encountered during the Phase II Testing

No operational issue was encountered during the conduct of the Phase II tests.

2.6 Data Collection

For the technical tests, the participants collected the following data:

- beacon simulator log data to collect the beacon IDs transmitted (if applicable),

- MEOLUT raw data as per csv format defined in Table J.1 of document C/S R.018,
- MEOLUT location data as per csv format defined in Table J.2 of document C/S R.018,
- MEOLUT pass schedule data as per csv format defined in Table J.3 of document C/S R.018.

For the operational tests, the participants collected raw data from the MEOSAR-ready MCCs as requested in section 5 of document C/S R.018. Then participants used the spreadsheet provided in order to produce the operational test tables needed for the analyses presented in this report.

All the data provided by the test participants were saved on the MEOSAR D&E FTP server.

- END OF SECTION 2 -

3. RESULTS OF THE TECHNICAL TESTS AND DISCUSSION

The following sections provide, for each test:

- references to the test participant's reports presenting the results of the MEOSAR D&E tests conducted during the Phase I testing,
- a summary of the interpretation of the test analyses, as provided by each administration.

3.1 Test T-1 (Processing Threshold and System Margin)

3.1.1 Analysis

The following test reports were provided by the participants:

Administration	Test report reference
France	"C/S D&E Phase 2 T-1 Test Report - Processing Threshold and System Margin", SAR-RE-DEMEO-911-CNES_01_01
Russia	T-1 Run-1 Test Participant report_Russia.pdf
Turkey	T-1 Phase 2 TRMEO Report v1 - 20.12.2015.doc
USA	Maryland MEOLUT Participant Report T1 Run01- ver2 03 June 2015 TG-3/2015/Inf.14 - Maryland MEOLUT Results for Tests T-1, T-3, and T-4 T1 USA Florida MEOLUT Report rev1.0 22 May 2015 T1 USA Hawaii MEOLUT Report rev1.0 22 May 2015

3.1.2 Interpretation

3.1.2.1 France

The configuration of the L-Band Space Segment was not improved since Phase I, which implies the L-Band satellites analysis was still very limited.

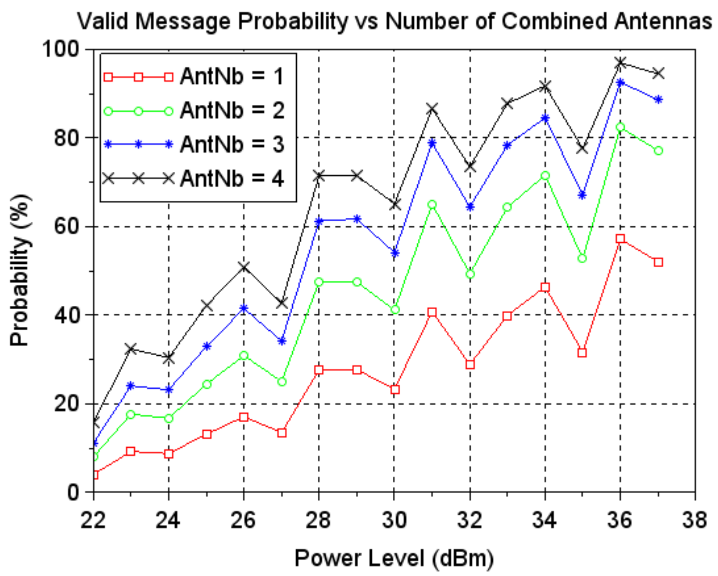
Regarding the automatic pass-schedule processing, the MEOLUT antennas track sometimes less than 4 satellites even if 4 or more satellites are in visibility conditions. This leads us to the conclusion that the optimization algorithm for computing the tracking plan of the French MEOLUT is not performant enough to provide coherent satellite tracking and this fact is degrading both detections and locations of the ground station.

The following summarizes the results obtained for Phase I and Phase II.

	Phase I				Phase II		
	Toulouse Run1	Toulouse Run2	Maryland Run1	Maryland Run2	Toulouse Run1	Maryland Run1	Florida Run1
Number of single satellite channels	25	28	20	21	25	19	19
Mean throughput probability of valid message at 37 dBm (%)	40	60	55	75	52	63	70
Mean throughput probability of complete message at 37 dBm (%)	35	45	40	55	39	49	49
Percentage of single satellite channels for which the system margin is defined (valid messages) (%)	12	25	35	71	8	42	37
Percentage of Single Satellite channels for which the system margin is defined (complete messages) (%)	8	0	0	3	0	16	11

Test T-1 Phase I and Phase II Results Summary

As observed during Phase I Run2, the throughput probability curves are strongly jagged, probably due to a frequency sweeping radar with a pulse period equal to 200 ms. The new parameter setting (from 0 to 2) of the bit error tolerance on bits 1 to 15 does not improve significantly the results. Consequently, we assume that many messages are out-filtered before the decoding process. This issue reduces both detection performances and location performances.



Valid Message Probability vs Antenna Number - Toulouse Transmission

In almost all the single satellite channel cases, the system margin value is undefined because the throughput detection probability never reaches the criteria of 70%. Consequently, it is not possible to determine a significant value representing the MEOSAR system margin.

The detection performance is improved using multi-antennas combination and a margin above the 70% threshold was achieved when at least two antennas were used.

The throughput probabilities computed from the Maryland and Florida transmissions at the nominal power were better than the results obtained from the Toulouse transmission.

At beacon level, the antenna pattern null at high elevation angle is a system limitation which was observed for both Phase I and Phase II runs.

As observed during Phase I Runs, an important gap between the throughput probability of valid and complete messages was observed even if the SP software version was updated. We can note that this issue is fixed on the SP software version of the European MEOLUTs.

The probability to detect processing anomaly was around $14.3 \cdot 10^{-4}$ (requirement: 10^{-4}) during Toulouse transmission. This high value seems to be due to the low transmission power of most of the bursts. No processing anomaly was detected from 2 or more satellites but 1 anomaly was detected by 2 antennas which tracked the same satellite. All the processing anomalies correspond to 2-bit errors on the field PDF1/BCH1.

3.1.2.2 Russia

The interpretation of results of the test indicated that the Processing Threshold in a standalone MEOLUT analysis varied from 22 to 28 dBm and System Margin therefore ranged from 9 up to 15 dB and was subject to number of antennas and beacon simulator locations.

With respect to a single-satellite channel statistics, the System Margin varied from 8 to 15 dB and more. In several cases the anomalous values of less than 7 dB were observed. The additional analysis of a Toulouse beacon emission showed that after including the antenna gain variation information into account factors adversely affecting the Processing Threshold were:

- Interferences, that might temporarily or fully block the reception at a MEOLUT by overlapping with the beacon signal in frequency and time;
- Drop-off of the C/N_0 values that triggered the reception of invalid messages in the MEOLUT signal processor in the range of 270˚-310˚ azimuth degrees and 5˚-60˚ elevation degrees, where the effective beacon EIRP was less than expected possibly due to unknown reduction of the antenna gain value, presence of local obstructions or out-of-band interferences that could break in the GPS satellite repeater band (S-band repeater).

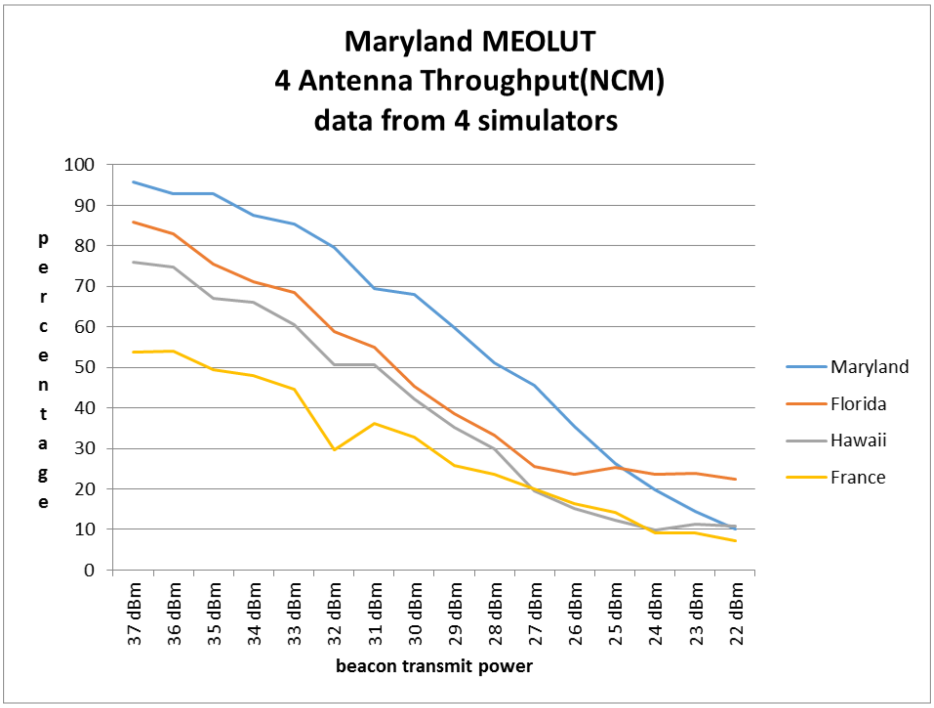
The investigation of anomalous occurrences in USA-based transmissions was not conducted as the beacon antenna gain patterns for USA beacon simulators was not available at the time of writing of the report.

3.1.2.3 Turkey

For the Toulouse transmission of 3-4 February 2015, the 6-channel Ankara MEOLUT reached the 70% system throughput threshold aimed by test T-1 at 26 dBm for valid messages and at 28 dBm for complete messages with corresponding average C/No values of 34.2 dB-Hz and 35.1 dB-Hz respectively.

Taking the valid messages into consideration, the results seemed to indicate a processing threshold of 26 dBm and a system margin of 11 dB. When complete messages were considered, the processing threshold became 28 dBm whereas the system margin decreased to 9 dB.

3.1.2.4 USA



Single Channel (i.e., a single satellite through a single antenna) results were provided to the MEOSAR D&E FTP server, but not repeated in the Maryland Participant Report because they vary considerably due to the following factors. They are affected by the beacon EIRP in the direction of the satellite, which is a combination of the transmit power, the antenna pattern, and any ground blockage. They are also affected by the amount of noise reaching the satellite's receive antenna along with the beacon signal. This noise varies but seems to have different characteristics based on the portion of the globe covered by the receive antenna. Therefore, single channel results are not all the same but vary as these variables change for a given satellite pass. For instance, a satellite pass that does not pass through the null of the beacon's antenna pattern will produce better results than one that does.

Multi-channel results (from the Maryland MEOLUT with four antennas) from the Maryland and Florida beacon simulators show that beacons that transmit at the minimum allowable power (35 dBm) and are within reasonable proximity to the Maryland MEOLUT have a greater than 77% probability of recovering a valid message on a single burst. The threshold for recovering a valid message on a single burst of 70% is achieved at a beacon transmit power of 30 dBm for the Maryland beacon simulator and 33 dBm for the Florida beacon simulator.

Even beacons transmissions from Hawaii show that for a beacon that transmit at the minimum allowable power (35 dBm) and are at great distances away from the MEOLUT (7,780 km), the probability of recovering a valid message on a single burst is 68%.

3.2 Test T-2 (Impact of Interference)

3.2.1 Analysis

The following test reports were provided by the participants:

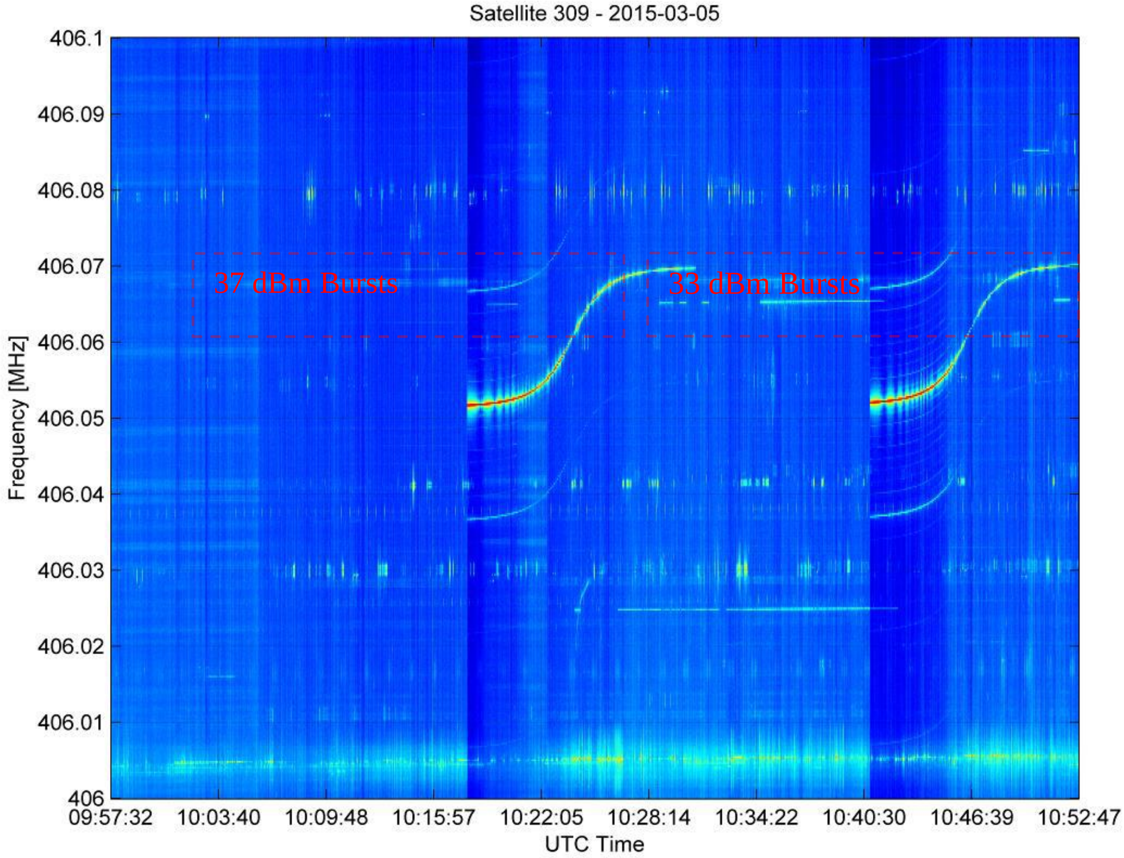
Administration	Test report reference
Canada	JC-31/10/3

3.2.2 Interpretation

3.2.2.1 Canada

Due to the Canadian MEOLUT at Shirley’s Bay not being operational for the majority of the MEOSAR D&E Phase II, spectrum monitoring files were only available for tests T-1 and T-3 and these were made available on the MEOSAR D&E FTP server. Unlike during Phase I testing, little use of the plots was made by other D&E participants, most likely due to the fact that tests T-1 and T-3, being single channel tests, did not yield significantly different results from Phase I – with one exception. As described at TG-3/2015/Inf.1 – Corr.1, when T-testing is performed coincidental with CTEC B.8 Testing (Translation and Transmitter Frequencies) interference will likely be observed on any channels tracking satellites with CTEC in their footprint. The B.8 transmission is in the upper half of the band, and does not interfere with operational beacons, however, in one case it did impact reception of T3 test transmissions.

The figure below provides an example of the interference which was observed.



Strong Interferences During T-3 Test on 5 March 2015 – observed at French MEOLUT

3.3 Test T-3 (Valid/Complete Message Acquisition)

3.3.1 Analysis

The following test reports were provided by the participants:

Administration	Test report reference
France	MEOSAR D&E Phase 2 Test T-3 REPORT - Valid/Complete Message Acquisition SAR-RE-DEMEO-913-CNES_01_01
Russia	T-3 Run-1 Test Participant report_Russia.pdf
Turkey	T-3 Phase 2 TRMEO Report v1 - 13.12.2015.doc
USA	Maryland MEOLUT Participant Report T3 Run01-26 May 2015 TG-3/2015/Inf.14 - Maryland MEOLUT Results for Tests T-1, T-3, and T-4 T-3 USA Florida MEOLUT Report rev 1.0 22 May 2015 T-3 USA Hawaii MEOLUT Report rev 1.0 22 May 2015

3.3.2 Interpretation

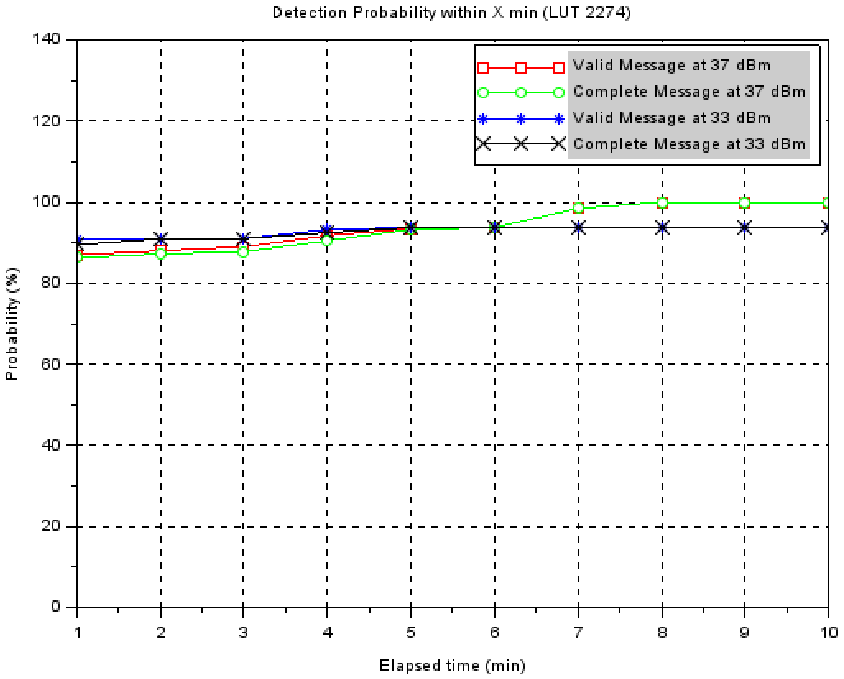
3.3.2.1 France

For Toulouse transmission, the valid message detection probability within 10 minutes is consistent with the document C/S R.012 requirement (> 99% within 10 minutes) at nominal power 37 dBm. However, a 16 hours period was impacted by a MEOLUT software breakdown, so the 24h coverage was not fully studied.

For US-Maryland transmission, the detection probability was degraded due to the less favourable co-visibility conditions, as Phase I modified test. The detection probability within 10 minutes, averaged over all 37 dBm slots, is equal to 89%. This value is not enough to consider that the standalone French MEOLUT achieves to cover a 6,000 km radius area in term of message detection. However, this objective should be achieved if the automatic pass schedule computation is improved to track the maximum number of satellites.

For US-Florida transmission, the results are similar to the ones from US-Maryland transmission. The detection probability within 10 minutes, averaged over all 37 dBm slots, is equal to 85%. This lower value is explained by the larger beacon-MEOLUT distance (7,400 km).

The satellite segment coverage was globally satisfactory in term of message detection because one or more satellites were in co-visibility over 24 hours for all transmissions. The future L-band satellite deployment should improve the message detection performances thanks to a better link budget and an increase of number of satellites in co-visibility.



Mean Detection Probability within X Minutes (slots 1-6 and 39-48) - Toulouse Transmission

The probability to detect processing anomaly was around $3.1x10^{-4}$ during Toulouse transmission. No anomaly was detected from 2 or more satellites. All the anomalies correspond to 2-bit errors on the field PDF1/BCH1. We also observe that the C/N_0 range of the processing anomalies is large.

3.3.2.2 Russia

The interpretation of results of the test indicated that the probability of detection of at least one Valid/Complete Message at the MEOLUT for the beacon simulators ID = 2 and 4 (Maryland and Florida) was 100% after 13 transmitted bursts (within 10 minutes after beacon activation) and 100% in after two transmitted bursts (within 2 minutes after beacon activation) for beacon simulator ID=1 (Toulouse) for all considered slots and beacon emission power values.

With respect to transmission of beacon simulator ID=3 (Hawaii) the probability of detection of at least one Valid/Complete Message at the MEOLUT was greater than 70% after seven transmitted bursts for both 33 dBm and 37 dBm values of beacon emission power. Furthermore, it was noted that the probability values for most of the slots did not keep increasing over time as it would be expected but rather reached their maximum values and became flat. It was noted from the analysis of this behavior that in every slot independently of the beacon emission power a few beacon events had a very scanty throughput (0 to 2 bursts per antenna). The beacon events had the following serial numbers: 2, 4, 6, 8, 10, 28, 30, 32 and 34 (or YYY in the beacon hex ID 9C9D000YYYD00XX). Further investigation has indicated that all beacon events with those serial numbers were emitted at 406.07 MHz frequency, while the signal processor software was configured to support beacon burst integration only at 406.064 ± 0.0025 MHz. A detailed investigation was not undertaken at this time with the view to have more results to analyze after emission from Hawaii was repeated.

3.3.2.3 Turkey

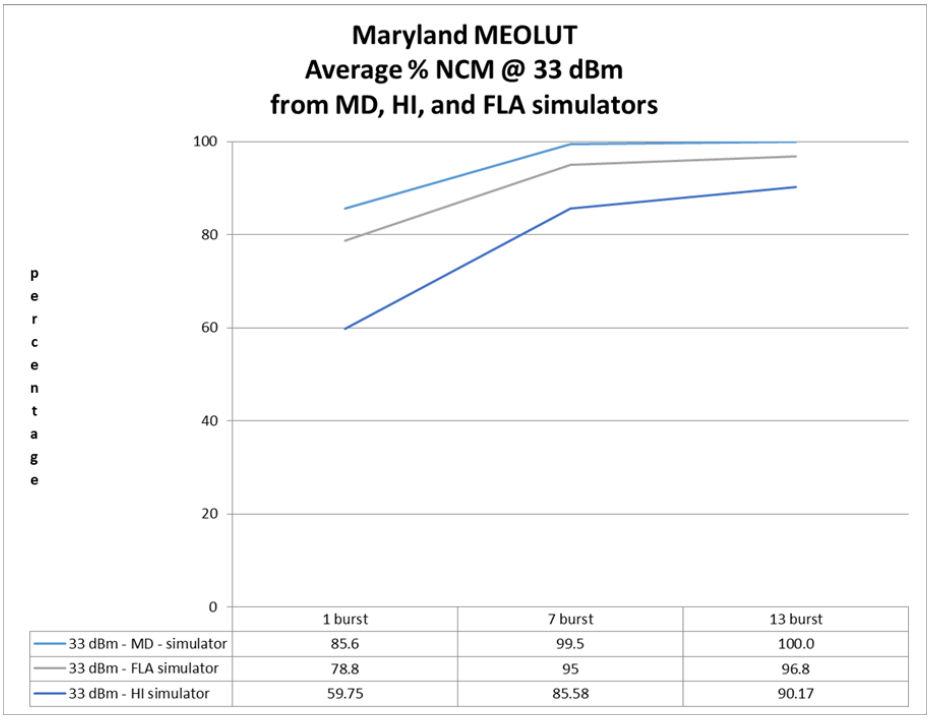
For the Toulouse transmission of 4-5 March 2015, the valid message average detection probability of the Ankara MEOLUT increased from 96% (resp. 99%) for 1 burst to 100% (resp. 100%) for 5+ bursts (resp. for 2+ bursts) for a beacon transmission power of 37 dBm (resp. 33 dBm). The Ankara MEOLUT complete message average detection probability increased from 95% (resp. 98%) for 1 burst to 100% (resp. 100%) for 5+ bursts (resp. for 2+ bursts) for a beacon transmission power of 37 dBm (resp. 33 dBm). Valid (resp. complete) message transfer times of 8.6 seconds (resp. 10.7 seconds) were obtained at 37 dBm, and valid (resp. complete) message transfer times of 5.3 seconds (resp. 5.6 seconds) were obtained at 33 dBm.

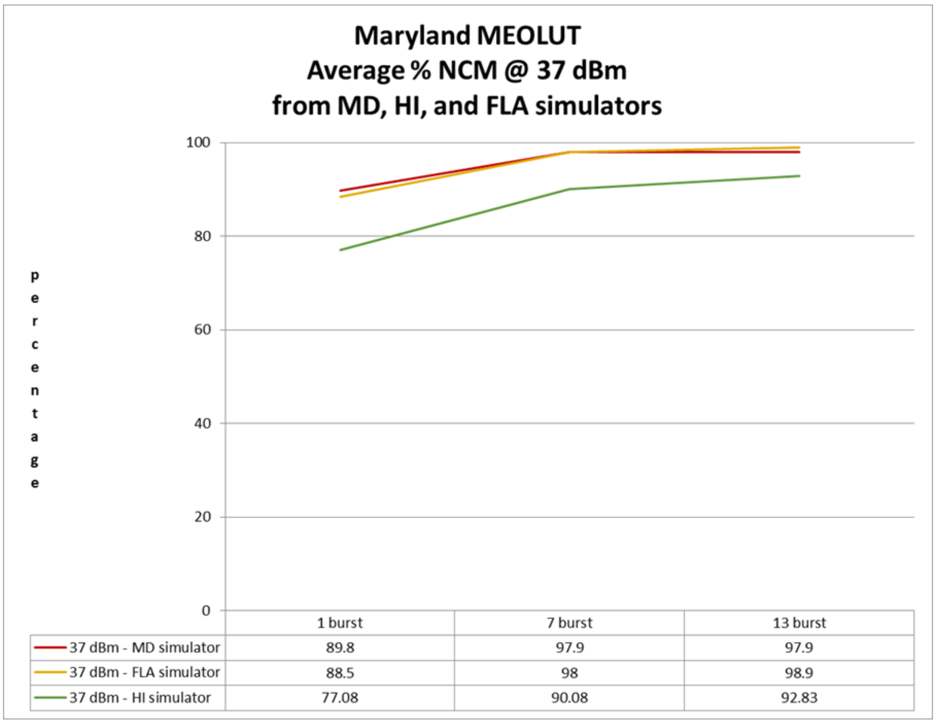
The results seemed to indicate that average detection probabilities improved, as expected, with the number of transmitted bursts. However, the expected correlation with the beacon transmission power (i.e., higher detection rates and shorter message transfer times for higher beacon transmission power) was not observed.

3.3.2.4 USA-Maryland

The following charts summarize the results from the Maryland MEOLUT over the entire 24-hour period of transmission from each beacon simulator. One chart is included for each beacon power level.

Note that the Maryland simulator did not transmit during the first 11 minutes of the test, which corresponds to the first 25 beacon ID's of slot1. However, we didn't compensate for this in our results.





The results demonstrate that the MEOSAR system is an excellent detector of beacon transmissions.

Results from the Maryland and Florida beacon simulators show that beacons that transmit at nominal power (37 dBm) and are within reasonable proximity to the Maryland MEOLUT have a greater than 89% probability of detection on a single burst. Of course, after five minutes this improves to over 98%.

Even at the other extreme of conditions, beacons transmissions from Hawaii show that for a beacon well below the minimum allowable transmit power (33 dBm) and at great distances away from the MEOLUT (7,780 km), the probability of detecting a beacon after a single burst is 60% and improves to 90% after ten minutes.

3.4 Test T-4 (Independent 2D Location Capability)

3.4.1 Analysis

The following test reports were provided by the participants:

Administration	Test report reference
France	"MEOSAR D&E Phase II Test T-4 Report - Independent 2D Location Capability" SAR-RE-DEMEO-916-CNES_01_01
Russia	T-4 Run-1 Test Participant report_Russia.pdf
Turkey	Data results files were uploaded to the FTP site.
USA	Maryland MEOLUT Participant Report T4 Run01v2 –Maryland 10 June 2015 T4 Hawaii MEOLUT Report Rev1.0 22 May 2015 T4 Florida MEOLUT Report Rev1.0 22 May 2015 CSC-55/OPN/Inf.11 USA Florida MEOLUT results 30 November 2015 JC-29/Inf.46 USA Florida & Hawaii MEOLUT status 5 September 2015

3.4.2 Interpretation

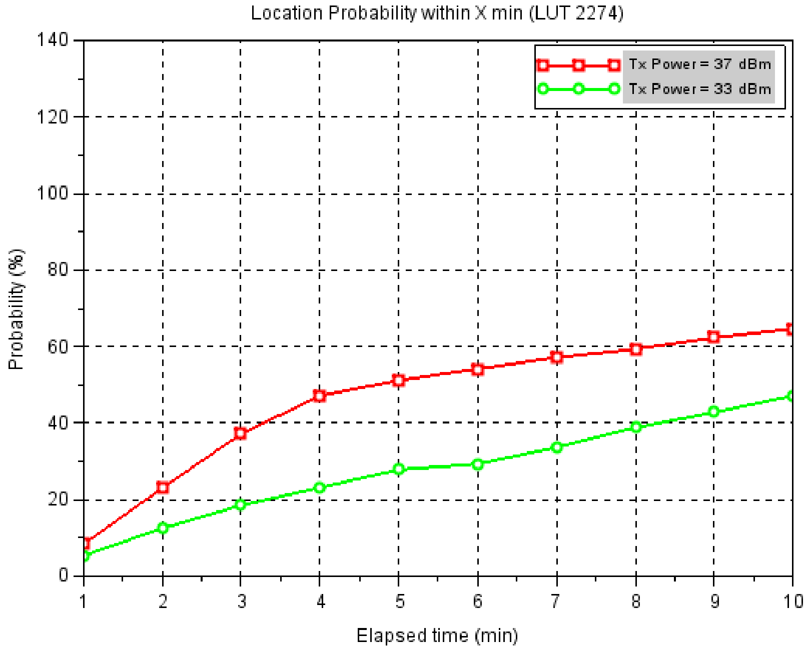
3.4.2.1 France

The location probability within 10 min is not consistent with the document C/S R.012 requirement for Toulouse, Maryland and Florida transmissions. To achieve this requirement, it seems necessary to improve the French MEOLUT software in terms of pass-schedule computation, mono-channel throughput probability and location processing time. Moreover, the multi-burst location algorithm needs to be upgraded, to take into account measurements from several successive bursts and not only perform an average of successive single burst locations.

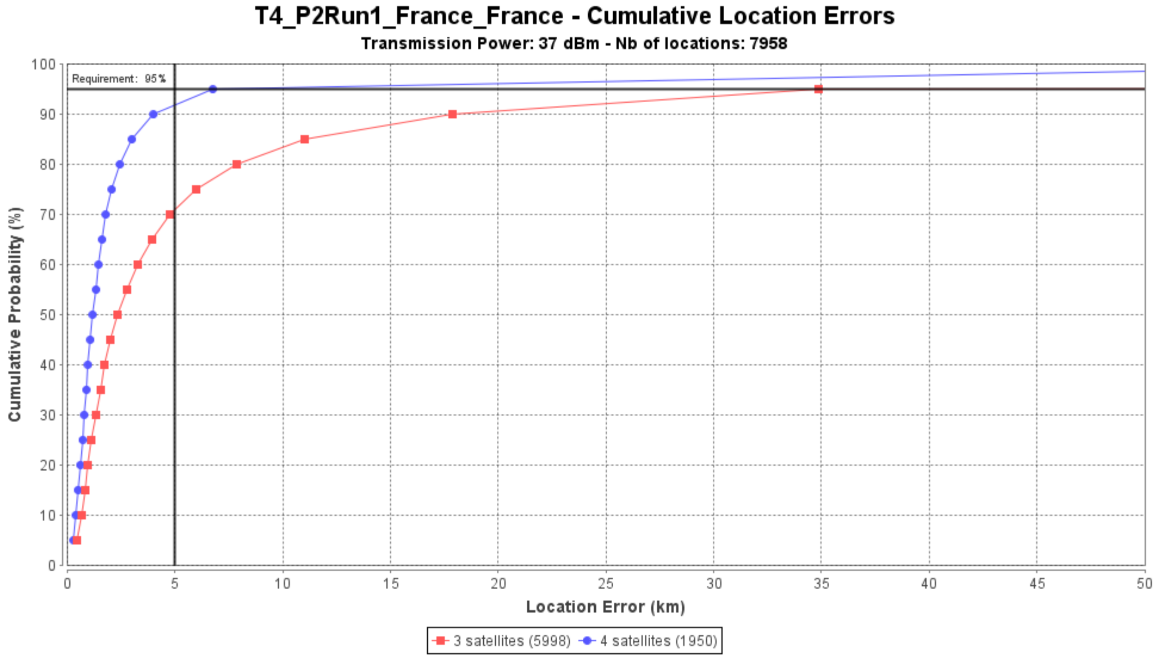
The location accuracy requirement (95% within 5 km) is quasi achieved by the locations computed through 4 satellites during Toulouse transmission (93.2% within 5 km).

The number of satellites to compute the location is the main parameter in term of location accuracy in the coverage area.

The location accuracy is slightly improved by the number of bursts used to compute the location, but this is not verified for all cases.



Mean Location Probability within X Minutes – Toulouse Transmission



Cumulative Distribution of Location Errors Depending on the Number of Satellites Used to Compute Location 37 dBm – Toulouse Transmission

The probability to detect a processing anomaly was around $2{\cdot}10^{-4}$ during Toulouse transmission. No anomaly was detected from 2 or more satellites. Most of the anomalies correspond to 2-bit errors on the field PDF1/BCH1.

3.4.2.2 Russia

The interpretation of results of the test T-4 run1 can be summarized as follows:

- the probability of producing an independent location was 0.99-1.0 after 13 bursts (10 minutes). This exceeds the MEOSAR requirement of 0.98 probability within 10 minutes from a first beacon burst transmission;
- the location accuracy was 1-1.5 km within 10 minutes from a first beacon burst transmission in 95% of the cases which is up to 3 times better than a requirement (5 km).
- average time to produce a location with errors less than 5 km was within 28-136 seconds from a first beacon burst transmission.
- no dependence of location and probability performance on the beacon simulator power modes (33 and 37 dBm) was noted; and
- a few anomalies in location performance were observed and caused:
  - mostly by poor satellite geometry (and, therefore, indicated by deviated JDOP value); and
  - by lack of bursts or low C/N_0 values of detected bursts possibly caused by high elevation angles between beacon simulator and a satellite or reductions in beacon simulator EIRP in a direction of a satellite caused by other factors.

3.4.2.3 USA

Maryland experienced a simulator problem during the execution of the test using the Maryland Simulator. The initial run stopped prematurely requiring the transmission to be restarted. Therefore, the Maryland simulator transmitted twice, run 1a and 1b. The first transmission began as planned but stopped prematurely because of a simulator issue. The second transmission ran for 24 hours.

In addition, the Maryland MEOLUT experienced antenna problems during the transmissions from the Maryland simulator requiring the selection of data from two non-contiguous periods of time. Therefore, the Maryland J.1 24-hour raw data file is data combined from two periods of time - March 24 17:00 to March 24 24:00 UTC (7 hours) and March 25 12:00 to March 26 05:00 UTC (17 hours). These time periods were selected because Maryland experienced antenna problems at the later ends of each Maryland simulator transmission.

Summary of Maryland MEOLUT results from Maryland Simulator

Parameter	Tx Power	13 bursts	7 bursts	5 bursts	3 bursts	2 bursts	1 bursts
Independent Location Probability (%)	33	98.83	94.17	90.83	81.04	82.09	67.83
	37	98.78	95.83	93.00	89.39	83.48	68.70
Independent Location Probability for errors less than 5 km (%)	33	88.83	83.00	75.83	66.61	59.30	48.70
	37	93.22	86.50	79.67	70.96	61.57	45.57
Independent Location Errors 95th Percentile (km)	33	5.55	6.91	7.69	13.25	10.98	10.80
	37	4.75	6.66	6.80	9.19	10.76	12.31

For the Maryland results from the Maryland Simulator, after ten minutes (13 bursts), we are very close to expectations even for the low power transmission. For single burst results, the probabilities are much lower but the errors are well bounded. The expectation is that all probabilities will improve when more operational L-band satellites are available because of their stronger link performance.

3.5 Test T-5 (Independent 2D Location Capability for Operational Beacons)

3.5.1 Analysis

The following test reports were provided by the participants:

Administration	Test report reference
Australia	Beacon deployment report (see annex of the Beacon Deployment Report, Rev.1, dated 10 August 2015, consolidated by the test coordinator)
EU	
France	"MEODAR D&E Phase II T-5 Test Report: Independent 2D Location Capability for Operational Beacons" SAR-RE-DEMEO-940-CNES_01_00 Beacon deployment report (see annex of the Beacon Deployment Report, Rev.1, dated 10 August 2015, consolidated by the test coordinator)
Italy	Beacon deployment report (see annex of the Beacon Deployment Report, Rev.1, dated 10 August 2015, consolidated by the test coordinator)
Norway	Beacon deployment report (see annex of the Beacon Deployment Report, Rev.1, dated 10 August 2015, consolidated by the test coordinator)
Russia	T-5 Run-1 Test Participant report_Russia.pdf, available on the FTP server
Turkey	T-5 Phase 2 TRMEO Report v1 - 11.08.2015.pdf T-5 Phase2 Turkey Beacon Deployment Report - 10.08.2015.pdf T-5 Phase2 Beacon Deployment Report - consolidated v2 - 20.08.2015.pdf
UK	Beacon deployment report (see annex of the Beacon Deployment Report, Rev.1, dated 10 August 2015, consolidated by the test coordinator)
USA	Maryland MEOLUT Participant Report T5 and with T7 Networking – 8 September 2015 JC-29/Inf.38 Maryland MEOLUT Results for T5, T5/T7 and T6 Beacon deployment report (see annex of the Beacon Deployment Report, Rev.1, dated 10 August 2015, consolidated by the test coordinator)

Figure 5 below provides the locations of the test beacons used for test T-5. More details on the beacon models, beacon features and their 24-hour activation periods are available in the Beacon Deployment Report (T-5 Phase2 Beacon Deployment Report - consolidated v2 - 20.08.2015.pdf) consolidated by the test coordinator from test participants' reports.

Figure 5: Location of the 35 Operational Beacons Deployed for T-5 and T-5/T-7 Phase 2 in April 2015

3.5.2 Interpretation

3.5.2.1 France

Up to 22 MEOSAR satellites (17 GPS, 3 Galileo and 2 Glonass) were configured for tracking.

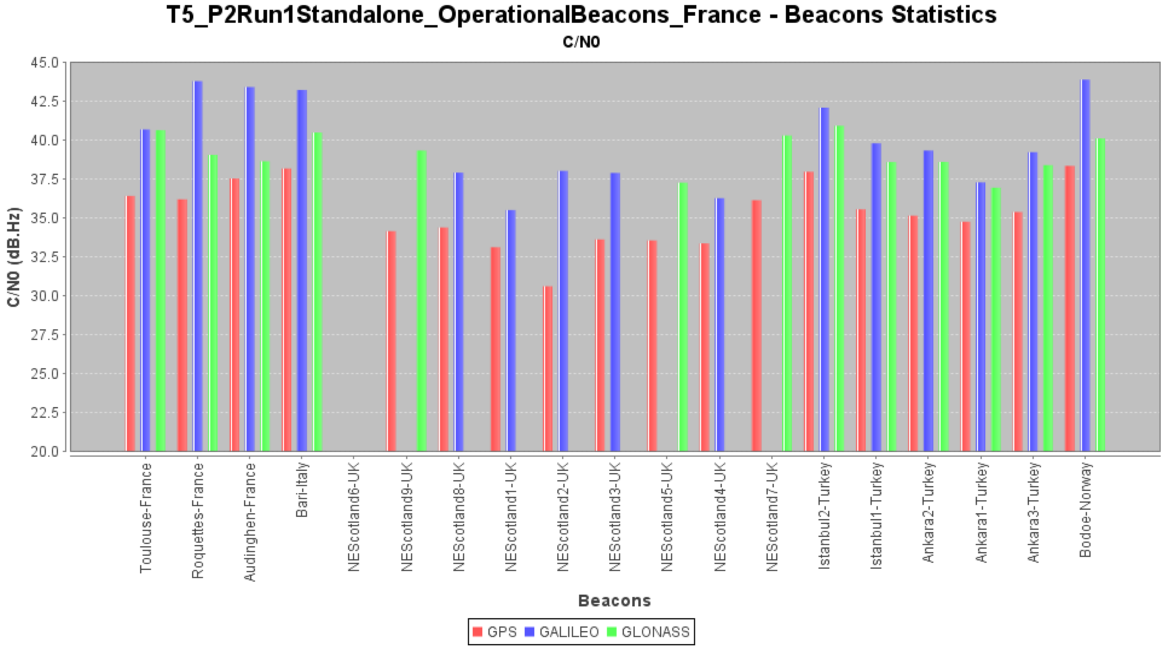
The system throughput was measured between 70% and 85% for beacons located less than 8,000 km away from the MEOLUT (except for beacons located in Scotland, and in North-East America, probably due to a low EIRP). System throughput increased to 98 % for beacons being located less than 1,500 km away from the MEOLUT (except for Toulouse-France beacon).

The results also show that the L-band satellites generally improved the link budget in terms of C/N_0 at MEOLUT level in comparison with the DASS S-band satellites (about 4 dB higher).

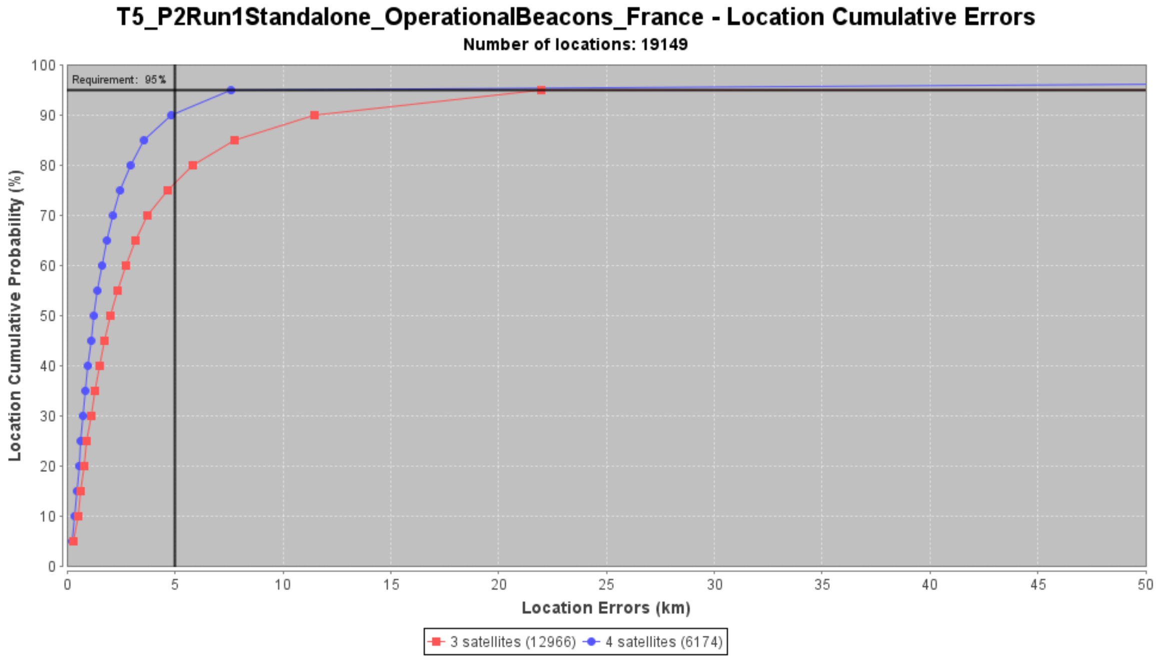
It can also be noticed that some beacons were received from GPS-DASS below the threshold of 34.8 dB.Hz which could explain the lower system throughput.

Regarding the location probability, for beacons located less than 3,000 km away from the MEOLUT, due to large variations in channel throughput, the probability of location extended from 0% to 80%, depending on beacons. Even for the "best" beacons, the results were far from the requirement of 98% within 10 min or 90% within 2 min.

Regarding location accuracy, the main factor is the number of satellites used for the location process. A significant improvement from three to four satellites can be observed. The best result is 95 % within 8 km for locations derived from four satellites. The location accuracy requirement (95% within 5 km) was still not met in this case. The main limitation was that most of locations are produced with only three satellites, and using a single burst location averaging method.



Average C/N0 for Beacons Detections (less than 3,000 km away)



Location Accuracy Cumulative Distribution vs. the Number of Satellites Used
(for Beacons Less than 3,000 km Away)

These results on operational beacons showed that the French MEOLUT is below expectations for location performances (probability and accuracy) with operational beacons.

3.5.2.2 Turkey

The Ankara MEOLUT exclusively tracked the 16 DASS satellites that were available at the time of the T-5 Phase II tests.

Regarding the detection of activated beacons, 33 out of the 35 beacons deployed were detected by the Ankara MEOLUT during test T-5, the remaining two beacons at Papeete, French Polynesia being located too far away from the MEOLUT. Fourteen of the 33 beacons detected were located more than 7,000 km away from the TRMEO, thus confirming the detection benefit of the MEOSAR system, even with a limited MEOSAR space segment.

Regarding the System Throughput (i.e., probability of burst detection with at least one satellite), on average around 85% of the transmitted bursts were detected, increasing to 98% for beacons in the immediate vicinity of the MEOLUT, a significant improvement over the Phase I System Throughput results. Concerning the detection of bursts by multiple channels, only 21.1% of the detected bursts were detected over the three days of week 1 tests through at least four satellites, and 47.7% through at least three satellites, a significant improvement, again, over the Phase I results even though still a concern from a location probability viewpoint.

Location probability was roughly in the 80% - 90% range for the beacons in the geographic region of the Ankara MEOLUT (a circle with a radius of 3,500 km centred at the MEOLUT).

Location accuracy was, as expected, better within the aforementioned geographic region around the MEOLUT, with a 50^{th} percentile (i.e., median value) of 1 km and a 75^{th} percentile of 2 to 3 km. However, at its 95^{th} percentile, the location accuracy went up to the 5 to 15 km range and sometimes beyond that range. In addition, the following observations were made:

- No significant improvement was noticed due to the integration of up to 7 bursts. In general, single-burst locations were almost as accurate as multi-burst locations (it was later discovered, after the end of the T-5 Phase II test, which TRMEO was configured for single-burst processing and averaging of single-burst locations only; the configuration was since modified to include multi-burst processing in addition to single-burst processing).
- The number of satellites used in the calculation of a location seemed to be the most significant factor determining location accuracy.

4+ satellite locations did meet the “less than 5 km 90% of the time” criterion whereas 3+ satellite locations did not meet that criterion.

Consequently, Turkey anticipated the definition of “nominal locations” as those locations derived from bursts obtained from four or more satellites, and “marginal locations” as those locations derived from bursts obtained from three or fewer satellites, possibly with the use, as well, of the DOP value in those definitions, pointing out the potential necessity for MEOLUT networking in the real world.

If the current detection rates were not significantly improved by the future L-band satellites, four-channel MEOLUTs might have difficulties in systematically generating locations derived from four satellites.

Turkey recommended that the following parameters be noted and taken into account in the ongoing work on MEOLUT Performance Specifications and Design Guidelines:

- impact on location accuracy of the number of satellites used to calculate a location,
- concept of "nominal" and "marginal" locations.

3.5.2.3 Russia

The interpretation of results of the test indicated that the probability of detection of valid messages (throughput) by the MEOLUT was within 0.99 -1.0 for most of the considered beacons. One beacon located almost 10,000 km away from the MEOLUT was received with throughput value of 0.55. An investigation in relation to this beacon was not conducted, however, it was noted that the lower values of throughput might be caused by:

- satellite geometry (the beacon was not seen by more than one antenna most of the time); and
- possible local obstructions (the elevation angles ranged between 0˚ - 20˚ for the most part of the visibility zone);

MEOSAR system requirement introduced in Annex E of document C/S R.012 on independent location accuracy to be produced within 10 minutes timeframe in 95% of the time (5 km):

- was met for all static beacon transmissions (28 out of 29) located within 3,000 km from the MEOLUT with error less than 3 km; and
- was not met for a Norway beacon when moved (error = 7.42 km) located within 3,000 km from the MEOLUT.

A derivation from MEOSAR system requirement on independent location probability to be produced within 10 minutes timeframe with errors less than 5 km (0.93):

- was met for 26 out of 29 beacon transmissions located within 3,000 km from the MEOLUT; and
- was not met for a Norway beacon when moved (P = 0.85) and for two Turkish beacons (P=0.92), all located within 3,000 km from the MEOLUT.

MEOSAR system requirement introduced in Annex E of document C/S R.012 on independent location probability to be produced within 10 minutes timeframe (0.98):

- was met for 26 out of 29 beacon transmissions located within 3,000 km from the MEOLUT; and
- was not met for one UK beacon (P=0.95) and two Turkish beacon transmissions (P=0.94 and P=0.95), all located within 3,000 km from the MEOLUT.

Accurate localization of moving first generation beacons in MEOSAR is possible if FOA measurements from six or more satellites are used. To this end, addition of another two antennas to Moscow MEOLUT is currently under consideration. Meanwhile, Russia is implementing means of determining whether the beacon was static or not during transmission to ensure locations with better accuracy.

3.5.2.4 USA

Single burst throughput is reasonable although not all beacon activations meet expectations. Location results seem to vary in a non-predictable way that is difficult to summarize. Some results are within expectation and some are not.

Because of the nature of the test, it is not possible to investigating the underlying causes of the fluctuations in performance. Sometimes beacons in the same location provide different results. This is complicated by the fact that MEOLUT hardware issues impacted the results from the beacon activations of the most interest.

Further testing with commercial beacons may be necessary in order to collect the deployment information necessary to better evaluate the results.

3.6 Test T-6 (MEOSAR System Capacity)

3.6.1 Analysis

The following test reports were provided by the participants:

Administration	Test report reference
France	MEOSAR D&E Phase 2Test T-6 Report - MEOSAR System Capacity SAR-RE-DEMEO-930-CNES_01_01
Russia	T-6 Run-1 Test Participant report_Russia.pdf, available on the FTP server
Turkey	
USA	Maryland MEOLUT Participant Report T6 Run01-08 September 2015 JC-29/Inf.38 Maryland MEOLUT Results for T5, T5/T7 and T6

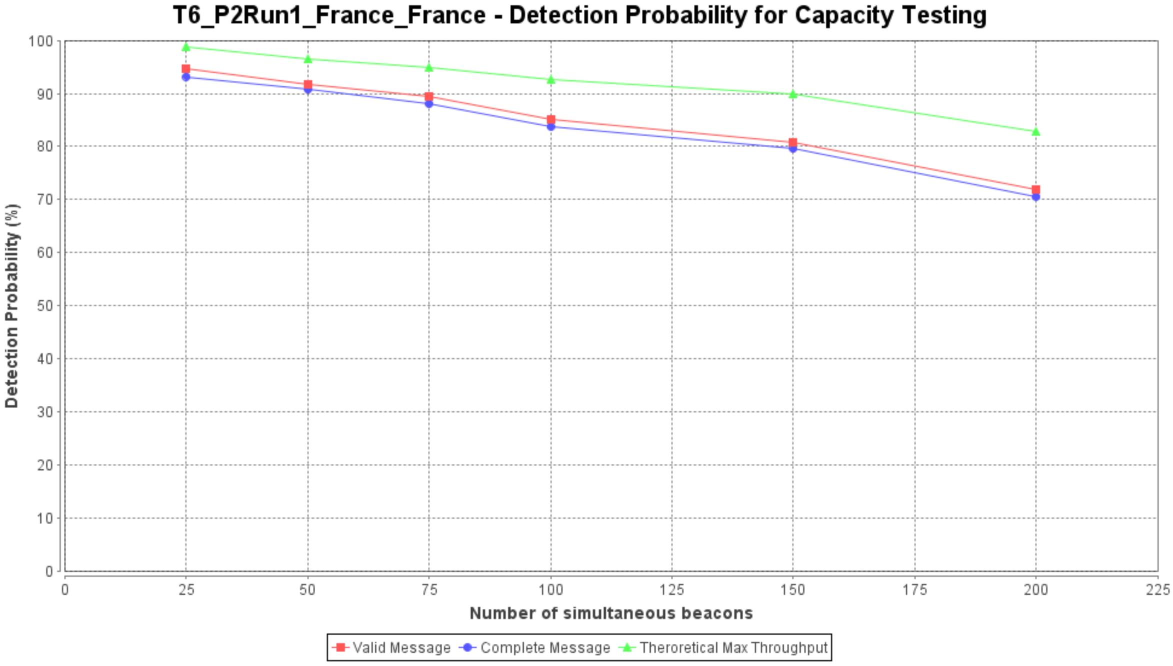
3.6.2 Interpretation

3.6.2.1 France

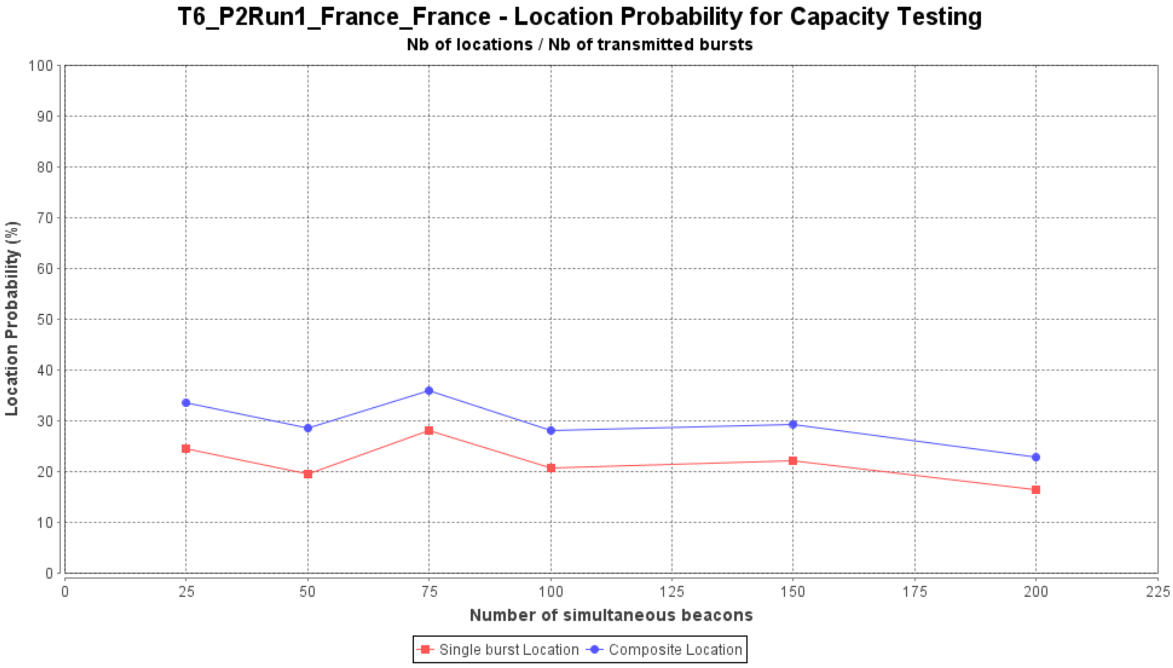
The analysis was mainly focused on the French MEOLUT results obtained during the French simulator transmission as the space segment conditions of the document C/S R.018 were not fulfilled for the Maryland transmission.

The results did not permit to characterize accurately the MEOSAR System Capacity as the maximum number of simultaneous beacons is most likely higher than NB=200. Indeed, the expected performance drop-off with the system saturation has never occurred.

The system throughput performance shows a slight influence of number NB, but the other analyses on time to first message, or location probability/accuracy show no particular correlation with this number.



Valid/Complete Message Detection Probability for Capacity Testing - Toulouse Transmission



Independent Location Probability - Toulouse Transmission

The probability to detect a processing anomaly was around 0.53×10^{-4} (requirement: 10^{-4}) during Toulouse transmission. No anomaly was detected from two or more satellites. All the processing anomalies correspond to 2-bit errors on the field PDF1/BCH1. We also observe that the C/N_0 range of the anomalies is large.

3.6.2.2 Russia

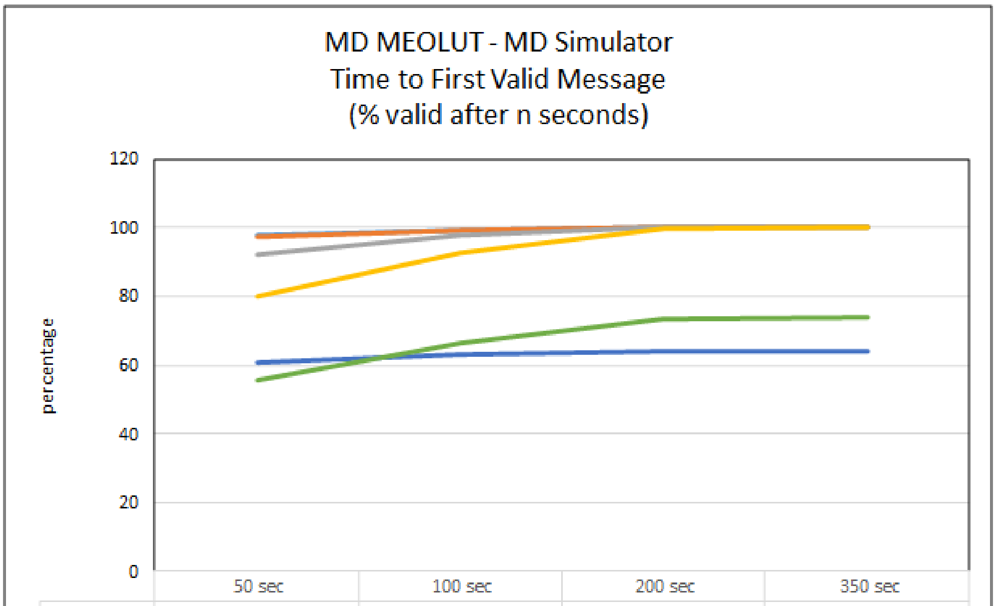
The results on System capacity using the MEOLUT throughput performance for both Toulouse and Maryland transmissions indicated that:

- if compared against the MIP requirement for detection probability the threshold of 99% was not crossed even for a traffic load representing 200 operational beacons within 350 seconds. The System Capacity in a detection probability domain was, therefore, more than 200 beacons, and
- if a throughput criteria was assumed the MEOLUT throughput of 70% was reached in the zone between 150 and 200 simultaneous beacons.

The results on System Capacity using the MEOLUT location performance for both Toulouse and Maryland transmissions showed that no curve drop-off was identified, assuming that the value of System Capacity was 200 beacons or more.

3.6.2.3 USA

Throughput Performance:

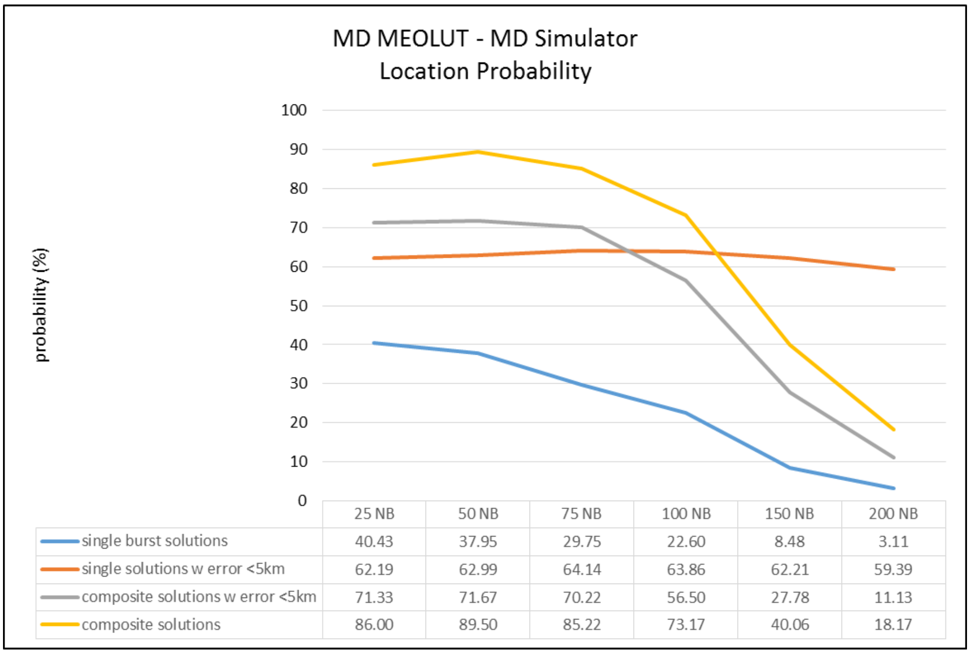


	50 sec	100 sec	200 sec	350 sec
25 NB	97.67	99.33	100.00	100.00
50 NB	97.33	99.33	100.00	100.00
75 NB	91.89	97.89	100.00	100.00
100 NB	80.00	92.58	99.50	100.00
150 NB	60.78	63.00	63.78	63.78
200 NB	55.38	66.21	73.38	73.63

Probability of a Valid Message as a Function of Time for Different Values of NB

Location Performance:

Note: Only seven bursts are transmitted and available to generate the composite locations



Probabilities of any Single Burst and Composite Locations and the Probabilities that those Locations are Less than 5 km.

The probability of generating a valid or complete message within 5 minutes after beacon activation is 100% for at least 100 simultaneous beacons.

Single burst location probability suffers most as the number of simultaneous beacons increases but the accuracy of those locations seems to remain fairly consistent.

The probability of generating a location five minutes after beacon activation remains fairly consistent until the number of simultaneous beacons is between 75 and 100. Similarly, the accuracy of those locations remains fairly consistent until then as well.

Based on this data from the four channel Maryland MEOLUT, it appears that the beacon capacity is near 100 simultaneous beacons. However, it is reasonable to expect this value to improve with additional antennas, which will be investigated during future testing. In addition, locations that are generated ten minutes after beacon activation rather than the currently tested five minutes would also likely improve results.

3.7 Test T-4/T-7 (Networked MEOLUT Advantage)

3.7.1 Analysis

Administration	Test report reference
EC/France	MEOSAR D&E Phase 2 Test T-4/T-7 Report - Independent 2D Location Capability in Networked Mode SAR-RE-DEMEO-922-CNES_01_00
USA	Maryland MEOLUT Participant Report T-4/ T-7 09 June 2016

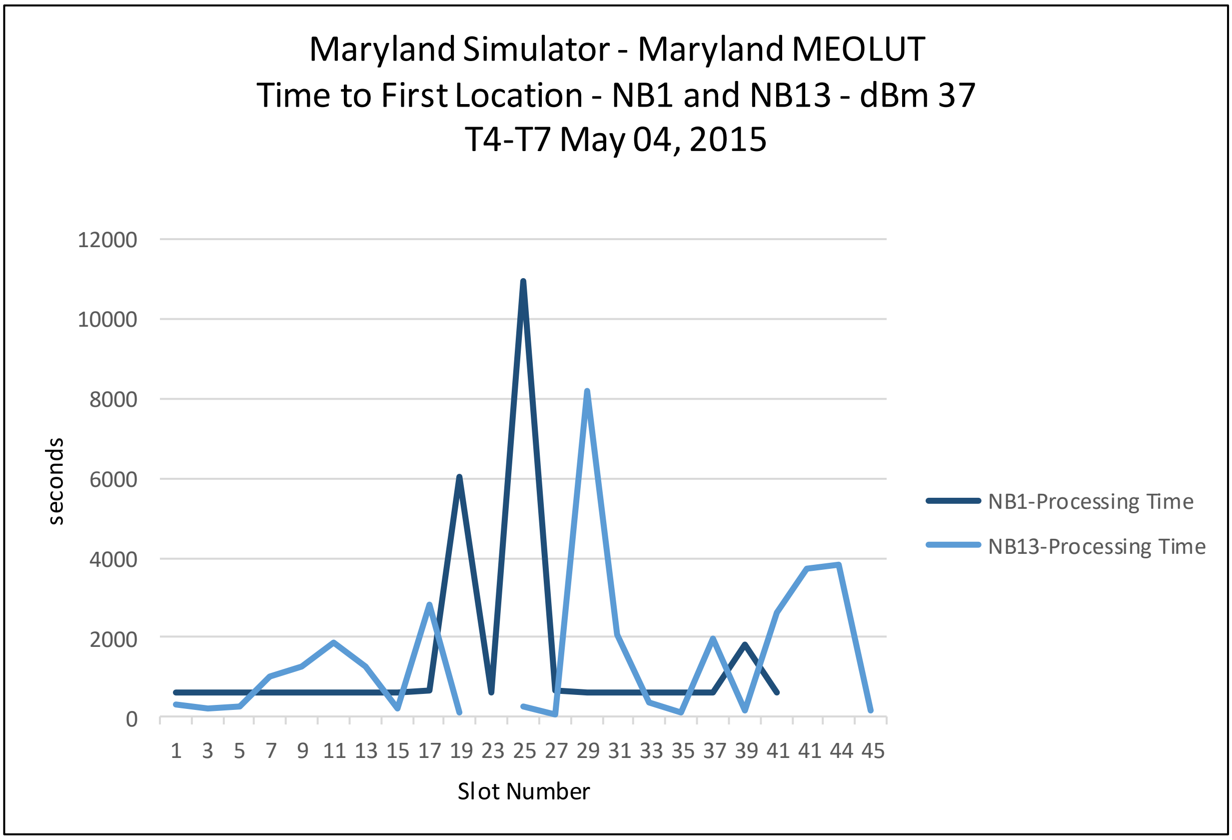
3.7.2 Interpretation

3.7.2.1 USA

The table below is a summary of the results collected for the Maryland MEOLUT using the Maryland simulator.

Parameter	Tx Power	13 burst	7 burst	5 burst	3 burst	2 burst	1 burst
Independent Location Probability (%) Any	33	70.00	54.83	54.83	52.00	48.50	43.00
	37	69.67	76.83	71.50	73.50	65.67	47.33
Independent Location Probability for errors less than 5 km (%)	33	66.50	48.83	47.17	43.17	38.50	29.00
	37	68.67	74.33	67.00	66.00	56.33	35.67
Independent Location Errors 95th Percentile (km)	33	8.08	7.64	8.61	8.24	9.12	14.36
	37	5.16	4.11	5.56	6.60	7.56	7.63

This chart summarizes Time to First Location for the beacon transmit power of 37 dBm.

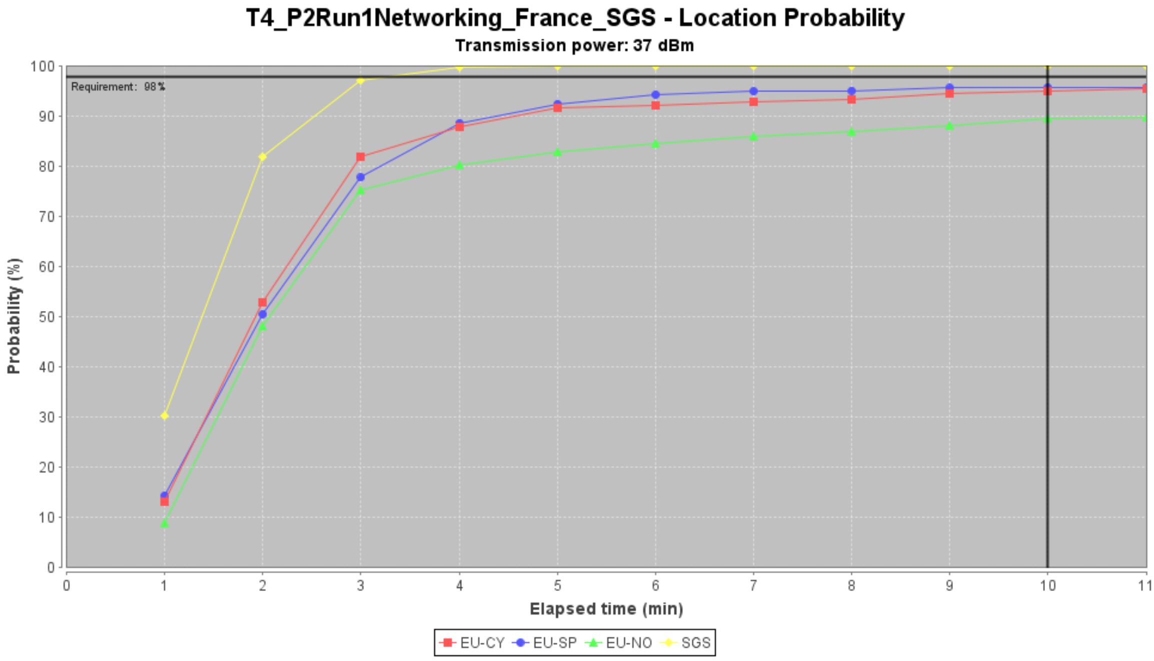


When comparing the Maryland T-4/T-7 summary results to the Maryland T-4 summary results, overall improvement resulting from networking can be seen. However the volume of network data that results from the T-4/T-7 test is large because of the high density of beacon transmissions. This caused backlogs in the MEOLUTs location processing as demonstrated by the spikes in the Time to First Location chart above. This impacted performance and caused the improvement from networking to be less than expected. We are investigating solutions for handling large volumes of network data.

3.7.2.2 EC/France (European MEOLUTs)

For Toulouse transmission, at MEOLUT level, none of the three MEOLUTs reaches the 98% probability to have an independent location within 10 minutes (requirement given by document C/S R.012, Annex E). We can observe a lower performance at EU/Spitsbergen MEOLUT with only 90% achieved to be compared to 95% at both others. At SGS level, the 98% probability to have an independent location within 10 minutes is reached. For Maryland and Florida transmission, the probability of location is still above 82% at 37 dBm.

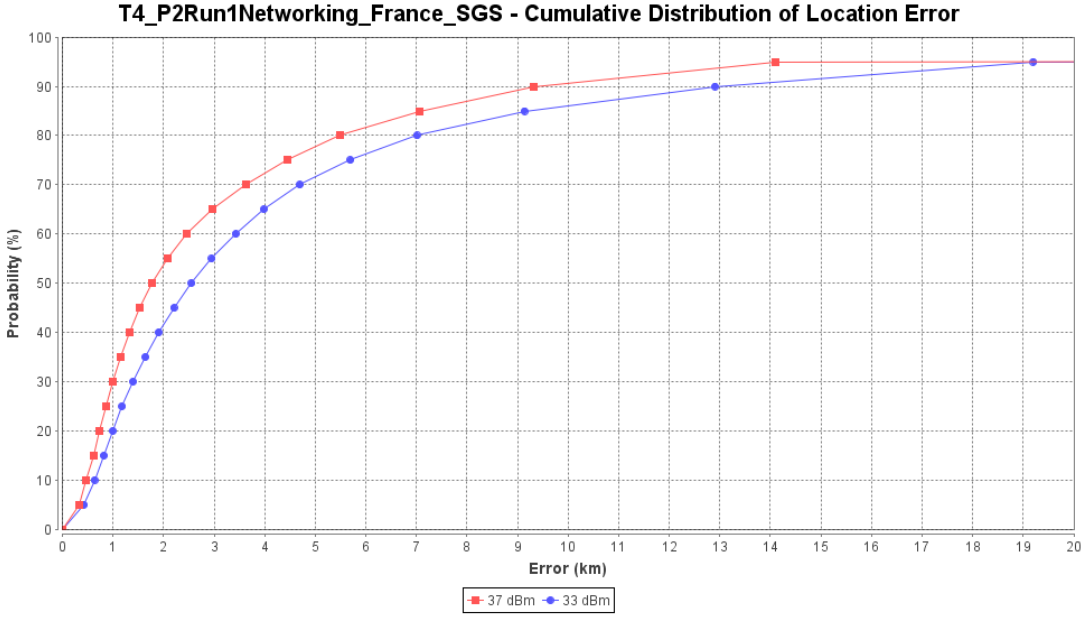
This shows the advantage of networking for the location probability.



Mean Independent Location Probability Over All Slots within X Minutes by each MEOLUT and the Overall SGS

The SGS curve is computed considering that a location has been produced by at least one MEOLUT. This means that the location is potentially transmitted to one of the three MCCs connected to a MEOLUT.

The requirement of having an independent location solution within 5 km 95% of the time is not achieved. Indeed, 95% of the time the SGS provides a solution within 20 km. However, the requirement is achieved with locations computed with 5 or more satellites and when using satellites broadcasting accurate ephemeris.



Cumulative Distribution of Location Error-Toulouse Transmission

3.8 Test T-5/T-7 (Networked MEOLUT Advantage)

3.8.1 Analysis

The following test reports were provided by the participants:

Administration	Test report reference
EC/France	MEOSAR D&E Phase 2 Test T-4/T-7 REPORT - Independent 2D Location Capability in Networked Mode SAR-RE-DEMEO-929-CNES_01_00
USA	Maryland MEOLUT Participant Report T5 and with T7 Networking – 8 September 2015 JC-29/Inf.38 Maryland MEOLUT Results for T5, T5/T7 and T6

3.8.2 Interpretation

3.8.2.1 EC/France (European MEOLUTs)

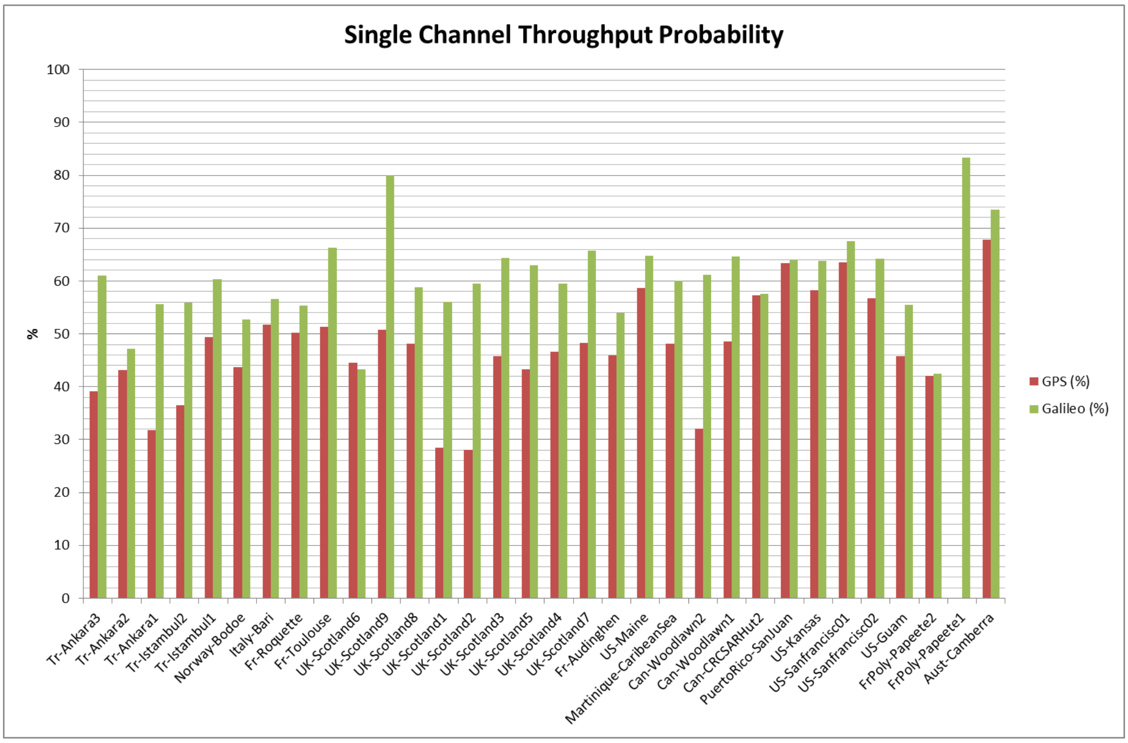
Up to 19 MEOSAR satellites (16 GPS and 3 Galileo) were configured for tracking.

The system throughput was measured between 87.4% (beacons Scotland1&2) and 100% for beacons located on the ECA area. A system throughput drop was observed at around 5,000 km.

The L-band satellites generally improved the link budget in terms of C/N_0 at MEOLUT level in comparison with the DASS S-band satellites (about 4 dB higher).

In addition to the C/S R.018 methodology, the single channel throughput depending on satellite constellation was analysed (figure below). To suppress masking effects at low beacon-satellite elevation angle, the transmission period was defined as the time interval between the first detected message and the last detected message during a satellite pass. From the beacons located on the Europe area (Tr-Ankara3 to Fr-Audinghen), the overall single channel throughput for each downlink type was the following:

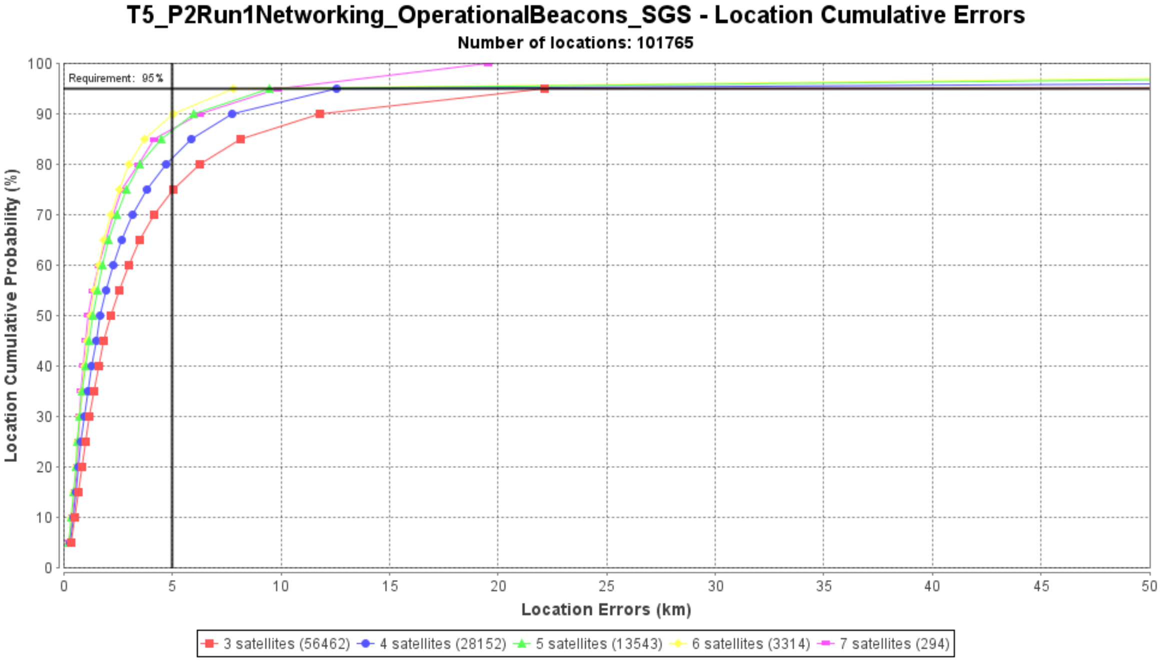
- S-band: 44%
- L-band: 59%



Single Channel Throughput Depending on Satellite Constellation

Regarding the location probability with error less than 10 km, for beacons located inside the ECA area, the mean probability of location is 98%, which is compliant with the location probability 98% within 10 min.

Regarding location accuracy, the main factor is the number of satellites used for the location process. A significant improvement from three to four satellites can be observed. The best result is 95 % within 8 km for locations derived from 6 satellites. The location accuracy requirement (95% within 5 km) was still not met in this case. The main limitations were that most of locations are produced with only 3 or 4 satellites and that the TLE files are used to compute the orbits of the satellites 418 and 420.



Location Accuracy Cumulative Distribution vs. the Number of Satellites Used (ECA Beacons)

Improvements of the location performances should be observed in Phase III thanks to the L-Band satellite deployment.

3.8.2.2 USA-Maryland

Beacon activations with MEOLUT data exchange enabled generally produced better results than when data exchange was disabled. Of course, the degree of the improvement depended on the location of the beacon relative to the MEOLUTs involved. That is, beacons that were located far from any MEOLUT involved in the data exchange were less affected.

Further testing with commercial beacons may be necessary in order to collect the deployment information necessary to better evaluate the results.

- END OF SECTION 3 -

4. RESULTS OF THE OPERATIONAL TESTS AND DISCUSSION

For each operational test conducted, the following sections provide:

- test periods and MEOLUT mode of operation expected,
- a description of each MCC configuration, per Administration,
- operational test results provided by each Administration, and
- a summary of the interpretation of the test analyses, as provided by each Administration.

4.1 Expected MEOLUT Configuration and Time Periods

MEOSAR D&E Phase II Operational Tests were carried out in two parts:

Phase II	Start	End	MEOLUT Mode of Operation Expected
Part 1	7 April 2014 00:00 UTC	12 May 2014 00:00 UTC	Standalone
Part 2	19 January 2015 00:00 UTC	20 April 2015 00:00 UTC	Standalone
	20 April 2015 00:00 UTC	11 May 2015 00:00 UTC	Networking

4.2 MCC Configuration

The following information on MEOSAR-ready MCC configuration was provided by the participants.

4.2.1 France

4.2.1.1 LEO/GEO FMCC

The FMCC-LEO/GEO filters out from the processed data all the beacon IDs that correspond to inverted sync frame (test beacons) and orbitography/reference beacons.

4.2.1.2 French MEOSAR-Ready MCC

The French MEOSAR-ready MCC filters out from the processed data all the beacon IDs that correspond to inverted sync frame (test beacons) and orbitography/reference beacons.

It is to be noted that on the French MEOSAR-ready MCC, some of the MCCs towards which SITs are sent are purely virtual. Those would be received if the network link was established. Actually, the French MEOSAR-ready MCC sent data to:

CYMCC, ITMCC, JAMCC, NMCC, SPMCC, TRMCC and USMCC

In addition, the French MEO-Ready MCC receives data from:

CYMCC, ITMCC, JAMCC, NMCC, TRMCC and USMCC

The means used at the FMCC were:

- the French MEOLUT, in version FP 1.7b, SP and LP 1.5,
- the French MEO-ready MCC, an in-house development,
- the French MCC v2.7 for LEOSAR and GEOSAR alert data.

4.2.2 Italy

The MEOSAR-ready ITMCC was not associated with any MEOLUT.

MEOSAR data was received via FTP/VPN from the following MEOLUTs through their associated MEOSAR-ready MCCs:

- Toulouse (France)
- EU Spitsbergen (Norway)
- Ankara (Turkey)
- EU Larnaca (Cyprus)
- Brasilia (Brazil)
- Florida – Maryland – Hawaii (USA)

The Italian MEOSAR-ready MCC was available for the whole test period.

The MEOSAR-ready ITMCC:

- Name/Manufacturer: McMurdo Inc
- Hardware / Software: HP ML 350 running Windows Server
- Version (Core Processing): Insarcore 6.0.2.0
- Configuration / Status: MEOSAR ready MCC in D&E Version

4.2.3 Japan

The MEOSAR-ready JAMCC is following condition:

- MEOSAR data was received from USMCC and FMCC during the D&E test period.
- The MEOSAR-ready JAMCC had not provided data for anywhere.

National MEOLUT is under construction. (Not operating). Therefore, in this test period, the MEOSAR-Ready JAMCC did not receive MEOSAR data from a national MEOLUT. JAMCC received MEOSAR data from international MEOLUTs via USMCC and FMCC.

The MEOSAR-ready JAMCC:

- Name/Manufacturer: Techno-Sciences Inc
- Hardware / Software: HP ML 350 / Windows Server 2012
- Version (Core Processing): Insarcore 6.0.0.0
- Configuration / Status: MEOSAR ready MCC in D&E Version
- Connected MEOLUT: Not Applicable

4.2.4 Norway

The MEOSAR-ready NMCC was connected to the four-channel EU/Spitsbergen MEOLUT through direct FTPV link. MEOSAR data was also exchanged with the following MEOSAR-ready MCCs:

- FMCC
- ITMCC
- CYMCC

International MEOLUTs from which data was received:

- France via FMCC
- Brasilia via BRMCC and FMCC
- Ankara via TRMCC and FMCC
- Florida via USMCC and FMCC

The MEOSAR-ready NMCC:

- Name/Manufacturer: Techno-Sciences, Inc
- Hardware / Software: HP ML350 Gen 8 running Windows Server 2012 64-bit
SQL Server 2012
- Version: Insarcore 6, 0, 2, 0
- Configuration / Status: Configured for D&E support
- Connected MEOLUT: EU/MEOLUT Spitsbergen

During part of the standalone and networked mode periods the EU/Spitsbergen MEOLUT was not filtering orbitography or test protocol coded beacons. Nor did the Norwegian MEOSAR-ready MCC filter out QMS data properly, resulting in a high amount of transmitted MEOSAR alert messages, particularly to those destinations which have an orbitography beacon located in their region.

Because the EU/Spitsbergen MEOLUT was going through some heavy test campaigns simultaneously as the D&E Operational tests occurred, it was challenging to maintain present configuration state at all times for all subsystems. In the post processing NMCC attempted to remove those cases from the analysis, to sustain a higher degree of reliability in the calculations. Additionally, NMCC experienced two occasions where the MEOLUT was disconnected from MEOSAR-ready MCC. There may also be other circumstances where we experienced reduced availability because of conflicting SGS tests, or other anomalies, but these possible incidents are not consistently preserved throughout the test periods.

4.2.5 Spain

Spain collected data for Phase II Part 1 and Phase II Part 2. However, given some limitations on the participation in Part 1, the sample size was very reduced, and for this reason, only data for Phase II Part 2 is presented.

The MEOSAR-ready SPMCC was connected and receiving MEOSAR data from the EU/Maspalomas MEOLUT in two possible operating modes:

- in Standalone Mode, the EU/Maspalomas MEOLUT processed data coming from the 4 MEOLUT local channels and sent alert data to the MEOSAR-ready SPMCC,
- in Networking Mode, the EU/Maspalomas MEOLUT can combine its own generated alert data with TOA/FOA data coming from EU/Spitsbergen MEOLUT (Norway) and/or EU/Larnaca MEOLUT (Cyprus).

The MEOSAR-ready SPMCC was connected to the MEOSAR-ready FMCC and USMCC for receiving MEOSAR alert data.

The MEOSAR-ready SPMCC was not configured to transmit MEOSAR data coming from the EU/Maspalomas MEOLUT to other MCCs, because only the 30 Hex 406 MHz alert format messages were being processed from the MEOLUT (not the 36 Hex 406 MHz format message). Therefore, the MEOSAR-ready SPMCC was not sending real messages to any destination and all messages generated were internally stored.

During the standalone mode period (19 January 2015 00:00 UTC – 20 April 2015 00:00 UTC), sometimes, the MEOSAR-ready SPMCC was receiving data from the MEOLUT configured in networking mode, or with the MEOLUT configured to send self-test alert messages to the MCC. In those cases, either the data was removed from the statistics, considering only a group of selected time periods for the analysis, instead of the whole period, or the MEOLUT was disconnected from the MEOSAR-ready SPMCC.

The MEOSAR-ready SPMCC:

- Name/Manufacturer: McMurdo Inc
- Hardware / Software: HP ML 350p Gen8 running Windows Server 2012, 64 bits
- SW InsarGIS: Version 8.3.0.16 – 12/June/2014.

- SW InsarMP: Version 4.2.0.0 – 12/July/2012.
- SW Version (Core Processing): Insarcore 6.0.2.0 – 17/Jan/2014.
- Configuration / Status: MEOSAR-ready MCC in D&E Version.

4.2.6 USA

Part 1

The USA MEOSAR-ready MCC:

Name/Manufacturer: this is an “in house” implementation
Hardware/Software: rack mount Windows Servers running windows applications
Version (Core Alert Processing): 1.15
Configuration/Status: configured for D&E support and fully operational

National MEOLUTs participating[1]:

Hawaii: fully operational for full duration
Florida: fully operational until 26 April 2014, then down for maintenance
Maryland: fully operational for full duration

International MEOLUTs for which data was received:

France via FMCC: fully operational for full duration
Norway via NMCC and FMCC: fully operational for full duration
Brasilia via BRMCC: fully operational for full duration

Connections to other MEOSAR MCCs:

FMCC: two way exchange of alert data for full duration
BRMCC: two way exchange of alert data for full duration
SPMCC: US transmitted alert data for full duration
PEMCC: US transmitted alert data for full duration
JAMCC: US transmitted alert data for full duration

Part 2

The MEOSAR USMCC:

Name/Manufacturer: this is an “in house” implementation
Hardware/Software: rack mount Windows Servers running windows applications
Version (Core Alert Processing): 1.31
Configuration/Status: configured for D&E support and fully operational

[1] Further information on the availability of MEOLUTs over time is provided below in Figure 1.

National MEOLUTs participating:
- Hawaii
- Florida
- Maryland

International MEOLUTs for which data was received:
- France via FMCC
- Norway via NMCC and FMCC
- Brasillia via BRMCC
- Ankara via TRMCC and FMCC
- Larnaca via CYMCC and FMCC

MEOLUTs connected when networking was active:
- Hawaii
- Florida
- Maryland

Connections to other MEOSAR MCCs:
- FMCC: two way exchange of alert data
- BRMCC: two way exchange of alert data
- SPMCC: US transmitted alert data
- PEMCC: US transmitted alert data
- JAMCC: US transmitted alert data

4.3 Test O-1 Potential Time Advantage

The test O-1 measures the elapsed time between the receipt at an MCC of MEOSAR distress alert messages as compared to those from the existing system (LEOSAR and GEOSAR alert messages).

4.3.1 O-1 Test Result

The following test reports were provided by the participants:

Administration	Test report reference
France	JC-29/4/13 – DE Phase II part II Test O1 Report France_04082015.pdf
Italy	JC-29/Inf. 19
Japan	Sections 4.3.1.3 and 4.3.2.3 to this document.
Norway	Sections 4.3.1.4 and 4.3.2.4 to this document.
Spain	JC-29/Inf.42
USA	Sections 4.3.1.6 and 4.3.2.6 to this document.

4.3.1.1 France

Standalone mode

PTA Summary Results for AOI = FMCC service area (in minutes)

AOI=FMCC service area	PTAE	PTAL	PTAA	PTAC	PTAO	PTAU (vs LEO)	PTAU (vs GEO)
Mean	-2.34	14.27	6.78	25.35	-2.01	11.60	-0.79
Median	0.37	9.73	3.87	18.23	0.74	6.12	0.65
Std Deviation	14.74	17.31	17.70	30.25	21.97	45.08	14.53
N	21	26	49	14	126	38	81

PTA Summary Results for AOI = FMCC service area and participating MEOLUTs coverage (in minutes)

AOI=FMCC service area + MEOLUTs coverage	PTAE	PTAL	PTAA	PTAC	PTAO	PTAU (vs LEO)	PTAU (vs GEO)
Mean	-0.17	14.75	10.25	25.76	-1.19	12.48	-0.88
Median	0.22	10.43	5.68	17.88	0.78	6.20	0.72
Std Deviation	2.15	17.49	16.08	31.45	21.28	45.37	14.89
N	11	25	36	13	111	37	77

Networking mode

PTA Summary Results for AOI = FMCC service area (in minutes)

AOI=FMCC service area	PTAE	PTAL	PTAA	PTAC	PTAO	PTAU (vs LEO)	PTAU (vs GEO)
Mean	-1.13	4.29	3.31	36.15	3.62	18.80	3.27
Median	-1.13	3.87	1.72	24.80	2.47	7.61	2.74
Std Deviation	1.19	19.24	16.79	36.22	7.02	28.34	5.66
N	2	10	13	5	39	12	30

PTA Summary Results for AOI = FMCC service area and participating MEOLUTs coverage (in minutes)

AOI=FMCC service area + MEOLUTs coverage	PTAE	PTAL	PTAA	PTAC	PTAO	PTAU (vs LEO)	PTAU (vs GEO)
Mean	-1.13	6.92	5.05	36.15	3.70	15.05	2.96
Median	-1.13	3.87	1.72	24.80	2.47	7.37	2.27
Std Deviation	1.19	18.35	15.71	36.22	6.96	26.42	4.35
N	2	8	11	5	36	11	27

4.3.1.2 Italy

Standalone mode

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	1.08	19.01	15.50	54.30	0.78
Median:	0.99	13.27	7.88	41.88	0.88
Standard Deviation:	5.45	36.57	33.12	63.51	17.79

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	1.08	17.78	14.21	41.08	0.81
Median:	0.99	11.81	7.75	33.52	0.88
Standard Deviation:	5.45	32.31	28.99	54.03	18.23

Networking mode

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	-2.37	26.95	24.75	20.35	2.23
Median:	-2.37	17.42	14.81	17.65	0.55
Standard Deviation:	N/A[1]	34.19	33.48	29.06	12.00

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	-2.37	28.53	25.99	24.37	2.34
Median:	-2.37	18.58	17.42	19.94	0.55
Standard Deviation:	N/A[1]	35.62	34.83	31.90	12.19

[1] The number of samples for PTAE, in networking mode, was equal to one, therefore, Standard Deviation value cannot be calculated, which is indicated as N/A in the corresponding table cell.

4.3.1.3 Japan

Standalone mode

PTA Summary Results for All Data (in minutes)					
	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	15.42	-148.91	-115.85	-178.93	-22.17
Median:	3.43	-38.10	-1.18	-43.57	2.02
Standard Deviation:	67.02	300.21	280.99	323.19	168.82

PTA Summary Results for AOI Applied (in minutes)					
	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	-0.52	-88.87	-35.86	N/A	11.86
Median:	0.80	-88.87	0.80	N/A	3.12
Standard Deviation:	9.89	171.25	98.60	N/A	94.17

Networking mode

PTA Summary Results for All Data (in minutes)					
	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	−67.79	−50.31	−48.46	40.47	−13.09
Median:	3.67	0.50	0.58	3.85	4.68
Standard Deviation:	215.85	203.21	190.95	300.77	142.10

PTA Summary Results for AOI Applied (in minutes)					
	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	N/A	N/A	N/A	N/A	−10.45
Median:	N/A	N/A	N/A	N/A	4.68
Standard Deviation:	N/A	N/A	N/A	N/A	47.16

4.3.1.4 Norway

Standalone mode

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	12.49	17.39	17.23	17.25	14.67
Median:	3.00	15.65	14.30	21.00	5.71
Standard Deviation:	14.03	48.93	48.62	52.66	36.03

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	10.11	15.58	15.38	8.46	13.12
Median:	3.00	12.25	11.62	5.13	4.90
Standard Deviation:	12.91	52.82	52.34	56.76	35.93

Networking mode

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	4.73	5.98	5.86	24.42	9.95
Median:	6.43	10.07	8.72	22.00	5.17
Standard Deviation:	4.55	40.40	38.34	62.81	16.05

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	4.73	14.14	13.09	32.80	10.15
Median:	6.43	12.87	9.80	31.82	5.32
Standard Deviation:	4.55	20.74	19.78	65.37	16.09

4.3.1.5 Spain

Standalone mode

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	6.93	17.90	23.92	32.90	3.89
Median:	1.40	17.43	7.13	44.42	1.48
Standard Deviation:	22.53	134.84	97.82	133.03	86.07

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	5.08	18.21	17.94	35.14	0.50
Median:	1.40	9.83	4.57	42.22	1.22
Standard Deviation:	18.19	121.04	97.12	102.50	85.49

Networking mode

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	-1.24	52.63	34.96	162.00	16.78
Median:	-0.43	22.65	8.32	72.69	0.97
Standard Deviation:	5.27	103.27	91.82	272.33	70.48

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	-1.24	27.66	13.74	187.79	14.19
Median:	-0.43	18.75	5.22	73.13	0.52
Standard Deviation:	5.27	30.83	25.77	325.51	71.12

4.3.1.6 USA

Part 1 (Stand-Alone Only)

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	4.25	-16.35	-11.09	-58.97	6.16
Median:	0.14	11.48	4.13	18.95	0.88
Standard Deviation:	20.09	159.10	133.52	331.72	20.40

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	4.25	-7.13	-4.61	-52.21	6.04
Median:	0.14	11.05	4.08	17.11	0.90
Standard Deviation:	20.09	117.38	98.19	327.65	20.26

Part 2 – Stand-Alone

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	-2.67	-4.09	-5.21	5.36	0.06
Median:	-0.02	6.11	1.11	17.70	0.27
Standard Deviation:	18.77	68.05	57.98	96.94	25.43

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	-2.67	-4.15	-5.26	5.66	0.01
Median:	-0.01	6.15	1.14	17.98	0.27
Standard Deviation:	18.82	68.30	58.17	97.37	25.47

Part 2 – Networked

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	2.38	5.98	4.74	25.31	-2.02
Median:	0.18	4.07	2.00	13.07	0.28
Standard Deviation:	10.47	63.11	52.88	80.35	33.04

PTA Summary Results for AOI Applied (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	2.38	5.98	4.74	25.31	-2.02
Median:	0.18	4.07	2.00	13.07	0.28
Standard Deviation:	10.47	63.11	52.88	80.35	33.04

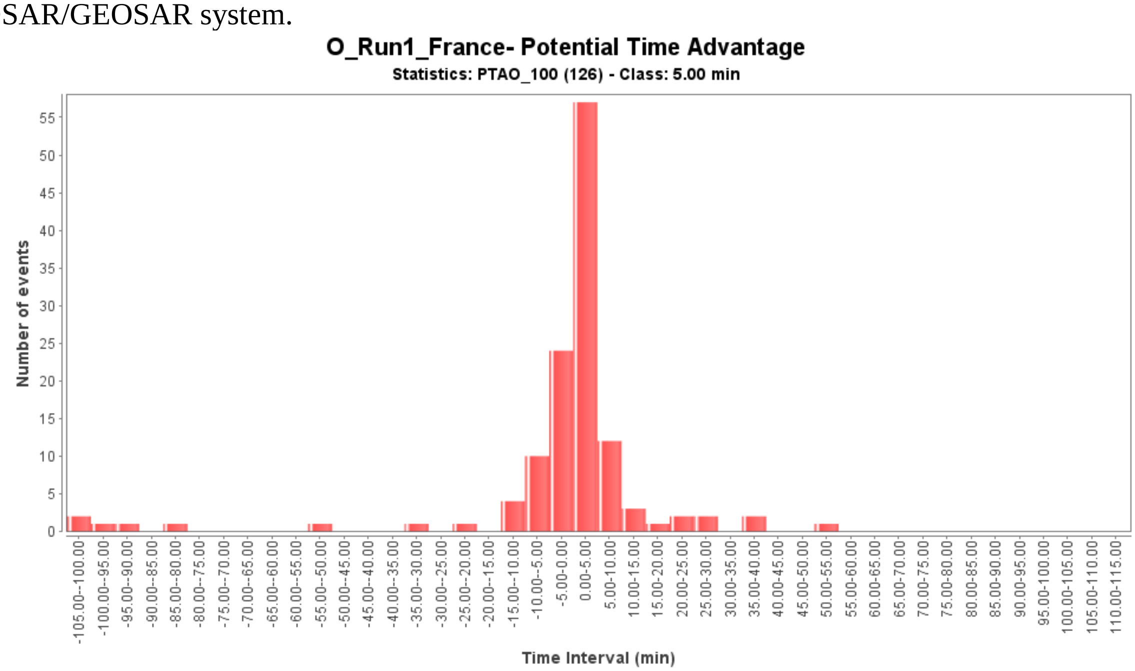
4.3.2 O-1 Test Result Interpretation

4.3.2.1 France

With the samples collected during D&E Phase II part II, it could be noticed that there was:

- a potential time advantage of the MEOSAR system for location confirmation.
- an improvement of this result when networking between MEOLUTs was ensured.
- a potential time advantage of the MEOSAR system for location,
- a very slight advantage of the MEOSAR system for encoded alert messages (in networking only),
- the trend of the analyses shows some potential time advantage to the MEOSAR system that reaches a few minutes in most of the cases. Although the timing is sometimes better for LEOSAR/GEOSAR alerts, this is expected to occur rather less by the time when the MEOSAR constellations are complete. The space segment current characteristics can explain part of the large differences in the alert delays. The trend of the data set indicates that MEOSAR should provide at least as good as LEOSAR/GEOSAR alert timing, but it is expected that the time advantage be especially better for position confirmation data.

A first complementary analysis on the PTAO distributions (highest number of samples) has been conducted. It shows that the PTAO for MEOSAR is between 0 and 5 minutes for almost 45% of the samples. The left hand side of this histogram on the following figure illustrates the events for which the LEOSAR/GEOSAR data was available before the MEOSAR data. Cases where the difference is beyond 30 minutes occurred more often for beacon alerts that were first notified by the LEOSAR/GEOSAR system.

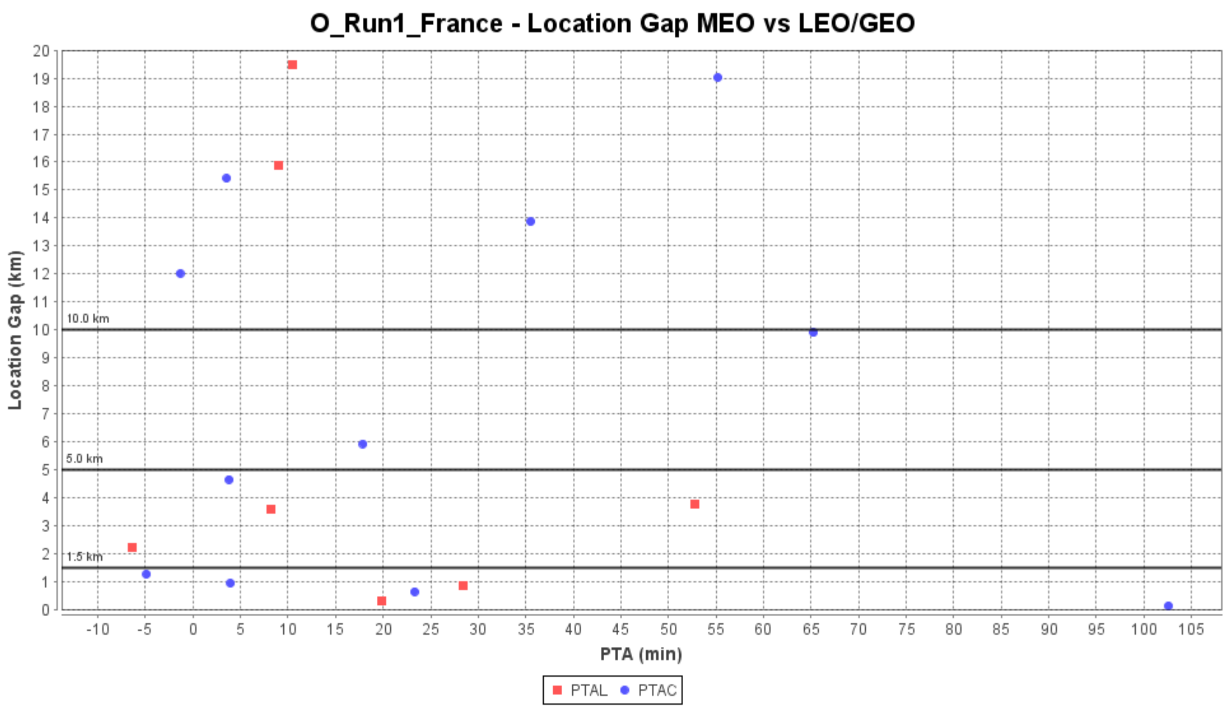


Overall Time Advantage in Stand-Alone Mode (FMCC Service Area)

A second complementary analysis aimed to put into perspective the Potential Time Advantage versus the location accuracy. As the beacon's locations are unknown, the LEOSAR/GEOSAR computed positions are considered as references and the MEOSAR location errors are calculated relatively to them. Therefore, the "errors" presented here represent the distance between MEOSAR and LEOSAR/GEOSAR computed positions.

As shown in the following figure:

- The locations errors do not show any visible trend with respect to both PTAL and PTAC. The general expected trend would be to have larger errors in case of high PTAs but it is not always the case,
- As expected, the location confirmations (PTAC) show better accuracy with time,
- A large part of the locations "errors" are within 20 km (only 10 points >20km, and 4 points >100 km). Most of the high error values are linked to a great distance between the locating MEOLUT and the beacon LEOSAR/GEOSAR position. However, it is known that MEOLUT location accuracy is currently very variable in time and depends on the space segment/beacon/MEOLUT instant geometry: as no clear trend seems to appear, and due to the limited amount of data to process, drawing a relevant conclusion is premature.



Distance Between MEOSAR and LEOSAR/GEOSAR Locations vs Potential Time Advantage for MEOSAR (Stand-Alone)

4.3.2.2 Italy

The Area of Interest was defined by the portion of ITMCC Service Area covered by participating MEOLUTs within a radius of 3,000 km.

Overall, the MEOSAR system reported a time advantage in the notification of alerts of about 1 minute, compared to the existing system.

In the computation of independent location (PTAL) and confirmation of position (PTAC), the new system performed better reporting a median value of 14 minutes and 35 minutes, respectively. The high standard deviation values however demonstrate the variability of results most likely due either to the current space segment configuration or ground segment availability and performance.

The results for MEOLUTs in networking mode are based on 29 samples that are not representative enough, however all the categories reported positive performance of the MEOSAR system, except for PTAE where the lack of data did not make a comparison possible.

Complementary analysis showed the time delay (median value) for the LEOSAR-system-only to detect and process a beacon compared to the MEOSAR system while comparison to GEOSAR-system-only produced only a slight difference.

4.3.2.3 Japan

In respect of this O-1 test, participants shall report results for an AOI that coincides with the MCC service area. However, since there are not many beacons in JAMCC service area, we shall provide the results that includes alerts in China, the Philippines, Korea, Vietnam, and other areas in the NWPDDR. In both periods, JAMCC could receive enough alerts on this area to analyse.

During the standalone mode period, JAMCC received 283 alerts.

- With respect to PTAC, 30% of alerts show positive with Potential Time Advantage of MEOSAR. Alert sample size was 65.
- With respect to PTAO, 70% of alerts were positive and the median showed 2 minutes PTA of MEOSAR.

During the network mode period, 119 alerts were received.

- With respect to PTAC, 55% of alerts showed positive Potential Time Advantage of MEOSAR and the median was about 4 minutes. Alert sample size was 35.
- With respect to PTAO, 75% of alerts showed a positive MEOSAR time advantage and the median showed 4 and a half minutes of PTA of MEOSAR.

Conclusions from results.

- In standalone mode period, remarkable time advantage wasn’t apparent.
- A slight time advantage was shown in the networking mode period.

4.3.2.4 Norway

The Area of Interest (AOI) was comprised of the NMCC service area consisting of supported SPOCs and Norway covered by the EU/MEOLUT – Spitsbergen. Standalone period was based on 236 samples, while in networking period there was 59 recorded alert notifications where both MEOSAR and LEOSAR/GEOSAR had detections for the same beacon ID. Such a small sample of data in the networking period may not be sufficiently representative, and results from the two periods might not be directly comparable because of the shorter test period.

From the data collected at NMCC during D&E Phase II Part 2 it could be noted:

- A potential time advantage of about 5 minutes for all categories during standalone and networking mode of operations,
- For independent location (PTAL) and confirmation of position (PTAC) the MEOSAR system demonstrated time advantages with a median of about 12 and 5 minutes, respectively, while for MEOLUTs in networking mode the PTAL and PTAC values were 12 and 32 minutes,
- An improvement for position confirmation when MEOLUTs in network mode,
- A minor time advantage of the MEOSAR system for encoded alert messages.

Based on the analysis of the collected data sample there is a potential positive time advantage in favour of the MEOSAR system. This premature conclusion should be supported by another test campaign where the test period duration is expanded to provide more representative analyses and results. However, the current interpretation of results is that this time advantage will be further substantiated when the MEOSAR space and ground segment is more complete.

4.3.2.5 Spain

The dataset provided covered all the SPMCC Service Area.

During the standalone mode period (19/Jan/2015 00:00 UTC – 20/Apr/2015 00:00 UTC), sometimes the data received from EU/Maspalomas MEOLUT suffered a processing delay at the MEOSAR-ready MCC. When an excessive time delay was noted, this time delay was compensated, adjusting the original delayed time tag to a time close to the transmission time of the MEOLUT. Alert messages coming from MEOSAR-ready USMCC or FMCC did <u>not</u> suffer from this delay, being processed in real-time.

For the networking mode period (20/Apr/2015 00:00 UTC – 11/May/2015 00:00 UTC), the above-mentioned processing delay was accumulative since the very beginning, and it was not possible to correlate, in most of the cases, the data coming from external MCCs for the same beacon activation with the local EU/Maspalomas MEOLUT data. Therefore, for this period, and for the most of the cases analysed, the detection, localization and confirmation messages came from external MCCs, which did not suffer the processing delay.
Based on EU/Maspalomas MEOLUT Networking configuration, solutions provided by MEOSAR-ready FMCC, coming from MEOSAR-ready NMCC or CYMCC, could have their origin in TOA/FOA data computed by EU/Maspalomas MEOLUT, covering, in this way, the SPMCC AOI.

- The data sample for standalone mode period was 225 alerts and the data sample for the networking mode period was 58 alerts.
- In general, the Potential Time Advantage of MEOSAR versus LEOSAR/GEOSAR is positive, mainly in the PTAC (Potential Time Advantage Confirmation), which presented a median value of around 43 minutes.
- The networking mode provides an improvement in PTAL and PTAC over the positive values already obtained for standalone mode. The median value for PTAC is increased by 30 minutes, reaching a value around 73 minutes.
- In networking mode the PTAE values are negative. As commented above, during this time the data from EU/Maspalomas MEOLUT was not directly available due to a processing delay for the local data. Therefore, the data readily available at the MEOSAR-ready MCC came from external MCCs which, due to communications latency, could produce the slight negative PTAE figures observed.
- The “AOI Applied” table does not show, in general, an improvement, with respect to the “All Data” table. On the contrary, for some PTAs they are even worse in the “AOI Applied” table with respect to “All Data” table. One possible explanation is that beacons out of the Maspalomas AOI are located southward near the coast of Togo, and in this area, with low latitudes, LEOSAR presents more latency, that is, the nearer a location is to the Equator, the longer the periods between LEOSAR passes. Therefore, in these cases the MEOSAR could provide a better PTA response than LEOSAR, however, that contribution is removed when applying the 3000 km AOI radius. Therefore, the “All Data” versus “AOI Data” results comparison suggests that AOI radius filtering could be increased beyond 3000 km, at least with respect to the Potential Time Advantage of MEOSAR versus LEOSAR. In the following table, all data within AOI have been removed, only data OUT of AOI is presented. It can be noted the high number of positive PTAs versus negative PTAs and also the value of the median figures. There is only one large negative sample (about -650 minutes) which makes standard deviation increase in PTAL and PTAC.

PTA Summary Results for All Data (in minutes)

	PTAE	PTAL	PTAA	PTAC	PTAO
Mean:	44.93	16.78	52.28	28.42	38.71
Median:	44.93	28.28	30.17	51.65	7.14
Standard Deviation:	71.06	179.31	98.61	182.65	86.48
MAX PTA:	95.18	417.08	417.08	187.87	359.55
MIN PTA:	-5.32	-621.43	-67.80	-679.47	-28.15
N (Positive PTA):	1	16	16	15	14
N (Negative PTA):	1	4	4	5	6

- An alternative analysis is provided in the following table for the standalone period with calculations of PTAU and PTAE of MEOSAR vs LEOSAR and MEOSAR vs GEOSAR, and it was noted that:

- The Potential Time Advantage from MEOSAR versus GEOSAR is only slightly positive, for both Unlocated and Encoded Located alerts (PTAUVG and PTAEVG), which seems to indicate that in the SPMCC case at least, where the Service Area is covered by three GEOSAR Satellites (GOES-E, M2 and M3), the improvement provided by MEOSAR for Unlocated and/or Encoded Only alerts over GEOSAR is not so high.
- However, it was noted that the Potential Time Advantage MEOSAR versus LEOSAR for Unlocated and Encoded Located alert (PTAUVL and PTAEVL) presented higher PTA values than those obtained for MEOSAR vs GEOSAR.
- Given that the high number of Encoded Located GEOSAR detections can bias the PTAE global measurement, it is worth presenting PTAE values separated by PTA of MEOSAR versus LEOSAR (PTAEVL) and PTA MEOSAR versus GEOSAR (PTAEVG).
- Therefore, in order to have a better perspective of the MEOSAR behaviour versus the LEOSAR/GEOSAR system, it is considered interesting to include, in future spreadsheets, the analysis of the PTAEVG and PTAEVL measurements.
- For the same reason, given that same behaviour was noted also for unlocated alerts, it is also considered interesting to add the PTAUVG and PTAUVL to the spreadsheet.

PTA Summary Results for All Data (in minutes)

	PTAUVG	PTAUVL	PTAEVG	PTAEVL
Mean:	3.41	13.46	5.60	42.44
Median:	0.72	4.38	0.67	16.32
Standard Deviation:	21.56	136.94	17.76	74.93
MAX PTA:	193.28	539.30	95.18	336.95
MIN PTA:	-63.45	-306.30	-5.32	-42.42
N (Positive PTA):	71	17	23	22
N (Negative PTA):	34	5	12	1

PTA Summary Results for AOI Applied (in minutes)

	PTAUVG	PTAUVL	PTAEVG	PTAEVL
Mean:	3.11	13.46	3.21	40.05
Median:	0.73	4.38	0.67	13.92
Standard Deviation:	21.04	136.94	8.65	77.40
MAX PTA:	193.28	539.30	36.85	336.95
MIN PTA:	-63.45	-306.30	-3.97	-42.42
N (Positive PTA):	67	17	22	20
N (Negative PTA):	33	5	11	1

4.3.2.6 USA

Part 1

MEOSAR appeared to be faster at providing unlocated alerts to the system.

MEOSAR did not show a time advantage in located alerts.

A limited satellite constellation appears to provide an explanation for the underlying cause of poor MEOSAR performance as it relates to located alerts.

The USA O-1 results appear to diminish slightly within the AOI relative to the service area.

Part 2

Key observations on the results analysis process are as follows:

- Removing the data with extremely large gaps improves the statistics for MEOSAR, and is likely a more realistic measure of performance
- Applying the AOI appears to have little or no impact on the results
- The median appears to be a better measure of performance as the mean (or average) is easily skewed by data with very large values, and the average should perhaps be removed
- The category PTAO includes notifications for unlocated alerts while no other column reports this data, and this could lead to confusion when interpreting the results, so a PTAU column should perhaps be added
- The time of notification for unlocated alerts is generally a minute or two faster for LEOSAR/GEOSAR than MEOSAR, and the suspected reasons are potential configuration details in USA MEOLUTs as well as a slightly more efficient communications path for GEOLUT data (MEOLUT data goes through an additional FTP server).

Conclusions determined from these results are as follows:

- Using the median is a more practical measure of performance
- MEOSAR provides a clear time advantage in the independent location related categories (PTAL and PTAC) but does not with respect to detect only data
- MEOLUT networking further increased this time advantage in the independent location related categories

4.4 Test O-2 Unique Detections by MEOSAR System as Compared to Existing System

4.4.1 O-2 Test Result

The following test reports were provided by the participants:

Administration	Test report reference
France	France D&E Phase 2 Part 2 Operational Tests Report Sections 6.1.2 & 6.2.2, SAR-RE-DEMEO-917-CNES
Italy	JC-29/Inf. 20
Japan	Section 4.4.1.3 and 4.4.2.3 to this document.
Norway	JC-29/4/5 O-2 additional analysis
Spain	JC-29/Inf.42 / Additional analysis on Standalone Period in Section 4.4.1.5 to this document.
USA	Section 4.4.1.6 and 4.4.2.6 to this document.

4.4.1.1 France

Standalone mode

PTA Summary Results for AOI = FMCC service area (in minutes)

	Any Detection		Unlocated		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	91	13.15	47	11.33	1	1.05	30	28.30	13	17.11
MEO only	477	68.93	332	80.00	90	94.74	41	38.68	14	18.42
Both Systems	124	17.92	36	8.67	4	4.21	35	33.02	49	64.47
Total	692	100.00	415	59.97	95	13.73	106	15.32	76	10.98

PTA Summary Results for AOI = FMCC service area and participating MEOLUTs coverage (in minutes)

	Any Detection		Unlocated		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	79	13.74	46	11.14	0	0.00	23	23.47	10	16.39
MEO only	387	67.30	331	80.15	3	100.00	40	40.82	13	21.31
Both Systems	109	18.96	36	8.72	0	0.00	35	35.71	38	62.30
Total	575	100.00	413	71.83	3	0.52	98	17.04	61	10.61

Networking mode

PTA Summary Results for AOI = FMCC service area (in minutes)

	Any Detection		Unlocated		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	20	6.39	11	5.82	1	1.75	7	16.28	1	4.17
MEO only	254	81.15	170	89.95	55	96.49	21	48.84	8	33.33
Both Systems	39	12.46	8	4.23	1	1.75	15	34.88	15	62.50
Total	313	100.00	189	60.38	57	18.21	43	13.74	24	7.67

PTA Summary Results for AOI = FMCC service area and participating MEOLUTs coverage (in minutes)

	Any Detection		Unlocated		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	19	6.29	11	5.82	1	1.96	6	15.00	1	4.55
MEO only	247	81.79	170	89.95	49	96.08	21	52.50	7	31.82
Both Systems	36	11.92	8	4.23	1	1.96	13	32.50	14	63.64
Total	302	100.00	189	62.58	51	16.89	40	13.25	22	7.28

4.4.1.2 Italy

Standalone mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	85	12.02%	2	0.28%	29	4.10%	10	1.41%
MEO only	459	64.92%	39	5.52%	51	7.21%	39	5.52%
Both Systems	163	23.06%	2	0.28%	46	6.51%	88	12.45%
Neither System	0	0.00%	664	93.92%	581	82.18%	570	80.62%
Total Beacon Events	707		707		707		707	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	79	12.04%	1	0.15%	25	3.81%	9	1.37%
MEO only	434	66.16%	39	5.95%	33	5.03%	32	4.88%
Both Systems	143	21.80%	9	1.37%	29	4.42%	47	7.16%
Neither System	0	0.00%	607	92.53%	569	86.74%	568	86.59%
Total Beacon Events	656		656		656		656	

Networking mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	23	11.00%	0	0.00%	11	5.26%	2	0.96%
MEO only	157	75.12%	11	5.26%	19	9.09%	12	5.74%
Both Systems	29	13.88%	0	0.00%	4	1.91%	18	8.61%
Neither System	0	0.00%	198	94.74%	175	83.73%	177	84.69%
Total Beacon Events	209		209		209		209	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	21	10.45%	0	0.00%	9	4.48%	2	1.00%
MEO only	152	75.62%	11	5.47%	16	7.96%	10	4.98%
Both Systems	28	13.93%	0	0.00%	7	3.48%	6	2.99%
Neither System	0	0.00%	190	94.53%	169	84.08%	183	91.04%
Total Beacon Events	201		201		201		201	

4.4.1.3 Japan

Standalone mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	176	14.70%	10	0.84%	39	3.26%	37	3.09%
MEO only	827	69.09%	176	14.70%	20	1.67%	25	2.09%
Both Systems	194	16.21%	6	0.50%	33	2.76%	72	6.02%
Neither System	0	0.00%	1005	83.96%	1105	92.31%	1063	88.81%
Total Beacon Events	1197		1197		1197		1197	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	112	11.16%	8	0.80%	6	0.60%	8	0.80%
MEO only	782	77.89%	176	17.53%	0	0.00%	3	0.30%
Both Systems	110	10.96%	5	0.50%	0	0.00%	1	0.10%
Neither System	0	0.00%	815	81.18%	998	99.40%	992	98.80%
Total Beacon Events	1004		1004		1004		1004	

Networking mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	63	16.15%	1	0.26%	18	4.62%	16	4.10%
MEO only	269	68.97%	5	1.28%	11	2.82%	20	5.13%
Both Systems	58	14.87%	1	0.26%	16	4.10%	22	5.64%
Neither System	0	0.00%	383	98.21%	345	88.46%	332	85.13%
Total Beacon Events	390		390		390		390	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	31	10.51%	1	0.34%	1	0.34%	1	0.34%
MEO only	234	79.32%	1	0.34%	0	0.00%	0	0.00%
Both Systems	30	10.17%	0	0.00%	0	0.00%	0	0.00%
Neither System	0	0.00%	293	99.32%	294	99.66%	294	99.66%
Total Beacon Events	295		295		295		295	

4.4.1.4 Norway

Standalone mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	76	9.07 %	0	0.00 %	29	3.46 %	26	3.10 %
MEO only	718	85.68 %	25	2.98 %	25	2.98 %	26	3.10 %
Both Systems	44	5.25 %	1	0.12 %	14	1.67 %	25	2.98 %
Neither System	0	0.00 %	812	96.90 %	770	91.89 %	761	90.81 %
Total Beacon Events	838		838		838		838	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	71	8.55 %	0	0.00 %	27	3.25 %	23	2.77 %
MEO only	716	86.27 %	23	2.77 %	25	3.01 %	26	3.13 %
Both Systems	43	5.18 %	0	0.00 %	11	1.33 %	20	2.41 %
Neither System	0	0.00 %	807	97.23 %	767	92.41 %	761	91.69 %
Total Beacon Events	830		830		830		830	

Networking mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	185	18.14 %	37	3.63 %	11	1.08 %	121	11.86 %
MEO only	808	79.22 %	33	3.24 %	9	0.88 %	14	1.37 %
Both Systems	27	2.65 %	0	0.00 %	6	0.59 %	19	1.86 %
Neither System	0	0.00 %	950	93.14 %	994	97.45 %	866	84.90 %
Total Beacon Events	1020		1020		1020		1020	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	184	18.24 %	37	3.67 %	10	0.99 %	121	11.99 %
MEO only	805	79.78 %	33	3.27 %	8	0.79 %	12	1.19 %
Both Systems	20	1.98 %	0	0.00 %	4	0.40 %	11	1.09 %
Neither System	0	0.00 %	939	93.06 %	987	97.82 %	865	85.73 %
Total Beacon Events	1009		1009		1009		1009	

4.4.1.5 Spain

Standalone mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	65	7.78%	8	0.96%	12	1.44%	25	2.99%
MEO only	486	58.13%	55	6.58%	45	5.38%	30	3.59%
Both Systems	285	34.09%	12	1.44%	75	8.97%	147	17.58%
Neither System	0	0.00%	761	91.03%	704	84.21%	634	75.84%
Total Beacon Events	836		836		836		836	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	52	6.97%	8	1.07%	8	1.07%	16	2.14%
MEO only	458	61.39%	55	7.37%	30	4.02%	17	2.28%
Both Systems	236	31.64%	25	3.35%	35	4.69%	67	8.98%
Neither System	0	0.00%	658	88.20%	673	90.21%	646	86.60%
Total Beacon Events	746		746		746		746	

Networking mode

All Data

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	30	10.07%	2	0.67%	5	1.68%	16	5.37%
MEO only	202	67.79%	20	6.71%	17	5.70%	6	2.01%
Both Systems	66	22.15%	0	0.00%	23	7.72%	31	10.40%
Neither System	0	0.00%	276	92.62%	253	84.90%	245	82.21%
Total Beacon Events	298		298		298		298	

AOI Applies

	Any Detection		Encoded Position		Independent Position		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	20	7.46%	2	0.76%	5	1.87%	6	2.24%
MEO only	194	72.39%	18	6.87%	14	5.22%	3	1.12%
Both Systems	54	20.15%	0	0.00%	8	2.99%	10	3.73%
Neither System	0	0.00%	248	92.54%	241	89.93%	249	92.91%
Total Beacon Events	268		268		268		268	

4.4.1.6 USA

Part 1 (Stand-Alone Only)

All Data	Any Detection		Encoded Position		Independent		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	276	16.42%	9	0.54%	64	3.81%	50	2.97%
MEO only	792	47.11%	58	3.45%	29	1.73%	32	1.90%
Both Systems	613	36.47%	20	1.19%	128	7.61%	239	14.22%
Neither System	0	0.00%	1594	94.82%	1460	86.85%	1360	80.90%
Total Beacon Events	1681		1681		1681		1681	

AOI Applies	Any Detection		Encoded Position		Independent		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	250	16.17%	9	0.58%	48	3.10%	40	2.59%
MEO only	780	50.45%	58	3.75%	26	1.68%	23	1.49%
Both Systems	516	33.38%	28	1.81%	69	4.46%	144	9.31%
Neither System	0	0.00%	1451	93.86%	1403	90.75%	1339	86.61%
Total Beacon Events	1546		1546		1546		1546	

Part 2 Stand-Alone

All Data	Any Detection		Encoded Position		Independent		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	970	17.67%	37	0.67%	296	5.39%	318	5.79%
MEO only	2704	49.25%	418	7.61%	102	1.86%	91	1.66%
Both Systems	1816	33.08%	74	1.35%	475	8.65%	694	12.64%
Neither System	0	0.00%	4961	90.36%	4617	84.10%	4387	79.91%
Total Beacon Events	5490		5490		5490		5490	

AOI Applies	Any Detection		Encoded Position		Independent		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	693	14.37%	36	0.75%	172	3.57%	166	3.44%
MEO only	2628	54.51%	386	8.01%	78	1.62%	71	1.47%
Both Systems	1500	31.11%	104	2.16%	237	4.92%	368	7.63%
Neither System	0	0.00%	4295	89.09%	4334	89.90%	4216	87.45%
Total Beacon Events	4821		4821		4821		4821	

Part 2 Networked

All Data								
	Any Detection		Encoded Position		Independent		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	253	7.85%	8	0.25%	93	2.89%	69	2.14%
MEO only	2379	73.84%	281	8.72%	39	1.21%	65	2.02%
Both Systems	590	18.31%	10	0.31%	134	4.16%	277	8.60%
Neither System	0	0.00%	2923	90.72%	2956	91.74%	2811	87.24%
Total Beacon Events	3222		3222		3222		3222	

AOI Applies								
	Any Detection		Encoded Position		Independent		Confirmed Position	
	Count	%	Count	%	Count	%	Count	%
LEO/GEO only	190	6.31%	8	0.27%	60	1.99%	39	1.29%
MEO only	2325	77.19%	268	8.90%	24	0.80%	39	1.29%
Both Systems	497	16.50%	30	1.00%	93	3.09%	103	3.42%
Neither System	0	0.00%	2706	89.84%	2835	94.12%	2831	93.99%
Total Beacon Events	3012		3012		3012		3012	

4.4.2 O-2 Test Result Interpretation

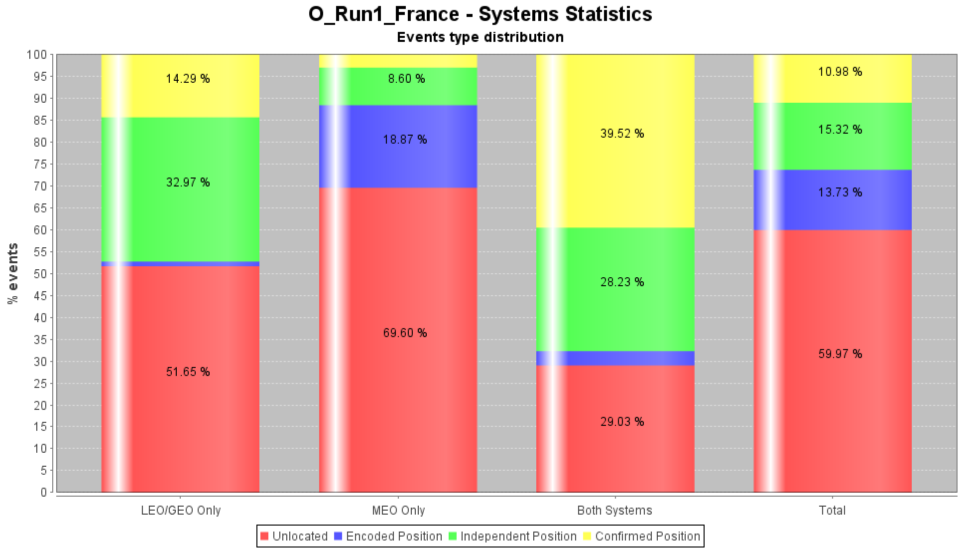
4.4.2.1 France

Results show that there is no difference when considering an area of interest defined by the FMCC service area or an area of interest defined by the FMCC service area extended by MEOLUTs coverage.

Comparison between the MEOSAR and the LEOSAR/GEOSAR system indicates a very high number of events generated by the MEOSAR system, two thirds of those being Unlocated alerts.

The MEOLUT networking operating mode seems to degrade the situation by relatively increasing the number of Unlocated detections that becomes 15 times higher than it is for the LEOSAR/GEOSAR system. Compared to the stand-alone operating mode, the networking operating mode increases the number of detections. In the data set collected during the “networking” part of the test the amount of MEOSAR detections doubles in relative size.

However, a small proportion of MEOSAR unique detections seem to lead to unique locations. Nonetheless, conclusions could not be taken on the realism of the MEOSAR alerts; the number of Unlocated alerts being excessive and some further analyses needs to be carried out on the existence of beacons located by the MEOSAR system.



Events type distribution for each system (standalone mode)

4.4.2.2 Italy

Overall the MEOSAR system detected more beacons and provided more independent locations than the LEOSAR/GEOSAR system.

Applying the Area of Interest produced only slight differences in all categories, most likely due to the fact that most of beacons were located inside the coverage area provided by participating MEOLUTs within a 3,000 km radius circle.

MEOLUTs in networking increased from 65% to 75% the number of MEOSAR-only detections.

The results from a complementary analysis showed the impact of unlocated alerts over the statistics demonstrating that 72% of beacons detected by MEOSAR-only were unlocated.

However, the LEOSAR/GEOSAR-system-only results underscored some lacks in the detection and in the computation of independent location compared to the new system, which needs further investigation.

4.4.2.3 Japan

There was little data in the JAMCC service area. Therefore, JAMCC analyzed beacon detections within the NWPDDR.

In the standalone period, the number of MEOSAR detections were 1,021 and LEO-GEO detection were 370. According to the data, MEOSAR detection were 3 times larger than LEO-GEO. And 70% of MEO had no location information.

In the networking period, the number of MEOSAR detections were 327 and LEO-GEO detections were 121. According to the data, MEOSAR detection were 3 times larger than LEO-GEO. And, 80% of MEO had no location information.

The results shows that MEOSAR detects more beacons than LEO/GEO.
It is considered possible that the fact that no MEOLUT in NWPDDR caused many alerts with no location data to be detected. There are no obvious difference between networking period and standalone period. This also may be influenced by there being no MEOLUTs in the NWPDDR.

4.4.2.4 Norway

As noted by Norway in previous O-2 additional analysis presented at JC-29 (JC-29/4/5), there is a high amount of unique MEO-only detections. MEO-only consists of approximately 86% of the total beacon events in standalone mode, and about 80% of the alerts in networking mode of operation is from MEO only detections. Most of the detections counted is from unlocated beacons, 89.4% of the detections was unlocated beacons during standalone mode, and 94% was unlocated during networking mode. In our interpretation of the results we find it remarkable that MEOLUTs in networking mode seems to increase the amount of detect only cases without impacting other categories significantly.

From the analysis results it is noted that there is little or no difference when applying an Area of interest defined by the MEOLUT coverage area. This is most probably because the MEOLUT CA of 3000 km radius extends the NMCC service area, and the greater part of the beacons were located inside the MEOLUTs coverage area.

Based on the collected data and analysis of unique detections by MEOSAR it is difficult to draw any conclusions at this stage. MEOSAR for sure proves its capability of detecting beacons, and the large amount of “phantom” beacons could be compensated by proper filtering methods at MCC and/or MEOLUT level. However we would recommend further investigation and additional operational tests to support and demonstrate the MEOSAR system advantages.

4.4.2.5 Spain

With respect to report JC-29/Inf.42, some refinement has been applied to the Standalone dataset, and the figures in section 4.4.1.5 have changed slightly with respect to the figures for Standalone period presented in JC-29 meeting report Inf.42.

A high percent of MEO Only detections was noted, that is, there were between 58% and 62% MEOSAR Only Detections in standalone mode, and between 68% and 72% of alerts detected by MEO Only in Networking mode of operation.

It was also noted that beacon alerts detected by both systems did not always contain the same history in the Beacon Alert Type, that is, some beacon events detected by LEO as U (Unlocated) could be detected by MEO as DC (DOA Confirmed) alerts.

Taking All Data detected in Standalone Mode of operation, and from those 285 alerts detected by both systems, a break-down per alert type categories was done, obtaining the following table:

ONLY	LEO/GEO	20	8	10	2	20	5	65
MEO	BOTH	U	E	D	ED	DC	EDC	Subtotal
356	U	51	0	15	0	15	1	82
55	E	1	11	1	1	0	5	19
43	D	37	0	17	0	4	0	58
2	ED	0	3	1	0	0	3	7
25	DC	20	0	12	0	50	4	86
5	EDC	0	11	0	0	0	22	33
486	Sub Total	109	25	46	1	69	35	285

Phase II Part 2 – Standalone Period

As it can be observed in the previous table, there is a diagonal in grey colour, which indicates which beacon alerts detected by both systems have exactly the same alert types. Symmetric to this diagonal appear the figures corresponding to those beacon events detected by both systems for all different Alert Types combinations.

At this point, the comparison between MEOSAR and GEOSAR/LEOSAR systems is performed using mirror pairs to this diagonal. As it can be observed in previous table, MEOSAR provided 37 beacon events with DOA, when those beacon events were provided as Unlocated by GEOSAR/LEOSAR system, and the LEOSAR system provided 15 Doppler beacon events, when those beacon events were provided as Unlocated by MEOSAR.

ONLY	LEO/GEO	7	2	5	0	14	2	30
MEO	BOTH	U	E	D	ED	DC	EDC	Subtotal
159	U	12	0	2	0	1	0	15
20	E	0	0	0	0	1	1	2
17	D	15	0	4	0	0	0	19
0	ED	1	1	0	0	0	0	2
5	DC	2	0	7	0	11	0	20
1	EDC	0	5	0	0	0	3	8
202	Subtotal	30	6	13	0	13	4	66

Phase II Part 2 – Networking Period

The previous table presents a similar analysis for the 66 beacon alerts detected by both systems, when All Data is considered in the Networking Mode of operation.

While admitting that the data sample is small, only 66 samples, it is noted the ratio of MEOSAR DOA detected when those alerts were detected Unlocated by LEO (15), over the number of GEOSAR/LEOSAR Doppler detected alerts when those alerts were detected Unlocated by MEOSAR (2).

It is also noted the number of MEOSAR Confirmed alerts with Encoded Position that were received as Encoded Only by LEOSAR (5) over the number of Encoded Only MEOSAR that were confirmed by GEOSAR/LEOSAR (1).

4.4.2.6 USA

Part 1

MEOSAR produces a large number of detect only cases, and a large portion of those are not detected by the LEOSAR/GEOSAR system

The USA O-2 results do not appear to improve within the AOI relative to the service area

Lack of opportunity (i.e., visibility) does not seem to provide an explanation for the underlying cause of many missed detections from either system

Part 2

Key observations on the results (all number references are from the complete data set) are as follows:

- MEOSAR produces a large number of detect only cases (4829 unlocated and 783 encoded only) relative to the LEOSAR/GEOSAR system (1144 unlocated and 129 encoded only), an increase by factor of 4 for unlocated and 6 for encoded only, and further analysis indicated that as much as 80% of this data appeared to be system generated anomalies
- The number of LEOSAR/GEOSAR only cases for all categories, but in particular for independent location (389) or confirmed positions (387), is a concern as these indicate a lack of detections for what are most likely all real beacon activations
- The data set is reduced, but statistics do not significantly change, when the AOI is applied
- Networking of MEOLUTs appears to increase the amount of detect only cases, but did not significantly impact other categories in this result set
- The number of MEOSAR only cases where there was independent location (141) or confirmed positions (156) demonstrates the value MEOSAR adds to the current system as these are most likely real beacon activations that went undetected by the LEOSAR/GEOSAR system due to gaps between LEOSAR satellite times of visibility

In the short term, concerns related to suspect alerts can be largely mitigated by appropriate filtering at MCCs. While the lack of MEOSAR detections needs to be improved, the significant number of MEOSAR only cases with independent location and confirmed position soundly demonstrates the value MEOSAR adds to the current system.

4.5 Test O-3 Volume of MEOSAR Distress Alert Traffic in the Cospas-Sarsat Ground Segment Network

4.5.1 O-3 Test Result

The following test reports were provided by the participants:

Administration	Test report reference
France	France D&E Phase 2 Part 2 Operational Tests Report, sections 6.1.3 & 6.2.3 SAR-RE-DEMEO-917-CNES
Italy	JC-29/Inf. 21
Japan	Sections 4.5.1.3 and 4.5.2.3 to this document.
Norway	Sections 4.5.1.4 and 4.5.2.4 to this document.
Spain	JC-29/Inf.42
USA	Sections 4.5.1.4 and 4.5.2.4 to this document.

4.5.1.1 France

All SIT messages sizes are assumed 1024 bytes.

Standalone Mode

Data received by the FMCC

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	Total	Data Volume (B)	Bandwidth (kbit/s)
LEO_GEO	48199	438	76	32347	590	5400	57	491	87598	89700352	0.09127159
MEO	12161	400	1190	5402	19262	11659	93	101	50268	51474432	0.05237609
Combined	60360	838	1266	37749	19852	17059	150	592	137866	141174784	0.14364768

Data sent out by the FMCC

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	Total	Data Volume (B)	Bandwidth (kbit/s)
LEO_GEO	2702	58	10	1780	187	1339	62	543	6681	6841344	0.00696201
MEO	6697	371	985	977	9374	12013	122	108	30647	31382528	0.03107630
Combined	9399	429	995	2757	9561	13352	184	651	37328	38223872	0.03785096

Networking Mode

Data received by the FMCC (Network)

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	Total	Data Volume (B)	Bandwidth (kbit/s)
LEO_GEO	14684	163	36	10375	163	1745	13	133	27312	27967488	0.11771571
MEO	14139	290	658	2921	10564	7520	57	56	36205	37073920	0.15605472
Combined	28823	453	694	13296	10727	9265	70	189	63517	65041408	0.27375194

Data sent out by the FMCC (Network)

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	Total	Data Volume (B)	Bandwidth (kbit/s)
LEO_GEO	835	14	5	617	60	410	13	141	2095	2145280	0.00904303
MEO	4922	168	315	494	3525	8757	86	51	18318	18757632	0.07895902
Combined	5757	182	320	1111	3585	9167	99	192	20413	20902912	0.08798943

4.5.1.2 Italy

Standalone Mode

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	#Total	Data Volume	Bandwidth
LEO_GEO	9416	269	134	3861	140	2208	9	133	16170	16558080	0.016849
MEO	19	1	0	28	374	66	29	54	571	584704	0.000602
Combined	9435	270	134	3889	514	2274	38	187	16741	17142784	0.017444

Notes
For QMS in the LEO/GEO system please note that ITMCC sent to the nodal FMCC:
- 6928 SIT 122 messages
- 2391 SIT 125 messages

Networking Mode

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	#Total	Data Volume	Bandwidth
LEO_GEO	2121	72	32	925	31	612	1	26	3820	3911680	0.017250
MEO	11	0	0	9	13	7	17	35	92	94208	0.000433
Combined	2132	72	32	934	44	619	18	61	3912	4005888	0.017665

Notes
For QMS in the LEO/GEO system please note that ITMCC sent to the nodal FMCC:

- 1640 SIT 122 messages
- 578 SIT 125 messages

It was assumed that the size of SIT 185 is 1400 bytes based on the computation of maximum size that the standard distress alert message could reach considering the current format, the following results were noted about the volume of traffic for communication between ITMCC and SPOCs.

SIT_LEO_GEO SIT_MEO	#185	Data Volume	Bandwidth
LEO_GEO	2035	2849000,00	0,002336
MEO	4896	6854400,00	0,005618
Combined	6931	9703400,00	0,007953

Summary Results from O-3 Spreadsheet - SIT 185

SIT_LEO_GEO SIT_MEO	#185	Data Volume	Bandwidth
LEO_GEO	1812	2536800,00	0,002588
MEO	4097	5735800,00	0,005839
Combined	5909	8272600,00	0,008421

Summary Results from O-3 Spreadsheet - SIT 185
Stand-Alone MEOLUT

SIT_LEO_GEO SIT_MEO	#185	Data Volume	Bandwidth
LEO_GEO	223	312200,00	0,001334
MEO	799	1118600,00	0,004745
Combined	1022	1430800,00	0,006069

Summary Results from O-3 Spreadsheet - SIT 185
Networked MEOLUTs

4.5.1.3 Japan

Calculation based on Transmitted Messages only as per document C/S R.018.

Standalone Mode

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137			
LEO_GEO	2147	33	15	3374	404	2436	32	689	9130	9349120	0.009513
MEO	959	55	3	140	234	108	33	9	1541	1577984	0.001606
Combined	3106	88	18	3514	638	2544	65	698	10671	10927104	0.011118

Networking Mode

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137			
LEO_GEO	536	9	5	834	109	551	6	203	2253	2307072	0.010172
MEO	574	6	2	44	89	34	21	1	771	789504	0.003481
Combined	1110	15	7	878	198	585	27	204	3024	3096576	0.013653

Calculation based on Transmitted and Received Messages.

Standalone Mode

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137			
LEO_GEO	14602	165	63	84912	1581	12278	54	1284	114939	117697536	0.119757
MEO	2585	1735	11211	375	3432	3095	90	31	22554	23095296	0.023499
Combined	17187	1900	11274	85287	5013	15373	144	1315	137493	140792832	0.143257

Networking Mode

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137			
LEO_GEO	3367	47	20	21115	382	2767	9	371	28078	28751872	0.126843
MEO	1404	939	4419	134	1324	1471	42	3	9736	9969664	0.043974
Combined	4771	986	4439	21249	1706	4238	51	374	37814	38721536	0.170776

4.5.1.4 Norway

Standalone mode

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	#185	#Total	Data Volume	Bandwidth
LEO_GEO	9508	23	14	5237	164	1593	2	102	1100	17743	18582432	0.018908
MEO	9056	80	9	850	7723	1095	3	9	0	18825	19276800	0.019615
Combined	18564	103	23	6087	7887	2688	5	111	1100	36568	37859232	0.038522

Networking mode

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	#185	#Total	Data Volume	Bandwidth
LEO_GEO	2065	3	1	1238	45	332	0	14	177	3875	4034552	0.017792
MEO	7531	60	2	747	1156	572	10	6	0	10084	10326016	0.045551
Combined	9596	63	3	1985	1201	904	10	20	177	13959	14360568	0.063327

Notes:
All QMS data included. MEO SIT 185 messages to SPOCs removed because of non-filtering orbitography and test protocol coded beacons.

4.5.1.5 Spain

Standalone mode

EU/Maspalomas MEOLUT connected to MEO-SPMCC (28 Jan – 20 Apr, with two gaps)

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#185	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137				
LEO_GEO	3186	137	30	2262	264	1760	50	281	2271	10241	11340680	0.017221
MEO	5838	316	11	1237	1950	698	35	218	21142	31445	40149072	0.060967
Combined	9024	453	41	3499	2214	2458	85	499	23413	41686	51489752	0.078188

EU/Maspalomas MEOLUT NOT connected to MEO-SPMCC (Gap #1: 19 Jan – 28 Jan, Gap #2: 5 March – 16 March)

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#185	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137				
LEO_GEO	1016	48	21	711	69	601	19	185	742	3412	3772880	0.017512
MEO	90	6	4	64	53	31	8	26	923	1205	1580968	0.007331
Combined	1106	54	25	775	122	632	27	211	1665	4617	5353848	0.024843

Networking mode

EU/Maspalomas MEOLUT connected to MEO-SPMCC (20 Apr – 11 May, with a gap between 29 Apr and 7 May)

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#185	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137				
LEO_GEO	727	42	5	546	49	390	3	58	306	2126	2292080	0.016674
MEO	2318	49	2	631	783	339	5	114	1392	5633	6291584	0.045352
Combined	3045	91	7	1177	832	729	8	172	1698	7759	8583664	0.062026

EU/Maspalomas MEOLUT NOT connected to MEO-SPMCC (29 Apr – 7 May)

SIT_LEO_GEO	#122	#123	#124	#125	#126	#127	#132	#133	#185	#Total	Data Volume	Bandwidth kb/s
SIT_MEO	#142	#143	#144	#145	#146	#147	#136	#137				
LEO_GEO	415	30	2	293	44	208	8	43	350	1393	1558032	0.017793
MEO	107	9	0	45	42	23	8	23	1109	1366	1815768	0.020796
Combined	522	39	2	338	86	231	16	66	1459	2759	3373800	0.038589

4.5.1.6 USA

Part 1

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	#Total	Data Volume (bytes)	Bandwidth (kbps)
LEO_GEO	808	29	2	935	187	649	3	115	2728	2793472	0.009251
MEO	1665	520	2	333	593	678	30	68	3889	3982336	0.013202
Combined	2473	549	4	1268	780	1327	33	183	6617	6775808	0.022438

Part 2 Stand-Alone

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	#Total	Data Volume	Bandwidth
LEO_GEO	2353	130	20	2560	565	1957	45	391	8021	8213504	0.008359
MEO	6280	2468	3534	908	2853	2939	210	172	19364	19828736	0.020178
Combined	8633	2598	3554	3468	3418	4896	255	563	27385	28042240	0.028536

Part 2 Networked

SIT_LEO_GEO SIT_MEO	#122 #142	#123 #143	#124 #144	#125 #145	#126 #146	#127 #147	#132 #136	#133 #137	#Total	Data Volume	Bandwidth
LEO_GEO	588	35	7	676	137	483	11	93	2030	2078720	0.008752
MEO	2912	1252	1059	336	807	916	126	80	7488	7667712	0.032272
Combined	3500	1287	1066	1012	944	1399	137	173	9518	9746432	0.041022

4.5.2 O-3 Test Result Interpretation

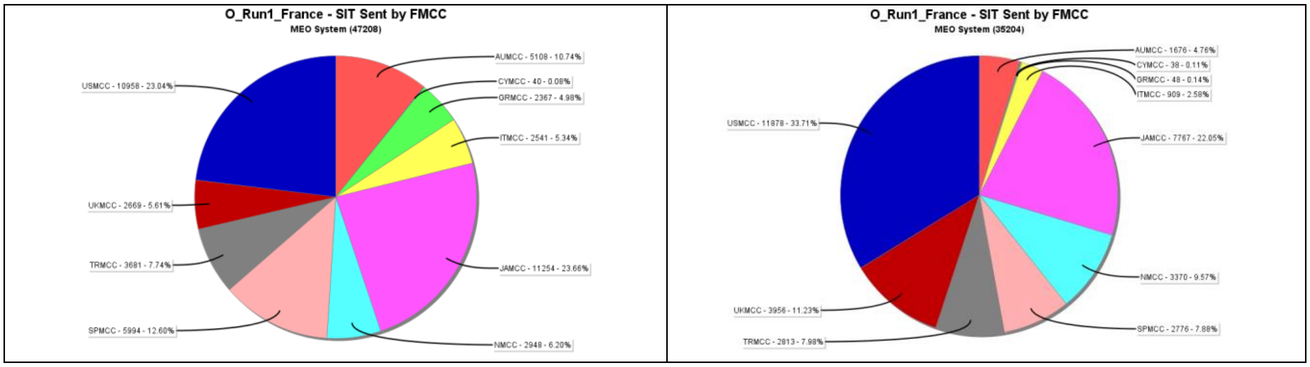
4.5.2.1 France

The MEOSAR system generates a considerable amount of SIT messages in comparison to the LEOSAR/GEOSAR system. A high number of position conflicts are generated by MEOSAR. The use of networking between MEOLUTs tends to excessively increase the volume of data transmitted.

From a technical point of view, the French MEOSAR-ready MCC is capable of handling the amount of transiting data. However, from an operational point of view, the high number of SIT messages may disturb the proper treatment and/or forwarding of the alert towards RCCs or SPOCs.

The trend of the analyses shows the Volume of MEOSAR distress alert traffic in the COSPAS-SARSAT ground segment network will be considerably higher than the traffic generated by the LEOSAR/GEOSAR system and may cause trouble at operational level for alert treatment.

Conclusions are taken with the limitations of the D&E testing phase II part II in terms of ground segment configuration.



MEOSAR Data Sent Daily by the FMCC in Stand-Alone (Left Side) and Networking (Right Side) Modes

4.5.2.2 Italy

SIT 185 messages generated by the MEOSAR-ready MCC were only noted and not sent to the SPOCs.

The MEOSAR-ready MCC not associated with a MEOLUT produces an additional outbound traffic that is negligible, compared to the current load as the outgoing messages towards other MCCs are related to beacons located in the Buffer Zone or to NOCR messages.

In that configuration, the ITMCC estimated the impact on data volume traffic and use of bandwidth, analysing the SIT 185 messages generated towards their RCCs and SPOCs. In fact, from a complementary analysis, the general additional data volume and use of bandwidth increased by around 2.2 times the current workload. With MEOLUTs in networking and MCCs set in continued transmission, the message traffic and bandwidth increased by around 3.5 times the current load.

The maximum bandwidth load recorded during the test period was 0.017665 Kbps for the combined MEOSAR and LEOSAR/GEOSAR systems and MEOLUTs in networking mode, being within the minimum network capabilities of current communication paths.

4.5.2.3 Japan

As the MEOSAR-ready JAMCC isn’t connected with a MEOLUT, it has not sent SIT messages to any MCCs. It causes low amount of MEOSAR data compared with LEO/GEO data. It also seems that the fact that JAMCC has exchanged many SIT message of LEO/GEO for MCCs as NODAL MCC influenced the large amount of LEO/GEO data.

With regards to bandwidth, the maximum load recorded during the test period was 0.013653kbps for the combined LEO/GEO/MEO in networking mode.

Considered with the forthcoming LEO/GEO/MEO common use period, it seems that the impact of data volume is not important.

4.5.2.4 Norway

Because of other EU/SGS qualification test campaigns running in parallel to the D&E phase II Part 2, Norway experienced sometimes that the MEOSAR-ready NMCC received data from the local

MEOLUT configured in networking mode, or with the MEOLUT configured to send self-test alert messages to the MCC. Those cases were attempted to be removed in the post-processing, which excludes some time periods for the analysis. However due to the comprehensive test intervals the volume of alert traffic may not be representative between the two systems at all times during standalone and networking mode.

The MEOSAR system used more data volume and bandwidth than the current LEOSAR/GEOSAR system. Overall the maximum bandwidth load recorded during networking was 0.063327 combined for both LEO/GEO and MEO systems. The most significant difference of bandwidth usage between the two systems also took place during networking, where MEOSAR reported an increase of data volume and bandwidth of about +250% (2.5 times the current load).

From the complementary analysis, where a large amount of MEO SIT 185 messages were included, it could be noted that the data volume and bandwidth load did not impact the processing capability of the current MEOSAR-ready NMCC. Based on this analysis the interpretation of summary results is that current communication links and MCC capability is suitable to cope with the additional traffic load from MEOSAR.

4.5.2.5 Spain

The MEOSAR-ready SPMCC transmitted messages only until Location Confirmation, as it is done for the LEO/GEO MCC system, thus, the number of SIT144 (Position Confirmation by Encoded) and SIT147 (Position Confirmation by DOA) should have been greater if the SEND AFTER RESOLVED configuration mode had been applied instead.

During some periods of time, the EU/Maspalomas MEOLUT data was directly available at the MCC, and during other periods of time data was not directly available at the MCC. Given that having or not an associated MEOLUT connected to the MCC is decisive for the amount of transmitted messages, different tables were shown in the O-3 Traffic Analysis, depending on the connection status between the MEOSAR-ready SPMCC and the EU/Maspalomas MEOLUT.

Taking into account the periods of time that the MEOSAR-ready SPMCC was connected to the EU/Maspalomas MEOLUT, the maximum global traffic ratio observed was for the MCC to SPOC communication link, with a MEOSAR traffic 9.3 larger than the LEOSAR traffic.

Several circumstances were identified which could lead to production of this large amount of messages to SPOCs. They seem to be related with the continuous transmission of Position Updates and Position Conflicts observed in some situations, and some SPOC areas which have double destination addresses, leading the MCC to send the messages, intended for those areas, twice.

With the current DDP rules, about the minimum period of time of several minutes that should elapse between consecutive position update and position conflict messages, the MCC to SPOC traffic load should be lesser.

4.5.2.6 USA

Part 1

The results of the O-3 test imply that for the combined MEO and LEO/GEO systems, there will be a data volume increase on the order of almost two and a half times the size of the existing LEO/GEO system. Likewise, the communication bandwidth of the combined system load will also be two and a half times the occupancy of the current system.

Part 2

The results of the O-3 test imply that for the combined MEO and LEO/GEO systems, there will be a data volume increase. As the data will be merged in the LEO/GEO/MEO system, the increase will not be as high, so the maximum increase (assuming networking is on) is perhaps 3.5 times the current load. However, given the relatively low overall bandwidth required, the impact of the additional traffic due to the MEOSAR system should be negligible.

4.6 Test O-4 406 MHz Alert Data Distribution Procedures

4.6.1 O-4 Test Result

The following test reports were provided by the participants:

Administration	Test report reference
France	France D&E Phase 2 Part 2 Operational Tests Report, sections 6.1.4 & 6.2.4 SAR-RE-DEMEO-917-CNES
Italy	JC-29/Inf. 22
USA	JC-29/Inf. 26 (section 5)

4.6.1.1 France

Standalone mode

Alert types repartition for the LEOSAR/GEOSAR system

Nb of sites: 215 Nb of solutions: 3425	FA UNL	FA ENC	FA DOP	FA DOP ENC CFM	FA DOP ENC DIF	NC DOP DOP DIF	NC DOP ENC DIF	NC ENC ENC DIF	CA DOP DOP CFM	CA ENC DOP CFM	CA DOP ENC CFM	CT CFM	CT DOP DIF	CT ENC DIF	RD DOP ENC	RD UNL
TOTAL	160	17	37	1	0	36	3	15	34	0	1	85	3	0	1088	1945
SITE LEVEL STAT. (%)	74.42	7.91	17.2	0.47	0.00				15.81	0.00	0.47					
SOLUTION LEVEL STAT. (%)	4.67	0.50	1.08	0.03	0.00	1.05	0.09	0.44	0.99	0.00	0.03	2.48	0.09	0.00	31.77	56.79

Alert types repartition for the MEOSAR system

Nb of sites: 601 Nb of solutions: 3403	FA UNL	FA ENC	FA DOA	FA DOA ENC CFM	FA DOA ENC DIF	NC DOA DOA DIF	NC DOA ENC DIF	NC ENC ENC DIF	CA DOA DOA CFM	CA ENC DOA CFM	CA DOP ENC CFM	CT CFM	CT DOP DIF	CT ENC DIF	RD DOP ENC	RD UNL
TOTAL	420	112	66	1	2	40	18	52	45	2	3	557	236	58	1155	636
SITE LEVEL STAT. (%)	69.88	18.64	10.9	0.17	0.33				7.49	0.33	0.50					
SOLUTION LEVEL STAT. (%)	12.34	3.29	1.94	0.03	0.06	1.18	0.53	1.53	1.32	0.06	0.09	16.37	6.94	1.70	33.94	18.69

Networking mode

Alert types repartition on the LEOSAR/GEOSAR system (Networking mode)

Nb of sites: 59 Nb of solutions: 910	FA UNL	FA ENC	FA DOP	FA DOP ENC CFM	FA DOP ENC DIF	NC DOP DOP DIF	NC DOP ENC DIF	NC ENC ENC DIF	CA DOP DOP CFM	CA ENC DOP CFM	CA DOP ENC CFM	CT CFM	CT DOP DIF	CT ENC DIF	RD DOP ENC	RD UNL
COLUMN TOTALS	43	4	12	0	0	13	0	3	5	1	0	18	0	0	243	568
SITE LEVEL STAT. (%)	72.88	6.78	20.34	0.00	0.00				8.47	1.69	0.00					
SOLUTION LEVEL STAT. (%)	4.73	0.44	1.32	0.00	0.00	1.43	0.00	0.33	0.55	0.11	0.00	1.98	0.00	0.00	26.70	62.42

Alert types repartition on the MEOSAR system (Networking mode)

Nb of sites: 293 Nb of solutions: 3693	FA UNL	FA ENC	FA DOA	FA DOA ENC CFM	FA DOA ENC DIF	NC DOA DOA DIF	NC DOA ENC DIF	NC ENC ENC DIF	CA DOA DOA CFM	CA ENC DOA CFM	CA DOP ENC CFM	CT CFM	CT DOP DIF	CT ENC DIF	RD DOP ENC	RD UNL
COLUMN TOTALS	213	56	24	0	0	27	0	13	20	0	1	874	141	43	1214	1067
SITE LEVEL STAT. (%)	72.70	19.11	8.19	0.00	0.00				6.83	0.00	0.34					
SOLUTION LEVEL STAT. (%)	5.77	1.52	0.65	0.00	0.00	0.73	0.00	0.35	0.54	0.00	0.03	23.67	3.82	1.16	32.87	28.89

4.6.1.2 Italy

Standalone mode

NUMBER OF SITES	708
NUMBER OF SOLUTIONS	6142

	FA UNL	FA ENC	FA DOA	FA DOA ENC CFM	FA DOA ENC DIF	NC DOA DOA DIF	NC DOA ENC DIF	NC ENC ENC DIF	CA DOA DOA CFM	CA ENC DOA CFM	CA DOA ENC CFM	CT CFM	CT DOA DIF	CT ENC DIF	RD DOA ENC	RD UNL
COLUMN TOTALS	481	74	144	7	2	161	32	5	99	11	2	758	2733	166	1391	124
SITE LEVEL STATISTICS	67.94%	10.45%	20.34%	0.99%	0.28%				13.98%	1.55%	0.28%					
SOLUTION LEVEL STATISTICS	7.83%	1.20%	2.34%	0.11%	0.03%	2.62%	0.52%	0.08%	1.61%	0.18%	0.03%	12.34%	44.50%	2.70%	22.65%	2.02%

Networking mode

NUMBER OF SITES	323
NUMBER OF SOLUTIONS	1190

	FA UNL	FA ENC	FA DOA	FA DOA ENC CFM	FA DOA ENC DIF	NC DOA DOA DIF	NC DOA ENC DIF	NC ENC ENC DIF	CA DOA DOA CFM	CA ENC DOA CFM	CA DOA ENC CFM	CT CFM	CT DOA DIF	CT ENC DIF	RD DOA ENC	RD UNL
COLUMN TOTALS	240	19	62	1	1	56	53	1	31	0	1	24	37	7	616	88
SITE LEVEL STATISTICS	74.30%	5.88%	19.20%	0.31%	0.31%				9.60%	0.00%	0.31%					
SOLUTION LEVEL STATISTICS	20.17%	1.60%	5.21%	0.08%	0.08%	4.71%	4.45%	0.08%	2.61%	0.00%	0.08%	2.02%	3.11%	0.59%	51.76%	7.39%

4.6.1.3 USA

Note: Only Part 1 results were provided by the USA for this test.

Standalone mode

NUMBER OF SITES	2974																	
NUMBER OF SOLUTIONS	84725																	
	FA UNL	FA ENC	FA DOA	FA DOA ENC CFM	FA DOA ENC DIF	NC DOA DOA DIF	NC DOA ENC DIF	NC ENC ENC DIF	CA DOA DOA CFM	CA ENC DOA CFM	CA DOA ENC CFM	CT CFM	CT DOA DIF	CT ENC DIF	RD	RD UNL
COLUMN TOTALS	2585	296	85	7	1	426	239	0	251	65	4	6435	4051	2512	4471	63297
SITE LEVEL STATISTICS	86.92%	9.95%	2.86%	0.24%	0.03%				8.44%	2.19%	0.13%					
SOLUTION LEVEL STATISTICS	3.05%	0.35%	0.10%	0.01%	0.00%	0.50%	0.28%	0.00%	0.30%	0.08%	0.00%	7.60%	4.78%	2.96%	5.28%	74.71%

Results (MEOSAR system)

Category	# of Sites (all)	% of Total (all)	# of Sites (Service Area)	% of Total (Service Area)
FA UNL	1857	67.8	887	78.9
FA ENC	162	5.9	95	8.5
FA DOA*	625	22.8	137	12.2
FA CFM*	95	3.5	5	0.4
Total	**2739**	**100%**	**1124**	**100%**

Summary Results for First Alerts (LEOSAR/GEOSAR system)

* For the LEOSAR/GEOSAR system, "DOA" refers to Doppler and "CFM" refers to ambiguity resolution. Figure 2 contains results for the same period as Figure 1.

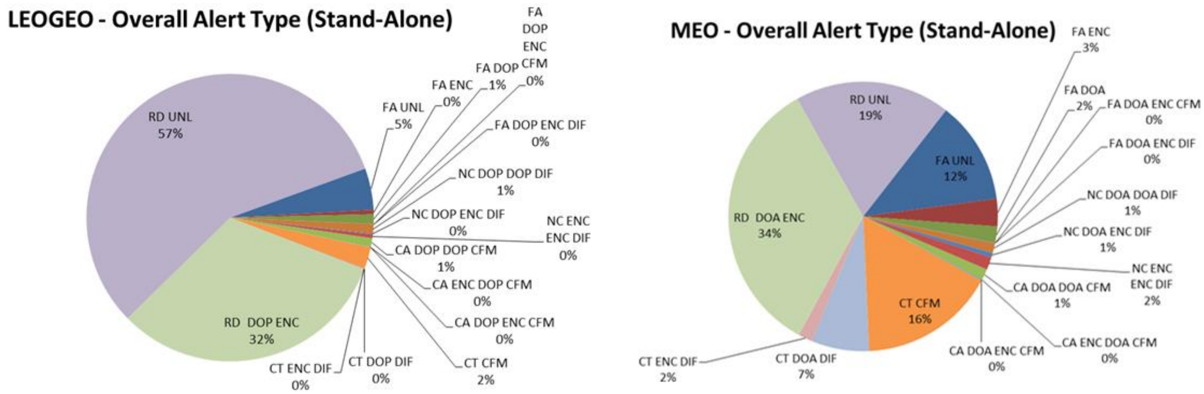
4.6.2 O-4 Test Result Interpretation

4.6.2.1 France

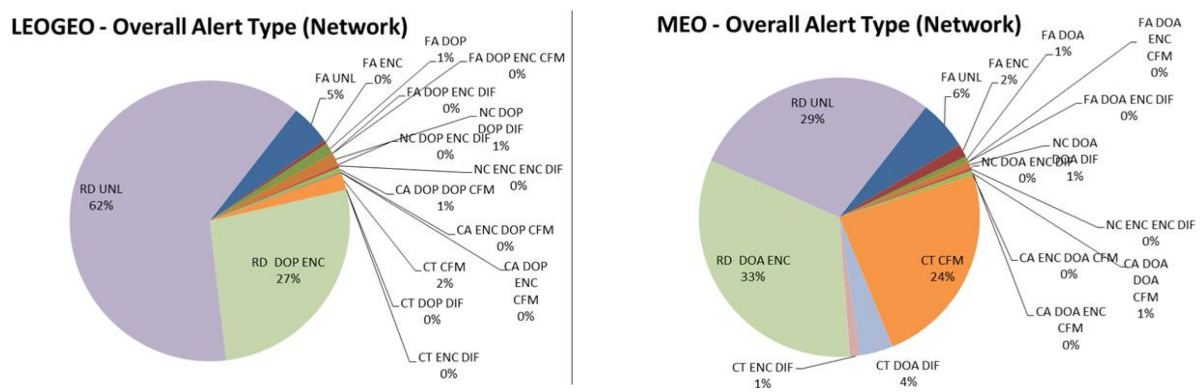
The O-4 test results show that the number of solutions of the MEOSAR system is much higher than that of the LEOSAR/GEOSAR system.

The LEOSAR/GEOSAR system has a large part of redundant data (89% of the alerts), whereas the generation of alerts for the MEOSAR system is more spread among the alerts types and shows a larger percentage of First Alerts and Position confirmation alerts than the LEOSAR/GEOSAR system.

With the MEOLUTs networking ON, the MEOSAR system generates an excessive amount of alert data. The proportion of redundant data increases as well as the proportion of continued transmission confirmation while the number of first alerts was rather lower in comparison with the period of test with the MEOLUT stand-alone mode.



O-4 Alert Types Repartition for the LEOSAR/GEOSAR System (Left Side) and the MEOSAR System in Stand-Alone(Right Side)



O-4 Alert Types Repartition for the LEOSAR/GEOSAR System (Left Side) and the MEOSAR System in Networking (Right Side)

4.6.2.2 Italy

The MEOSAR system detected 2.7 times the number of beacons detected by the LEOSAR/GEOSAR system.

In the computation of an independent location, the MEOSAR system performed better than the existing system, providing a higher percentage of alerts provided with position DOA (+7%).

The continued transmission provided a large number of solutions to the MCC that processed the data without performance degradation, being within the capabilities of the Cospas-Sarsat communications network, as demonstrated in the O-3 Summary results. In view of the benefits that it provides for a continuous monitoring beacon position to the destination MCC, the above results support the proposition that continued transmission should be the default setting for the future MCCs.

MEOLUTs in networking configuration increased the percentage of first alerts unlocated up to 74% (+6%) as well as the number of unlocated solutions up to 20% (+12%) compared to the Standalone mode.

First alerts with an independent position are very similar to the stand-alone mode, at around 20% of total first alerts.

Redundant data also reported a significant increase (+ 34.5%) representing 59% of solutions in total.

4.6.2.3 USA

Note: Only Part 1 results were provided by the USA for this test.

As shown in Figure 1, most MEOSAR alerts were unlocated during the test period. For beacon activations, about 87% of MEOSAR first alerts were unlocated, 10% of MEOSAR first alerts contained only encoded position and 3% of MEOSAR first alerts contained independent (DOA) position.

An appropriate area of interest (that is, all activations vs. activations in the MCC service area) should be selected in comparing the occurrence of output alerts by category between the MEOSAR and LEOSAR/GEOSAR systems. This is illustrated by fact that 26.3% of LEOSAR/GEOSAR first alerts contained Doppler location for all beacon activations vs. 12.6% of LEOSAR/GEOSAR first alerts in the USMCC service area, as shown in Figure 2. For all beacon activations processed by the USMCC, independent location was provided for 3.13% of MEOSAR first alerts compared to 26.3% of LEOSAR/GEOSAR first alerts.

Based on this analysis, the USA proposed modifications to the O-4 spreadsheet in document C/S EWG-1/2014/6/4.

It is expected that independent (DOA) location will occur more often as more MEOSAR satellites become available for use and when MEOLUT networking is performed. The availability and use of additional MEOSAR satellites will enable a more meaningful analysis of alert data distribution procedures to be implemented in the operational MEOSAR system.

4.7 Test O-5 SAR/Galileo Return Link Service

This test has been postponed to Phase III.

4.8 Test O-6 Evaluation of Direct and Indirect Benefits of the MEOSAR System

The following test reports were provided by the participants:

Administration	Test report reference
Argentina	Sec. 4.8.14
Australia	Sec. 4.8.7, 4.8.10, 4.8.11, 4.8.15, 4.8.17
Brazil	Sec. 4.8.1, 4.8.12
Italy	Sec. 4.8.8
New Zealand	Sec. 4.8.2, 4.8.3, 4.8.4, 4.8.6, 4.8.9, 4.8.13, 4.8.16
Norway	Sec. 4.8.5

4.8.1 Incident 1 – Brazil

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	6 October 2015 12:06 UTC
Location	Fazenda Guanabara Airport Mato Grosso do Sul (Brazil)
Incident Type	Aircraft emergency landing.
Beacon Type	ELT
Beacon Environment (land/sea/cliff/forest/dessert…)	On land
Beacon Speed (static/moving/drifting…)	Static
Local Time	09:06
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	Not reported
People Involved	3
People Rescued	2(Alive) / 1(Dead)
C/S MEOSAR Alert (Only/First/Later)	Later
Detection Time (Advantage/No Advantage)	No advantage.
Location Time (Advantage/No Advantage)	No locations for this site.
Location Accuracy (Advantage/No Advantage)	No locations for this site.

On 6 October 2015, a single-engine aircraft made an emergency landing at Fazenda Guanabara Airport in Brazil.

The ARCC-CW received a distress alert data from BRMCC of a registered radio beacon. During the investigation ARCC CW received information that the aircraft fell immediately after taking off. The aircraft was quite damaged. The crew were found alive, but one of them was seriously injured, dying at the hospital.

The aircraft’s ELT was detected by GEOSAR at 12:06 UTC and by MEOSAR at 12:07:58, both unlocated detections. As the ELT was registered, the search for the aircraft was able to commence.

In this incident, MEOSAR did not provide a time advantage.

4.8.2 Incident 2 – New Zealand

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	24 February 2016 23:45 UTC
Location	Ngunguru River, New Zealand
Incident Type	Injured walker
Beacon Type	PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Land
Beacon Speed (static/moving/drifting…)	Static
Local Time	12:45
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	Helicopter
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Later)	**Only**
Detection Time (Advantage/No Advantage)	Advantage
Location Time (Advantage/No Advantage)	Advantage
Location Accuracy (Advantage/No Advantage)	Location Accuracy (1.5 NM)

On 24 February 2016, an injured walker contacted NZ Police by phone but was unable to provide a location. The walker was carrying a PLB and was asked to activate the beacon. JRCC New Zealand was contacted by the NZ Police but there was no LEOSAR or GEOSAR data for the beacon. JRCC NZ contacted the AUMCC system manager and the MEOSAR system provided an encoded and MEOSAR location. The walker was successfully rescued. The encoded location was 45 m from the walker, the MEOSAR location was within 1.5 nautical miles. There were no LEOSAR or GEOSAR detections of the beacon.

In this incident, MEOSAR was the only detection for a successful rescue.

4.8.3 Incident 3 – New Zealand

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	1 May 2016 20:36 UTC
Location	Nelson Lakes National Park, New Zealand
Incident Type	Hiker with a shoulder dislocated.
Beacon Type	PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Forest/cliff
Beacon Speed (static/moving/drifting…)	Static
Local Time	2 May 2016 08:36
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	Helicopter
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Later)	**First**
Detection Time (Advantage/No Advantage)	Advantage (49 mins)
Location Time (Advantage/No Advantage)	Advantage (49 mins)
Location Accuracy (Advantage/No Advantage)	

On 1 May 2016 at 20:36 UTC, a MEOSAR alert was received for an unregistered New Zealand beacon. The Nelson rescue helicopter was dispatched to the encoded position and located a male tramper (hiker) who had taken a tumble and dislocated his shoulder. The man was airlifted to Nelson Hospital for treatment. A LEOSAR alert was received at 21:05 UTC. MEOSAR provided a location 49 minutes before the LEOSAR detection.

In this incident, MEOSAR provided a time advantage.

4.8.4 Incident 4 – New Zealand

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	25 April 2016 02:23 UTC
Location	Tararua, New Zealand
Incident Type	Hiker with a broken leg.
Beacon Type	PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Difficult terrain /fall
Beacon Speed (static/moving/drifting…)	Static
Local Time	16:23
Local Weather Conditions (winds, ice, hot, cold…)	Last light / Partially Cloudy
Resources moved (Helicopter/Vessel/Aircraft…)	Helicopter
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Later)	**First**
Detection Time (Advantage/No Advantage)	Advantage (50 mins)
Location Time (Advantage/No Advantage)	Advantage (50 mins)
Location Accuracy (Advantage/No Advantage)	

On 25 April 2016, JRCC NZ received a MEOSAR detection of a registered PLB about 50 minutes before the initial LEOSAR detection. A solo tramper (hiker) was rescued just before last light. Without the additional 50 minutes of time provided by the earlier MEOSAR detection, the rescue would most likely have required a land search at night in difficult terrain.

Further details are available at the following web site:
http://www.maritimenz.govt.nz/news/media-releases-2016/20160426a.asp.

In this incident, MEOSAR provided a time advantage that was critical to a successful rescue.

4.8.5 Incident 5 – Norway

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	9 January 2015 03:30 UTC
Location	North Sea
Incident Type	Fishing vessel sinking
Beacon Type	EPIRB
Beacon Environment (land/sea/cliff/forest/dessert…)	Sea / Life raft
Beacon Speed (static/moving/drifting…)	Drifting
Local Time	04:30 (Night)
Local Weather Conditions (winds, ice, hot, cold…)	Ice Cold water / Rough seas
Resources moved (Helicopter/Vessel/Aircraft…)	Helicopter
People Involved	5
People Rescued	5
C/S MEOSAR Alert (Only/First/Later)	**First**
Detection Time (Advantage/No Advantage)	Advantage (28 mins)
Location Time (Advantage/No Advantage)	Advantage (63 mins)
Location Accuracy (Advantage/No Advantage)	

On 9th January 2015 at 03:30 UTC JRCC-North Norway received information from the coastal radio that the fishing vessel "Oestbanken" (MMSI 259179000) was taking on water 60 NM north of Baatsfjord with 5 people on board.

The first MEOSAR alert was received at 03:50 UTC with a DOA position. An unlocated GEO alert was received at 04:18 UTC and a LEO alert with A and B positions was not received until 04:53 UTC.

The crew were rescued in rough seas in a life raft at 05:45 UTC.

See document JC-29/Inf 11 for a more detailed description of this incident.

In this incident, MEOSAR provided a 28 minute advantage in detection and a 63 minute advantage in providing a location.

4.8.6 Incident 6 – New Zealand

Type of Analysis (Real-time/Retrospective)	Retrospective
Date and Time	19 January 2016 03:26 UTC
Location	Mount Earnslaw, New Zealand
Incident Type	Hiker heart attack
Beacon Type	PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Valley
Beacon Speed (static/moving/drifting…)	Static
Local Time	16:26
Local Weather Conditions (winds, ice, hot, cold…)	Not known
Resources moved (Helicopter/Vessel/Aircraft…)	None
People Involved	6
People Rescued	1
C/S MEOSAR Alert (Only/First/Later)	**First**
Detection Time (Advantage/No Advantage)	Advantage (284 mins)
Location Time (Advantage/No Advantage)	Advantage (284 mins)
Location Accuracy (Advantage/No Advantage)	

At 03:26 UTC on 19 January 2016, the New Zealand JRCC received a LEOSAR detection for a beacon. The beacon had an encoded location. Just after the detection arrived at the JRCC, the JRCC was contacted by emergency services. The beacon was associated with a party of trampers (hikers), one of whom had suffered a suspected heart attack. The party had activated their beacon around five hours prior to detection by the LEOSAR system. After waiting for a considerable period, they ended up raising the alarm with some of the members hiking out and calling emergency services.

The beacon was confirmed by the MEOSAR system at 22:42 UTC on 18 January, four hours and forty-four minutes before the LEOSAR detection.

It is presumed that the beacon was not detected by any GEO satellite due to terrain shielding. The beacon was not detected for five hours by the LEOSAR system due to terrain shielding for earlier passes.

In this incident, if the MEOSAR data had been available to SAR authorities, MEOSAR would have provided detection and location advantage of 4 hours and 44 minutes.

4.8.7 Incident 7 – Australia

Type of Analysis (Real-time/Retrospective)	Retrospective
Date and Time	22 March 2016 05:40 UTC
Location	Bowen, Australia
Incident Type	Dory broken down at anchor
Beacon Type	EPIRB
Beacon Environment (land/sea/cliff/forest/dessert…)	Sea
Beacon Speed (static/moving/drifting…)	Drifting
Local Time	16:40
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	A dory
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Later)	**First**
Detection Time (Advantage/No Advantage)	Advantage (6 mins)
Location Time (Advantage/No Advantage)	Advantage (44 mins)
Location Accuracy (Advantage/No Advantage)	1st DOA Location (5.36 km)

On 22 March 2016, a distress beacon registered to a dory boat was detected in the vicinity of Dingo Reef, 50 miles east of Bowen, Queensland, Australia. The main trawler was contacted and reported that a dory was missing. A rescue helicopter was tasked and it located the dory which was broken down at anchor. A second dory was directed to the scene and assistance was provided.

The first LEO unlocated alert was received at 05:46 UTC. An initial LEO alert with suspect position data was received at 06:24 UTC; the closest Doppler position was 17.46 km from the beacon. A resolved LEO alert was received at 06:32 UTC with a position about 670 m from the beacon.

The MEOSAR system provided an initial alert at 05:40 UTC with a DOA position 5.36 km from the beacon. An updated location was received at 05:43 UTC with a DOA position 440 m from the beacon.

In this incident, if the MEOSAR data had been available to SAR authorities, MEOSAR would have provided a 6 minute advantage in detection and 44 minute advantage in time to determine location.

4.8.8 Incident 8 – Italy

Type of Analysis (Real-time/Retrospective)	Retrospective
Date and Time	4 November 2015 05:59 UTC
Location	South Sudan
Incident Type	Aircraft crash
Beacon Type	ELT
Beacon Environment (land/sea/cliff/forest/dessert…)	Land
Beacon Speed (static/moving/drifting…)	Static
Local Time	08:59
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	Crash near the airport
People Involved	43
People Rescued	2
C/S MEOSAR Alert (Only/First/Later)	**First**
Detection Time (Advantage/No Advantage)	Advantage (23 mins)
Location Time (Advantage/No Advantage)	Advantage (20 mins)
Location Accuracy (Advantage/No Advantage)	

On 4 November 2015 at 05:59 UTC, a cargo aircraft Antonov An-12BK, registration mark EY-406 and Tajikistan-registered crashed shortly after take-off from Juba International Airport in South Sudan, impacting terrain about 1,100 metres past the runway end.

Thirty-seven people died including the crew of six. Only two passengers survived the crash. The LEOSAR/GEOSAR system detected the ELT activation and alerts were processed by ITMCC, which informed the interested SPOCs.

The first LEOSAR detection occurred at 06:22 UTC, the first LEOSAR Doppler positions at 07:16 UTC and the first resolved position at 08:00 UTC.

The first MEOSAR detection was at 0559 UTC, the first DOA position at 06:56 UTC and DOA position was confirmed at 07:13 UTC.

See document CSC-55/OPN/Inf.10 for a more detailed description of this incident.

For this incident, if the MEOSAR data had been available to Search and Rescue authorities, MEOSAR would have provided a 23 minute advantage in detection time, a 20 minute advantage in detection of first position and a 47 minute advantage in time to confirmed position.

4.8.9 Incident 9 – New Zealand

Type of Analysis (Real-time/Retrospective)	Retrospective
Date and Time	29 March 2014 23:31 UTC
Location	Lake Christabel, New Zealand
Incident Type	Hiker stuck
Beacon Type	PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Rocky Precipice
Beacon Speed (static/moving/drifting…)	Static
Local Time	12:31
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	None
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Later)	**First**
Detection Time (Advantage/No Advantage)	Advantage (120 mins)
Location Time (Advantage/No Advantage)	Advantage (120 mins)
Location Accuracy (Advantage/No Advantage)	

In April 2014, the Australian Maritime Safety Authority (AMSA) received a query regarding a PLB activated in New Zealand. The owner of the beacon reported:

"I was out hunting in the weekend and I got myself into a really bad situation. I was climbing up some steep bluffs trying to get to the top of a ridge, and all of a sudden I realised that I could neither go up or down. I was stuck. I tried to figure out a way down, and my mate couldn't get up to me to help. As an absolute last resort I activated my RescueMe PLB. I was perched on a rocky precipice waiting for a helicopter.

I knew that I could not spend a night out here, so I told myself I was going to get down. I threw all of my gear down the bluffs including my rifle. It was the scariest thing I have ever done, but I did eventually manage to get down. It could easily have gone either way, one slip and I would have tumbled hundreds of feet.

We then walked back out to the car and as soon as I got into reception I called 111. There had been no reports of a PLB activated in my area."

There were no LEOSAR or GEOSAR detections of this beacon. If the beacon had been left turned on, the first LEOSAR detection would have occurred about 2 hours after the first detection by MEOSAR.

At this time the New Zealand MEOLUT had not been built. The MEOLUT in Hawaii (over 7,400 km away) detected the beacon at 23:31 UTC 29 March and had many detections of the beacon with an encoded location from 23:34 UTC to 01:45 UTC 30 March.

In this incident, if the MEOSAR data had been available to Search and Rescue authorities, MEOSAR would have provided an advantage of over 120 minutes in detection and location. See document JC-28/Inf.5 for a more detailed description of this incident.

4.8.10 Incident 10 – Australia

Type of Analysis (Real-time/Retrospective)	Retrospective
Date and Time	13 April 2016 06:15 UTC
Location	Deepwater, Australia
Incident Type	Road accident
Beacon Type	PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Valley
Beacon Speed (static/moving/drifting…)	Static
Local Time	16:15
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	None
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Later)	**Only**
Detection Time (Advantage/No Advantage)	Advantage (43 mins)
Location Time (Advantage/No Advantage)	Advantage (43 mins)
Location Accuracy (Advantage/No Advantage)	

A member of the public reported to the Australian Maritime Safety Authority (AMSA) that the person had activated their PLB at Ten Mile Rd, Deepwater NSW Australia about 4:15 pm 13 April 2016 until approximately 4:55 pm (local times) after arriving at the site of a road accident. The beacon was turned off when mobile phone contact was made to rescue authorities by climbing a hill.

There were no LEOSAR or GEOSAR detections of this beacon. The beacon was activated in a valley and it is presumed that terrain shielding prevented any LEOSAR or GEOSAR detections. If the beacon had been left turned on, the earliest LEOSAR detection would have been around 04:58 pm.

The New Zealand MEOLUT detected the PLB multiple times between 04:15 pm to 04:58 pm local time and provided an encoded position.

In this incident, if the MEOSAR data had been available to Search and Rescue authorities, MEOSAR would have provided at least a 43-minute advantage in detection and location compared with LEOSAR and GEOSAR.

4.8.11 Incident 11 – Australia

Type of Analysis (Real-time/Retrospective)	Retrospective
Date and Time	02 June 2016 04:44 UTC
Location	Moreton Bay, Australia
Incident Type	Moving fishing boat
Beacon Type	EPIRB
Beacon Environment (land/sea/cliff/forest/dessert…)	Sea
Beacon Speed (static/moving/drifting…)	Moving
Local Time	16:44
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	None
People Involved	1
People Rescued	0
C/S MEOSAR Alert (Only/First/Other)	**Other**
Detection Time (Advantage/No Advantage)	No advantage
Location Time (Advantage/No Advantage)	No advantage
Location Accuracy (Advantage/No Advantage)	1st location disadvantage (325 km)

At 04:44 UTC on 2 June 2016, an unlocated beacon was detected by the New Zealand MEOLUT and the GEOSAR system. The beacon was registered but details were unclear as the previous owner had sold the beacon.

The LEOSAR system generated A and B positions at 04:59. A conflict was generated at 06:31 before the LEOSAR system produced a resolved position at 06:34.

The first DOA position was generated at 05:56 UTC. The next DOA position was generated at 06:16 UTC.

The first DOA position was over 325 km from the final location of the beacon. All DOA locations after the first location at 05:56 were in the same area as the final location of the beacon.
Information from the incident indicates that the beacon was activated in a moving recreational fishing boat.

In this incident, if the MEOSAR data had been available to search and rescue authorities, the first DOA location may have confused the initial response. As the beacon was registered, information from the beacon emergency contacts (once determined) may have indicated that the first DOA location was grossly inaccurate. The second DOA position would also have indicated that there was a conflict in positions.

4.8.12 Incident 12 – Brazil

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	05 July 2016 21:40 UTC
Location	Santa Cruz Air Force Base (Brazil)
Incident Type	Jet plane crash
Beacon Type	ELT
Beacon Environment (land/sea/cliff/forest/dessert…)	Land
Beacon Speed (static/moving/drifting…)	Static
Local Time	18:40
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	Not reported
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Other)	**First**
Detection Time (Advantage/No Advantage)	Advantage (8 mins)
Location Time (Advantage/No Advantage)	Encoded Advantage (5 mins)
Location Accuracy (Advantage/No Advantage)	1^{st} Location (18 km)

On 5 July 2016 at 21:40:11 UTC a Brazilian Air Force jet plane crashed close to Santa Cruz Air Force Base due to landing gear problems. Both pilots successfully ejected before the accident. The aircraft's 406 MHz ELT was not activated, but the 406 MHz PLB attached to the pilot's ejection seat was automatically activated and its alerts were detected by LEOSAR, GEOSAR and MEOSAR Systems. See document JC-30/Inf. 26 for a more detailed analysis of this incident.

The first MEOSAR detection occurred at 21:40:17 UTC, the first MEOSAR detection with an encoded location was at 21:43:39 UTC and the first MEOSAR location was generated at 21:53:28 UTC.

The first LEOSAR detection and Doppler locations were generated at 21:48:51 UTC.

The first GEOSAR detection which included an encoded location occurred at 22:00:15.

The encoded location matched the reported position of the PLB. The LEOSAR positions were very close to the actual PLB location. After 36 minutes, the MEOSAR location was 959 meters from the actual PLB location.

In this incident, both LEOSAR and MEOSAR provided location data and an encoded location within 10 minutes. GEOSAR provided an encoded location within 20 minutes. The MEOSAR location data was less accurate than the encoded and LEOSAR location data.

4.8.13 Incident 13 – New Zealand

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	14 July 2016 18:56 UTC
Location	Nevada (USA)
Incident Type	Moving Aircraft
Beacon Type	ELT
Beacon Environment (land/sea/cliff/forest/dessert…)	Air
Beacon Speed (static/moving/drifting…)	Moving
Local Time	12:56
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	None
People Involved	0
People Rescued	0
C/S MEOSAR Alert (Only/First/Other)	**First**
Detection Time (Advantage/No Advantage)	No advantage
Location Time (Advantage/No Advantage)	No advantage
Location Accuracy (Advantage/No Advantage)	Location Disadvantage (11,000 km)

A beacon was detected by the New Zealand MEOLUT at 18:56 UTC on 14 July 2016. The beacon had a DOA position of (37 13.8S, 164 11.0E) and an encoded position of (38 03.33N, 116 16.80W), a difference of over 11,000 kilometres.

Later MEOSAR detections did not generate a DOA position.

Information from LEOSAR detections indicated that the encoded position was valid but on a moving aircraft (as the encoded position changed over time).

In this incident, the MEOSAR location was invalid. If the alert had not included an encoded location, the MEOSAR location may have resulted in an unnecessary Search and Rescue response.

4.8.14 Incident 14 – Argentina

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	04 August 2016 20:18 UTC
Location	Villa Llaquin, Neuquén, Argentina
Incident Type	Aircraft crash
Beacon Type	ELT
Beacon Environment (land/sea/cliff/forest/dessert…)	Land
Beacon Speed (static/moving/drifting…)	Static
Local Time	17:18
Local Weather Conditions (winds, ice, hot, cold…)	Not reported
Resources moved (Helicopter/Vessel/Aircraft…)	Not reported
People Involved	6
People Rescued	6
C/S MEOSAR Alert (Only/First/Other)	**First Location**
Detection Time (Advantage/No Advantage)	No advantage
Location Time (Advantage/No Advantage)	Location Advantage (75 mins)
Location Accuracy (Advantage/No Advantage)	1st DOA Location Accuracy (5.5 km)

On 4 August 2016 at 20:18 UTC, the ARMCC received an unlocated GEOSAR alert for an unregistered ELT.

At 20:24 UTC, the Argentina MEOLUT provided a position near Villa Llanquin town in the province of Neuquen, inside of Argentinian Patagonia, 40 km from Bariloche.

The local SAR forces were able to locate and rescue six persons from the aircraft that had crashed due to lack of propulsion. See document JC-30/Inf. 38 for further information.


Detection times are shown in the following table:

TIME (UTC)	SYSTEM	DISTANCE
20:18	GEO Unlocated alert (GOES -13)	--
20:24	MEO DOA Position	5,5 km
20:40	MEO Confirmed	3,2 km
21:39	LEO Initial alert (S-12) – Prob. 94% - Doppler A	0,8 km
22:05	LEO Resolved alert (S-07)	3,3 km

Locations are shown on the map below:

In this incident, MEOSAR provided an alert with an accurate position 1 hour and 40 minutes prior to the LEOSAR system which contributed to a successful rescue.

4.8.15 Incident 15 – Australia

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	14 August 2016 03:41 UTC
Location	Jurien Bay, Australia
Incident Type	Vessel broken up.
Beacon Type	EPIRB
Beacon Environment (land/sea/cliff/forest/dessert…)	Sea
Beacon Speed (static/moving/drifting…)	Static
Local Time	11:41
Local Weather Conditions (winds, ice, hot, cold…)	Persons in water
Resources moved (Helicopter/Vessel/Aircraft…)	Helicopter
People Involved	2
People Rescued	2
C/S MEOSAR Alert (Only/First/Other)	**Only**
Detection Time (Advantage/No Advantage)	Advantage (at least 169 mins)
Location Time (Advantage/No Advantage)	Advantage (at least 169 mins)
Location Accuracy (Advantage/No Advantage)	Location Accuracy (0.8 km)

A beacon was detected with a DOA location by the Australian and New Zealand MEOSAR system at 03:41 UTC on 14 August 2016. An unlocated GEOSAR detection was received by the Australian JRCC at 0359.

Although the beacon was registered, attempts to contact the emergency contacts for the beacon were unsuccessful.

SAR resources were tasked and at 06:00 UTC, two men were rescued off Jurien Bay in Western Australia (approximately 200 kilometres north of Perth). Both men were rescued from the water as their vessel had broken up.

If the beacon had been left turned on, the first LEOSAR detection would not have occurred until approximately 06:30 UTC.

The rescue helicopter reported that the MEOSAR location provided by the JRCC was within 800 metres of the actual beacon location.

In this incident, MEOSAR provided a 169 minute advantage in providing a location for a rescue with persons in the water.

4.8.16 Incident 16 – New Zealand

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	25 August 2016 21:48
Location	Mt Cook National Park, New Zealand
Incident Type	Hiker bad hand injury.
Beacon Type	PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Snow
Beacon Speed (static/moving/drifting…)	Static
Local Time	09:48
Local Weather Conditions (winds, ice, hot, cold…)	Ice, cold
Resources moved (Helicopter/Vessel/Aircraft…)	DOC Alpine Cliff Rescue Team / Helicopter
People Involved	1
People Rescued	1
C/S MEOSAR Alert (Only/First/Other)	**First Detection / Only Location**
Detection Time (Advantage/No Advantage)	Advantage (85 mins)
Location Time (Advantage/No Advantage)	Advantage in location
Location Accuracy (Advantage/No Advantage)	

At 21:48 UTC on 25 August 2016, RCCNZ received MEOSAR alerts for a PLB registered to the Canterbury University Tramping Club, with positions near Ball Shelter in Aoraki Mt Cook National Park. Contacts advised that two persons had borrowed the beacon before going back-country skiing. The DOC Alpine Cliff Rescue Team was tasked, along with a helicopter. The crew, including a paramedic, quickly found the pair, who had activated the PLB on behalf of an injured person they had come across. The tramper (hiker) had fallen and sustained a bad hand injury. The person was flown back to the SAR base for initial treatment then taken by ambulance to hospital

The only GEOSAR detection of the beacon was at 23:13 UTC with no encoded location. No location was generated by the LEOSAR or GEOSAR systems.

In this incident, MEOSAR provided an 85 minute advantage in detecting the beacon and provided a location that enabled the rescue of an injured person.

4.8.17 Incident 17 – Australia

Type of Analysis (Real-time/Retrospective)	Real-time
Date and Time	10 October 2016 05:33 UTC
Location	400 NM west of Cocos Island, Indian Ocean
Incident Type	Yacht total power failure
Beacon Type	EPIRB
Beacon Environment (land/sea/cliff/forest/dessert…)	Sea
Beacon Speed (static/moving/drifting…)	Drifting
Local Time	11:33 (Approx)
Local Weather Conditions (winds, ice, hot, cold…)	Rough seas
Resources moved (Helicopter/Vessel/Aircraft…)	Sighted by Aircraft / Picked up by Vessel
People Involved	2
People Rescued	2
C/S MEOSAR Alert (Only/First/Other)	**First**
Detection Time (Advantage/No Advantage)	Detection Advantage (180 mins)
Location Time (Advantage/No Advantage)	Location Advantage (>210 mins)
Location Accuracy (Advantage/No Advantage)	Location Accuracy varied (0.1 – 15) NM

At 05:33 UTC on 10 October 2016, the Australian JRCC received an initial alert with a MEOSAR location in the Indian Ocean, approximately 400 nautical miles west of Cocos Island. The beacon had a country of registration of French Polynesia and was associated with a yacht with two persons on board. An Australian defence force aircraft was tasked to respond and a 288 metre gas carrier was diverted to the area.

At 10:07 UTC the yacht was sighted by the aircraft and two persons were rescued by the gas carrier at approximately 10:50 UTC. The yacht had suffered a total power failure and was abandoned.

The first GEOSAR detection was sent to the FMCC at 08:28 UTC. This alert had no location data and was forwarded to JRCC in Tahiti (as the beacon had a country of registration of French Polynesia).

The first LEOSAR detection was at 08:50 UTC but again had no location data. At 09:08 UTC the AUMCC received a LEOSAR detection with two Doppler locations in the Indian Ocean. A resolved LEOSAR alerts was received by the Australian JRCC at 10:53 UTC.

Between 05:33 UTC and 10:52 UTC, 102 MEOSAR alerts were received by the Australian MEOSAR MCC from the Australian and New Zealand MEOLUTs. The MEOSAR location was confirmed at 05:50 UTC.

Using the location of the yacht at 10:07 UTC when sighted by the Australian aircraft, the MEOSAR detections ranged from 0.1 nautical miles to 15 nautical miles. Accuracy of the MEOSAR locations varied during the incident. The LEOSAR locations were within 1 nautical mile for the Doppler A position and the resolved position.

In this incident, MEOSAR provided a detection time advantage of three hours compared with GEOSAR and LEOSAR. As well, MEOSAR provided a time advantage of more than three and half hours in generating location data. The MEOSAR data allowed a successful rescue to be completed before LEOSAR produced a resolved location for this incident.

4.9 Test O-7 MEOSAR Alert Data Distribution – Impact on Independent Location Accuracy

4.9.1 O-7 Test Result

The following test reports were provided by the participants:

Administration	Test report reference
France	France D&E Phase 2 Part 2 Operational Tests Report, sections 6.1.5 & 6.2.5 SAR-RE-DEMEO-917-CNES
USA	Operational Test Phase II Part 1 USA Preliminary Analysis (section 6), per document JC-28/Inf.26 USA D&E Phase 2 Part 2 Operational Tests Report, per TG-2/2016 document “USA_O-7 PhaseII-Part2_Report” listed under “Other Documents”

4.9.1.1 France

Standalone mode

FMCC-MEOSAR ready Quality Factor success rate (standalone):

D&E Phase II O-7 / FMCC-MEO Results Summary (STAND-ALONE Mode)		
Category	**Count**	**Percentage**
Success#1 (better QF - better accuracy)	**209**	27.1%
Success#2 (worse QF - worse accuracy)	238	30.9%
Failure#1 (better QF - worse accuracy)	175	22.7%
Failure#2 (worse QF - better accuracy)	148	19.2%
Total Analyzed	**770**	**10.6%**
Not Analyzed (No DOA position in event)	3300	51.0%
Not Analyzed (QF scale not comparable HGT/TSI)	67	1.0%
Not Analyzed (No previous DOA position recorded)	17	0.3%
Not Analyzed (No change in QF [for HGT scale])	3065	47.4%
Not Analyzed (Change in QF less than 50 [for TSI scale]	18	0.3%
Total Not Analyzed	6467	**89.4%**
Grand Total	**7237**	**100.0%**
All Successes vs analyzed data	**447**	58.1%

Networking mode

FMCC-MEOSAR ready Quality Factor success rate (networking):

D&E Phase II O-7 / FMCC-MEO Results Summary (NETWORKING Mode)		
Category	**Count**	**Percentage**
Success#1 (better QF - better accuracy)	888	32.4%
Success#2 (worse QF - worse accuracy)	916	33.4%
Failure#1 (better QF - worse accuracy)	475	17.3%
Failure#2 (worse QF - better accuracy)	464	16.9%
Total Analyzed	2743	**14.0%**
Not Analyzed (No DOA position in event)	12018	71.4%
Not Analyzed (QF scale not comparable HGT/TSI)	161	1.0%
Not Analyzed (No previous DOA position recorded)	21	0.1%
Not Analyzed (No change in QF [for HGT scale])	4582	27.2%
Not Analyzed (Change in QF less than 50 [for TSI scale]	42	0.2%
Total Not Analyzed	**16824**	**86.0%**
Grand Total	**19567**	**100.0%**
All Successes vs analyzed data	1804	65.8%

4.9.1.2 USA

Part 1

Category	Count	Percentage
Success#1	17	47.2%
Success#2	7	19.4%
Failure#1	7	19.4%
Failure#1	5	13.9%
Total Analyzed	**36**	
Not Analyzed	132	
Grand Total	**168**	
All Successes	24	66.7%

Site#	BeaconId	ReceiveTime	Status	New Error	Exist Error	New QF	Exist QF	Error Dif	QF Dif	Outcome
261279	2DD7A763BF81FE0	2014/04/14 19:29:01	--	0.000	2.817	719	585	2.817	134	Success: Better QF and Better Accuracy
261284	ADCD02247942401	2014/04/14 19:46:55	--	3.703	3.733	734	734	0.029	0	N/A: Change in QF less than 50
261297	DBE8D04C35D64D1	2014/04/14 21:49:53	--	31.614	21.914	799	850	-9.700	-51	Success: Worse QF and Worse Accuracy
261352	1E86908266FFBFF	2014/04/15 05:48:15	--							N/A: No actual Lat/Lon provided
261354	2DC8691356FFBFF	2014/04/15 05:39:54	--	6.858	7.230	303	396	0.372	-93	Failure: Worse QF and Better Accuracy
261396	E0E75BD865D31D1	2014/04/15 11:11:31	--	4.877	8.992	925	865	4.115	60	Success: Better QF and Better Accuracy
261396	E0E75BD865D31D1	2014/04/15 11:08:13	--	8.992	9.776	865	611	0.784	254	Success: Better QF and Better Accuracy
261396	E0E75BD865D31D1	2014/04/15 11:14:46	--	4.257	4.877	938	925	0.621	13	N/A: Change in QF less than 50

Part 2 (Stand-Alone Only – Modified approach to analysis)

Distance Threshold	% Success vs. Total Analyzed	% Success of Grand Total	% Failure of Grand Total	Grand Total
None (0)	68.9	11.6	5.3	9790
0.5 km	70.3	10.9	4.6	9790
1 km	71.5	10.3	4.3	9790

Summary Quality Factor Reliability

Quality Factor Range	Cases	Med-ian	50th	75th	95th	< 5km Count	< 5km %	< 20km Count	< 20km %
0 to 49	36	0	17.66	36.88	64.79	5	13.9	21	58.3
50 to 99	4	86	10.86	35.14	35.14	1	25	3	75
100 to 149	**9**	**141**	**56.45**	**65.16**	**69.05**	**0**	**0**	**1**	**11.1**
150 to 199	6	189	77.36	80.39	80.39	1	16.7	1	16.7
200 to 249	8	224	21.43	27.06	81.11	1	12.5	2	25
250 to 299	**13**	**284**	**10.54**	**25.27**	**77.27**	**3**	**23.1**	**8**	**61.5**
300 to 349	30	325	17.23	25.7	42.31	3	10	17	56.7
350 to 399	19	381	18.56	23.85	62.2	1	5.3	12	63.2
400 to 449	**28**	**419**	**21.29**	**31.34**	**91.66**	**2**	**7.1**	**12**	**42.9**
450 to 499	30	476	12.9	23.95	40.86	3	10	21	70
500 to 549	57	524	13.2	21.09	30.94	10	17.5	42	73.7
550 to 5990	**141**	**563**	**7.2**	**13.75**	**31.45**	**48**	**34**	**120**	**85.1**
600 to 649	206	629	9.99	17.6	43.73	49	23.8	166	80.6
650 to 699	288	677	6.86	13.42	27.16	114	39.6	245	85.1
700 to 749	**500**	**728**	**7.78**	**13.08**	**24.67**	**165**	**33**	**456**	**91.2**
750 to 799	609	770	5.92	9.99	18.73	254	41.7	585	96.1
800 to 849	569	830	5.11	8.62	17.19	281	49.4	551	96.8
850 to 899	**712**	**870**	**4.03**	**6.47**	**11.87**	**430**	**60.4**	**711**	**99.9**
900 to 949	506	914	2.96	4.52	7.58	400	79.1	506	100
950 to 999	54	964	1.45	1.94	4.49	53	98.1	54	100
0 to 249	63	26	21.92	40.58	80.39	8	12.7	28	44.4
250 to 499	120	395	16.11	25.45	54.75	12	10	70	58.3
500 to 749	**1192**	**686**	**7.91**	**14.19**	**28.8**	**386**	**32.4**	**1029**	**86.3**
750 to 999	2450	853	4.2	7.22	14.58	1418	57.9	2407	98.2
Total	3825	792	5.3	9.8	24.0	1824	47.6	3534	92.3

Florida/Hawaii MEOLUT DOA Location Errors (km) vs. Quality Factor

4.9.2 O-7 Test Result Interpretation

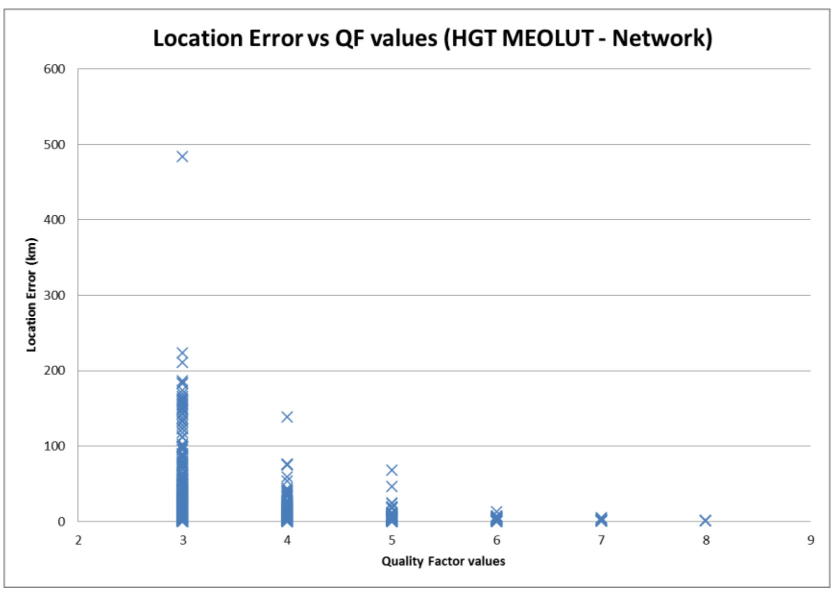
4.9.2.1 France

The O-7 test results fail to prove the operational and technical effectiveness of the location Quality Factor as it is currently used at the MEOSAR MCC level. The MEOLUT manufacturers use different scales and definitions of this factor which prevents complete analysis: in particular, in stand-alone mode the HGT MEOLUTs can only provide four distinct values. It also appears that QF strict dependence on the location error value is only verified in two thirds of the time (in network results which are slightly better than stand-alone).

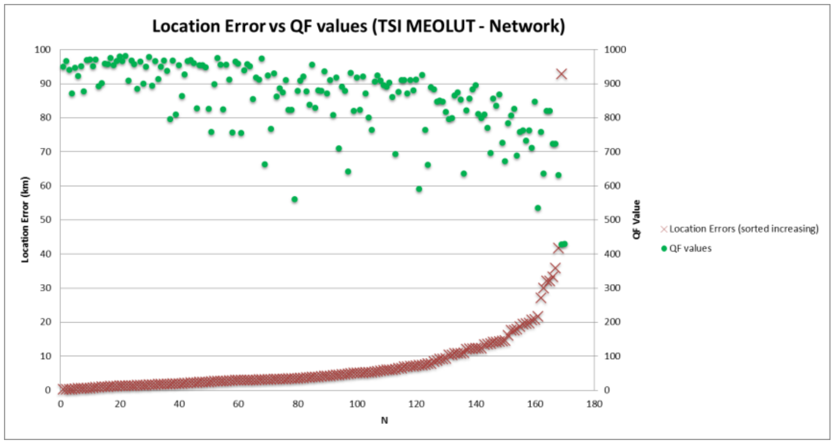
The results of the O-7 test depend on the proper use and definition of the Quality Factor, which differs from the one manufacturer to another. The idea to link it directly to the error location is working between 58% and 65% of the cases only, which is not satisfactory. This can be due to two factors:

- location error estimation by MEOLUT not always representative of the real error,
- other parameters than the location error estimation used in the QF processing.

The D&E Phase II O-7 results gathered by France lead to the necessity of re-defining a formal definition of the QF (linked to the location error and/or may be other parameters) and reaching an agreement between the manufacturers to use the same definition in the MEOLUTs' out-going messages.



Location Error as Function of QF (HGT / Network)



Location Errors Increasing and Corresponding QF (TSI/Network)

4.9.2.2 USA

Part 1

For a limited dataset and using the alert site composite location in the absence of ground truth, a significant change in quality factor was correlated with an improvement in location accuracy in 66.7% of cases. 50% of successful cases (i.e., cases where the quality factor and location accuracy were positively correlated) involved a location accuracy improvement of at least 2 km. This suggests that the analysis of quality factor could be refined by correlating a meaningful improvement in quality factor with an improvement in location accuracy that is meaningful to RCCs performing SAR.

This analysis provides evidence that a quality factor correlated with location accuracy can be achieved. To enable different quality factors to be assessed objectively by various C/S participants, quality factor algorithms should be distributed among C/S participants.

Keeping with the original objective of the test, the analysis is focused on redundant solutions, but it would be useful to extend the analysis to a broader data set, so that a quality factor could be provided to SPOCs.

Part 2 (Stand-Alone Only – Modified approach to analysis)

As shown in Figure A (see section 4.9.1.2 of this respect), a significant change in quality factor was correlated with improved location accuracy, and the degree of correlation increased as the distance threshold was increased. An increase in the distance threshold yielded fewer cases where success could be determined. With a distance threshold of 1 km, the quality factor was successful in 71.5% of applicable cases; however, this represents only 10.3% of total cases.
As shown in Figure B (section 4.9.1.2), an increase in the quality factor generally corresponds to a decrease in location error, in particular, for higher ranges of quality factor. For example, for every quality factor range of 50 above 700, a higher quality factor corresponded to higher location

accuracy; in particular, the 50th percentile location error decreased continuously from 7.78 km for range 700 - 749 to 1.45 km for range 950 - 999.

Since the algorithm used to compute quality factor is vendor specific, O-7 test results for USA MEOLUTs may differ significantly from the results for MEOLUTs provided by other vendors.

Conclusions derived from this analysis follow:

- The correlation between change in quality factor and change in location accuracy provides evidence that an MCC algorithm could be implemented to distribute or filter alerts based on significant changes in the quality factor.
- The correlation between quality factor and location accuracy, especially for higher quality factors, provides significant evidence that RCCs could be provided with reliable quality factor information for MEOSAR data.

- END OF SECTION 4 -

5. CONCLUSIONS AND RECOMMENDATIONS

This section provides the conclusions commonly agreed by participants in the MEOSAR D&E tests and their recommendations for future conduct of the tests in the MEOSAR D&E Phase III and the implementation of the MEOSAR system.

5.1 Conclusion

5.1.1 Test T-1 (Processing Threshold and System Margin)

- System margin for single-burst throughput using single-channel results

The detection percentage produced from the single-channel testing varied enough and for most of the MEOLUTs did not consistently surpass the 70% threshold defined in document C/S R.018. When this threshold was reached, the system margin ranged from 0 to 15 dB. Due to difference of results from various national administrations, it was difficult to determine a common system margin value for a single-burst throughput using single-channel results.

- System margin for single-burst throughput using multi-antenna results

Results for system margin were improved using multi antennas. Using the 70% threshold, the system margin from different MEOLUTs ranged between 4-15 dB and was also dependent on the number of MEOLUT antennas.

The resulting processing margin is between 22 and 33 dBm of beacon transmit power.

5.1.2 Test T-2 (Impact of Interference)

Due to the unavailability of the Canadian MEOLUT at Shirley's Bay for the majority of the MEOSAR D&E Phase II, there were fewer opportunities for T-Test participants to reconcile anomalies and unexpected results with spectrum plots in order to confirm and correlate with interference. However, one instance of interference during T-3 testing revealed the impact of MEOSAR D&E T-Testing running coincidental with CTEC B.8 Testing on the Sarsat LEOSAR SARR-1 instruments.

5.1.3 Test T-3 (MEOLUT Valid/Complete Message Acquisition)

For Phase II, the transmission script has been updated to include 13 bursts in order to be in line with the required time frame of 10 minutes, with two slots, first one at 37 dBm level and second one at 33 dBm level.

For nominal power of 37 dBm, and for beacon simulator at distance below 3,000 km from the MEOLUT, the results of the test T-3 has shown that the probability of detection of a valid message is in the range [88%- 100%] after 1 burst and higher than 99% after 13 bursts, which is compliant with expectation for minimum performance at full operational capability (FOC) contained in Annex E of document C/S R.012 (99% after 10 minutes) for most MEOLUTs.

Depending on MEOLUT, results at 33 dBm transmitted power are sometimes better than those obtained at 37 dBm, which was unexpected.

The main conclusions drawn from the test were the following:

- The results are compatible with the expectation for minimum performance at full operational capability (FOC) contained in Annex E of document C/S R.012 (MIP).
- The average detection probabilities improved with an increase of the number of transmitted bursts,
- The results have shown that due to reduced co-visibility, performances are decreasing at large distances but for a range [6,000 km- 9,000 km], the probability of detection of a valid message in 10 minutes is still above 80%, even reaching 100% for one MEOLUT.

It is expected that the results can still be improved for large distance as the MEOSAR L-band space segment is expanded in the future, with an increase of single channel throughput.

For Phase III, some improvements to the test could be proposed such as:

- The better results occasionally observed at 33 dBm vs 37 dBm could perhaps be explained by a better space segment configuration during the 33 dBm slots.

5.1.4 Test T-4 (Independent Location Capability)

Independent Location Probability

The probability that a MEOLUT provides an independent 2D location with a location error less than X km (X = 1, 5 or 10 km) did not always reach desired values. Performance for X = 5 km after ten minutes ranged from 82 to 99%.

Independent Location Accuracy

The 50th percentile, the 75th percentile, and the 95th percentile of the location error of 2D locations did not always reach desired values. At least one national administration reported results of less than 5 km for 95th percentile after ten minutes.

Time to First Independent Location

The time elapsed between the first burst transmitted and the first 2D independent location with an error less than X km (X = 1, 5 or 10 km) was not more than 2 to 3 minutes.

Conclusions

The results were improved from Phase I results because of the greater number of available satellites and improvements in MEOLUT processing. While not all results achieved the performance expected for full operational capability, some met or exceeded the requirements. It is expected that the results will improve in the future as more L-band satellites are added and MEOLUT processing is improved.

5.1.5 Test T-5 (Independent 2D Location Capability for Operational Beacons)

Detection benefit of the MEOSAR system

The tests carried out over 2 weeks with 35 operational beacons deployed worldwide soundly demonstrated the vast geographic range of individual MEOLUTs and confirmed the detection benefit of the MEOSAR system, even with a limited MEOSAR space segment that consisted, at the time of the tests, of 17 DASS, 3 Galileo and 2 Glonass satellites. Some participants only tracked the DASS satellites whereas other participants tracked all available satellites.

Detection capability (system throughput)
The MEOLUT system throughput gradually degraded as the distance between the beacons and the MEOLUTs increased and fewer satellites became available to select from to ensure the co-visibility of a MEOLUT, satellite and a beacon. L-band satellites generally improved the link budget in terms of C/N_0 at MEOLUT level in comparison with the DASS S-band satellites (about 4 dB higher). System throughputs in the range of 98% to 100% were reported by some MEOLUTs for beacons located in the geographic region around the individual MEOLUT.

Independent Location Probability
Single-burst location probabilities of 80% to 95%, and 10-minute location probabilities of up to 100%, were reported by various MEOLUTs for beacons located in the geographic region around the individual MEOLUT.

Independent Location Accuracy
Most of the presented results for independent location accuracy provided within 10 minutes did not meet the expectation for MEOSAR IOC/FOC minimum performance of “5 km accuracy 95% of the time” contained in document C/S T.019. The location accuracy was, as expected, better within the geographic region of the MEOLUTs (e.g., circle centred at the MEOLUT with a radius of 3,000 km); location error was frequently below 5 km within that geographic region especially for locations calculated with detections from a larger number of satellites. Composite locations calculated by the integration of up to 13 bursts over 10 minutes offered a higher probability to obtain a location accuracy sometimes meeting minimum performance of “5 km accuracy 95% of the time” contained in document C/S T.019. At least one administration reported location accuracy of 1 to 3 km, 95% of the time.

Therefore, these results confirmed the ability of a MEOLUT to meet the accuracy requirements using a hybrid space segment consisting of L- and S-band satellites.

More than one participant expressed the view that the main factor that affected location accuracy was the number of satellites used for the location process and that a significant improvement in location accuracy could be observed when the number of satellites used to calculate a location moved from three to four. However, results provided by one participant revealed that the accuracy requirement could be met with 3 satellites in many cases. That was made possible by selection of satellites that provided a better geometry and JDOP value.

Although the D&E assumes fixed beacons, it was also noted by a participant that movement of beacons impact the location accuracy. Although extremely limited by the test time, location accuracy evaluation results reported by one participant showed that for a slow-moving beacon activated in Bodoe, Norway the location accuracy was much worse in comparison with location accuracy obtained from fixed beacons and did not meet C/S T.019 requirements. This degradation was caused by inability to use FOA measurements in location processing due to extra Doppler shift caused by the beacon movement. It was noted that to produce an accurate location of a moving beacon, measurements obtained from at least 6 satellites per burst might be required, enabling processing of both the beacon location and the beacon velocity.

Conclusions

Phase II test results showed that:

- the MEOSAR system's capability to detect beacons is very good, sometimes beyond expectations,
- the single-burst location accuracy, although better than in Phase I, was still not good enough to meet all the related full operational capability (FOC) requirements in document C/S T.019, "MEOLUT Performance Specification and Design Guidelines",
- composite locations provided higher probability to obtain a location accuracy sometimes meeting the minimum performance of "5 km accuracy 95% of the time" contained in document C/S T.019,
- location accuracy for a moving beacon was worse than for fixed beacons and did not meet C/S T.019 requirements,
- the results did not provide clear guidance for the specifications and parameters regarding the exact coverage areas in which the calculated locations could meet the minimum performance expectation for location accuracy at full operational capability (FOC) as stipulated in document C/S T.019,
- one reason for the limitation in the location accuracy performance was the negative impact of interference on the channel detection rates,
- increasing the number of MEOLUT antenna-satellites pairings would improve the location probability and accuracy, as well as the time to locate, and
- selection of satellites and accuracy of TOA/FOA measurements (primarily FOA) were also very important to improve the MEOLUT performance.

5.1.6 Test T-6 (MEOSAR System Capacity)

The transmission script has been updated to include the following number of NB transmitted beacons 25, 50, 75, 100, 150, 200. Only Maryland and Toulouse simulators are able to transmit this script.

The results on System Capacity performance were not conclusive during Phase II. While there was no identifiable curve drop-off from the MEOLUTs monitoring the Toulouse beacon transmissions, suggesting that the value of system capacity might be 200 beacons or more, results for MEOLUTs monitoring the Maryland beacon transmissions showed some degradation in performance even below 100 beacons.

5.1.7 Test T-7 (Networked MEOLUT Advantage)

5.1.7.1 Test T-4/T-7

Independent Location Probability

The probability that a MEOLUT provides an independent 2D location with a location error less than X km (X = 1, 5 or 10 km) did not always reach desired values. Performance for X = 5 km only met the expected performance when number of satellites or processing bandwidth were not limiting factors.

Independent Location Accuracy

The 50^{th} percentile, the 75^{th} percentile, and the 95^{th} percentile of the location error of 2D locations did not reach desired values. Some reported results for performance for 95^{th} percentile after ten minutes was less than 5 km.

Time to First Independent Location

The time elapsed between the first burst transmitted and the first 2D independent location with an error less than X km (X = 1, 5 or 10 km) was typically not more than 2 to 3 minutes. However, for some participants the volume of data caused some processing issues that need to be resolved.

Conclusion

Many results improved as a result of networking but some results still did not achieve the performance expected for full operational capability. It is expected that the results will improve in the future as MEOLUT processing of network data is improved

5.1.8 Test T-8 (Combined MEO/GEO Operation Performance (Optional))

T-8 testing was not completed in Phase II.

5.1.9 Test O-1 Potential Time Advantage

All participants noted a time advantage for the independent location provided in MEOSAR alert data versus LEOSAR alert data when the median figure was observed, with the exception of Japan during the standalone period, which presented some negative median values in PTAL and PTAC, likely due to MEOLUTs were located to some distance from Japan. The results also showed that, in general, there was not a significant improvement when the AOI filtering was applied.

The MEOSAR did not show a significant time advantage with respect to detect-only data category, where the GEOSAR system reduced the time advantage near to zero. In results provided by one participant the MEOSAR system presented a time advantage with respect to detect-only cases provided by LEOSAR data.

Networking period results showed a time advantage for the MEOSAR system in the provision of independent locations (PTAL and PTAC), in fact, the median values for all participants showed a time advantage during this period.

5.1.10 Test O-2 Unique Detections by MEOSAR System as Compared to Existing System

Overall the O-2 Testing during Phase II of the MEOSAR D&E produced useful results, some highlighting concerns to be addressed, and some clearly indicating the benefits of MEOSAR.

Summarizing results from all participants with respect to unique detections by the MEOSAR and LEOSAR/GEOSAR systems leads to three prevailing key observations:

- MEOSAR produced an extremely large number of detect only (unlocated and encoded only) cases relative to the LEOSAR/GEOSAR system,
- There were always some beacon activations that were recorded by LEOSAR/GEOSAR only, and when independent locations or confirmed positions were involved these statistics indicate a failure by MEOSAR to record actual beacon activations,
- Similarly, but more expected, the increased coverage capabilities of MEOSAR were demonstrated as MEOSAR recorded many actual beacon activations with independent locations or confirmed positions that went undetected by the LEOSAR/GEOSAR system, mostly likely due to gaps in periods of satellite visibility for LEOSAR.

With regard to the collection of statistics and the analysis methodology, the following observations were common among most participants:

- The size of the data set is sometimes reduced, but overall, performance statistics do not significantly change when the AOI is applied,
- Networking of MEOLUTs appears to increase the amount of detect only cases, have limited impact in other categories, and overall did not significantly impact key observations.

The single most significant outcome for the O-2 test lies in the large numbers of detect only cases recorded by the MEOSAR system only. Follow-on analysis performed by several participants indicated that a majority of these cases appeared to be system generated anomalies (i.e., not real beacons). Ultimately, JC-29 developed related data distribution procedures that would help mitigate the impact of these suspect alerts in the short term (during EOC), but further important work remains to address this matter.

And while the lack of MEOSAR data for some actual beacon activations needs attention as well, the significant number of MEOSAR only cases with independent location and confirmed position soundly demonstrates the value that MEOSAR data adds to the current system.

5.1.11 Test O-3 Volume of MEOSAR Distress Alert Traffic in the Cospas-Sarsat Ground Segment Network

According to document C/S R.018, the O-3 test should:

- Evaluate the volume of 406 MHz MEOSAR distress alert messages exchanged between MCCs, compare it to the traffic for the existing system (LEOSAR and GEOSAR), and

- Provide additional information on the combined totals and data volumes in bytes and corresponding bandwidths

With respect to the volume of MEOSAR distress alert messages exchanged between MCCs during the overall test time span, the major difference was noted between MEOSAR-ready MCCs which were connected to a MEOLUT versus those MEOSAR-ready MCCs that were not connected to a MEOLUT.

Those MEOSAR-ready MCCs that were not connected to a MEOLUT transmitted MEOSAR message traffic at a lower volume than LEOSAR/GEOSAR message traffic, due to the production of data from their local LEOLUT/GEOLUT systems. In this case, the MEOSAR message traffic was less than one half that of the LEOSAR/GEOSAR message traffic.

Those MEOSAR-ready MCCs that were connected to a MEOLUT transmitted a MEOSAR message traffic at a greater volume than MCC LEOSAR/GEOSAR message traffic. Calculating the ratio between the MEOSAR Data Volume versus the LEOSAR/GEOSAR Data Volume, for most of the participants, the MEOSAR Data Volume ranges between 1 and 4 times the LEOSAR/GEOSAR Data Volume, except for FMCC that showed a ratio which ranges from 4 to 9. These ratios can also be derived from the Bandwidth occupancy (because a fixed value of 1024 bytes per message was considered) as follows:

Standalone

	CONNECTED TO A MEOLUT				NOT CONNECTED TO A MEOLUT		
	FMCC	**NMCC (QMS)***	**SPMCC**	**USMCC**	**ITMCC (QMS)***	**JAMCC**	**SPMCC**
LEO/GEOSAR BW	0.00696201	0.018908	0.017221	0.008359	0.016849	0.009513	0.017512
MEOSAR BW	0.03107630	0.019615	0.060967	0.020178	0.000602	0.001606	0.007331
COMBINED	0.03785096	0.038522	0.078188	0.028536	0.017444	0.011118	0.024843
RATIO	4.46	1.04	3.54	2.41	0.04	0.17	0.42

Networking

	CONNECTED TO A MEOLUT				NOT CONNECTED TO A MEOLUT		
	FMCC	**NMCC (QMS)***	**SPMCC**	**USMCC**	**ITMCC (QMS)***	**JAMCC**	**SPMCC**
LEO/GEOSAR BW	0.00904303	0.017792	0.016674	0.008752	0.017250	0.010172	0.017793
MEOSAR BW	0.07895902	0.045551	0.045352	0.032272	0.000433	0.003481	0.020796
COMBINED	0.08798943	0.063327	0.062026	0.041022	0.017665	0.013653	0.038589
RATIO	8.73	2.56	2.72	3.69	0.03	0.34	1.17

(QMS)*: *QMS data included.*

Each participant presented different LEOSAR/GEOSAR bandwidth occupancy, but in general, for MCC to MCC communications, the LEOSAR/GEOSAR message traffic bandwidth was below 0.02 kb/s. This figure includes the QMS message traffic for non-nodal MCCs.

Considering the distribution of operational alert messages only and taking into account that most MCCs provided an overall MEOSAR message traffic which was below 4 times their LEOSAR/GEOSAR message traffic, we concluded that the MEOSAR bandwidth between MCCs kept below 0.08 kb/s, except for the FMCC case which reached the figure of 0.09 kb/s in the networking mode.

Therefore, in these conditions (MCC being connected to a MEOLUT, no orbitography, test reference or self-test beacons exchanged and the overall test time span considered), and considering the worst case presented by France, the LEOSAR/GEOSAR/MEOSAR combined bandwidth used per MCC for transmission of messages to other MCCs kept below 0.1 kb/s.

The analysis above takes into account neither traffic peaks nor the communications with RCCs/SPOCs which in some situations presented some differences with respect to the MCC to MCC communications, due to the MCC configuration context.

This configuration context is related with the MCC behavior after confirmation of the alert (e.g., some MEOSAR-ready MCCs during D&E behaved as LEOSAR/GEOSAR MCC after confirmation of alerts not sending messages), the distance match criterion of 10 km, transmission of conflict messages as they were received from the MEOLUT (without any time restriction between conflict messages) and the number of SPOCs involved in every particular alert (given the special characteristics of some areas, two SPOCs could be defined to cover the same area, therefore, alerts for that area are sent duplicated).

Given this configuration context, some message traffic peaks to the SPOCs were identified, mainly related with conflict alerts which were transmitted to the SPOC destinations right after those conflict messages were received from the MEOLUT. Those traffic peaks kept below a bandwidth of 1 kb/s in 15 minutes (i.e., below 80 SIT185 messages of 1,400 bytes each in 15 minutes).

It had to be taken into account that a significant number of suspect MEOSAR alerts could have impacted the Test O-3 results (see documents JC-29/4/5 (Norway) and JC-29/4/11 (USA) about suspect MEOSAR alerts).

5.1.12 Test O-4 406 MHz Alert Data Distribution Procedures

Test O-4 analyses (counts) alerts by MCC distribution category (e.g., first alert with no location, position confirmation DOA and encoded position, redundant DOA) in order to assess and improve MCC alert data distribution procedures. Results presented by France, Italy and the USA compare counts in the MEOSAR and LEOSAR/GEOSAR systems by MCC processing category, but have not directly led to modifications in MCC data distribution procedures.

Significant differences in counts between the two systems reflect:

- inherent system capabilities (e.g., only the MEOSAR system can generate independent location with one burst),
- the relatively limited implementation of the space and ground segments in the MEOSAR system, and
- differences in MCC alert data distribution procedures (e.g., continued transmission after position confirmation in the MEOSAR system).

The higher number of alert sites (and solutions) in the MEOSAR system reflects a high detection capability, but also reflects a high incidence of suspect (i.e., uncorroborated) MEOSAR alerts, as described in the analysis for test O-2 (per section 5.1.10).

As reported by France, the LEOSAR/GEOSAR system generates significantly more redundant alerts than the MEOSAR system (89% vs. 53% in standalone mode). This is likely due in large part to two factors:

a) alerts are sent after position confirmation only in the MEOSAR system (making LEOSAR/GEOSAR alerts redundant and not transmitted after position confirmation); and

b) the LEOSAR/GEOSAR ground segment is more fully implemented (thereby increasing opportunities for redundancy).

France and Italy reported that a higher percentage of MEOSAR first alerts contained DOA position when MEOLUTs operated in standalone mode, per data extracted in the table below. This is curious, given that MEOLUT networking should increase the number of TOA/FOA measurements available to the MEOLUT for given beacon bursts and thus increase the probability of location. Some possible factors are identified below:

a) communication delays hamper the benefit of MEOLUT networking (e.g., a MEOLUT distributes an unlocated first alert prior to receiving or processing networked TOA/FOA data that would have enabled a DOA position to be computed);

b) networked TOA/FOA data is largely redundant due to lack of coordinated satellite tracking schedules between MEOLUTs (i.e., different MEOLUTs are tracking the same satellites at the same time);

c) the high incidence of suspect (uncorroborated) alerts, while MEOLUTs are networked, increases the number of unlocated first alerts distributed between MCCs (e.g., an uncorroborated burst for an Italian coded beacon detected by the Norway MEOLUT could be networked to the MEOLUTs in France and Cyprus, and distributed as a unlocated alert by the NMCC, CYMCC and FMCC to the ITMCC); and

d) other factors coincident with the test periods affects results (e.g., poorer satellite visibility in the period when MEOLUTs were networked).

	Standalone Mode			Networking Mode		
	# With DOA	# Total	% with DOA	# With DOA	# Total	% with DOA
France	69	601	11.5	24	293	8.2
Italy	153	708	21.6	64	323	19.8
Total	222	1309	17.0	88	616	14.3

MEOSAR First Alerts with DOA Position (Standalone and Networking Mode)

The USA reported than only 3.1% of MEOSAR first alerts contained independent location (in standalone mode), compared to 26.3% in the LEOSAR/GEOSAR system. Per comparable data reported by France, 11.5% (69 / 601) of MEOSAR first alerts contained independent location versus 17.7% (38 / 215) of LEOSAR/GEOSAR first alerts. As reported by the USA, it is expected that the availability of first alert DOA locations (i.e., near real-time) will increase as more MEOSAR satellites become available for use and when MEOLUT networking is performed.

5.1.13 Test O-5 SAR/Galileo Return Link Service

Test O-5 has been postponed to Phase III.

5.1.14 Test O-6 Evaluation of Direct and Indirect Benefits of the MEOSAR System

The results from O-6 were generally positive.

Seventeen incidents were reported for test O-6 in Phase II of the MEOSAR D&E. Six countries provided data; twelve of the seventeen incidents were from Australia and New Zealand.

In eleven incidents MEOSAR provided a time advantage for detection of the beacon and/or a time advantage for generating a location. The time advantage varied from 5 minutes to 284 minutes.

The benefit of the time advantage to an RCC is difficult to characterise. In some incidents a time advantage is not likely to affect the successful outcome; however people in distress are rescued sooner. In other incidents (for example Incident 4) the time advantage was critical to the successful outcome of the rescue.

In two incidents MEOSAR provided the only detection in a successful rescue. In another incident, MEOSAR provided the only location.

There were three incidents where MEOSAR did not provide an advantage. In two of those, the initial location provided by MEOSAR was highly inaccurate due to a moving beacon.

5.1.15 Test O-7 MEOSAR Alert Data Distribution – Impact on Independent Location Accuracy

Based on reports provided by France and the USA, the quality factor and location accuracy were correlated in 58% to 72% of cases where an assessment was possible. For the French MEOLUT, the correlation was higher in networking mode (65%) than in stand-alone mode (58%). For USA MEOLUTs, all results were reported for stand-alone mode and the correlation was higher when a distance threshold was included in the analysis (72% vs. 69%). The algorithm used to compute the quality factor is vendor specific, and the French and USA MEOLUTs are provided by different vendors.

O-7 test results do not prove the operational and technical effectiveness of the quality factor, as reported by France. However, as reported by the USA, correlations between the quality factor and location accuracy provide evidence that RCCs could be provided with a reliable quality factor and that an MCC algorithm could be implemented to distribute alerts based on a significant change in the quality factor.

5.2 Recommendations for the Conduct of Subsequent D&E Phases

5.2.1 Test T-1 (Processing Threshold and System Margin)

It is recommended to maintain the test in Phase III as foreseen, in order to evaluate the space segment improvement and the updates/upgrades of the MEOLUTs.

5.2.2 Test T-2 (Impact of Interference)

Canada and Test coordinators should collaborate during MEOSAR D&E Phase III and any other test campaigns that might be impacted by B.8 testing at CTEC. Specifically, Canada and Test coordinators should:

- schedule MEOSAR D&E testing, MEOSAR space segment commissioning and SGB testing with CTEC B.8 Testing (Translation and Transmitter Frequencies) which is routinely scheduled in the third full week of the month),
- when circumstances dictate, de-conflict CTEC B.8 Testing with unexpected re-testing,
- Use the finalised schedule with the dates and times of B.8 test runs provided by CTEC after the fact, to help to investigate any anomalies or unexpected results which might have been caused by inadvertent scheduling of MEOSAR D&E Phase testing coincidental with CTEC B.8 Testing.

5.2.3 Test T-3 (MEOLUT Valid/Complete Message Acquisition)

It is recommended to maintain the test in Phase III as foreseen, in order to evaluate the space segment improvement and the updates/upgrades of the MEOLUTs.

It is suggested that participants optionally analyse the processing anomalies following the C/S T.020 methodology.

5.2.4 Test T-4 (Independent Location Capability)

It is recommended that further analyses be conducted to evaluate the relationship between location Expected Horizontal Error (EHE) and various parameters (e.g., DOP, number of satellites used in location determination, C/No measurements, etc.).

It is suggested that participants optionally analyse the processing anomalies following the C/S T.020 methodology.

5.2.5 Test T-5 (Independent 2D Location Capability for Operational Beacons)

It is recommended to continue monitoring the 406 MHz spectrum and it is suggested that participants optionally analyze the detection rates per channel and per satellite type (L-band vs. S-band).

It is recommended to evaluate in detail the MEOLUT's ability to locate (within test T-5) slowly moving beacons (float-free/aboard of moving vessels).

5.2.6 Test T-6 (MEOSAR System Capacity)

It is recommended to maintain the test in Phase III. It is suggested to include an optional networking test T-6/T-7 to evaluate the potential risk of processor overload when exchanging TOA/FOA data.

5.2.7 Test T-7 (Networked MEOLUT Advantage)

It is recommended to maintain the test in Phase III as foreseen, in order to evaluate the advancement in MEOLUT Networking.

5.2.8 Test T-8 (Combined MEO/GEO Operation Performance (Optional))

T-8 testing was not completed in Phase II.

5.2.9 Test O-1 Potential Time Advantage

Given that there were no significant differences in test results for AOI versus MCC service area, it is recommended that Phase III analysis be performed for the MCC service area only.

Recognizing the bias produced by the GEOSAR alerts on the PTAE measurement, consider analysing MEOSAR detect-only cases versus LEOSAR and GEOSAR detect cases separately.

5.2.10 Test O-2 Unique Detections by MEOSAR System as Compared to Existing System

Given that there were no significant differences in test results for AOI versus MCC service area, it is recommended that Phase III analysis be performed for the MCC service area only.

5.2.11 Test O-3 Volume of MEOSAR Distress Alert Traffic in the Cospas-Sarsat Ground Segment Network

It is suggested to perform O-3 test again in Phase III, focusing not only on the MCC to MCC primary communication paths, but also on the MCC to SPOC communication paths and MCC to MCC secondary communication paths.

5.2.12 Test O-4 406 MHz Alert Data Distribution Procedures

As approved by the Council in December 2015, document C/S A.001 (Data Distribution Plan) has been updated with alert data distribution procedures for LEOSAR/GEOSAR/MEOSAR (LGM) capable MCCs. Given that the primary purpose of test O-4 is to validate (and improve) data distribution procedures for the MEOSAR operational system, further analysis of test O-4 should be based on agreed data distribution procedures for LGM capable MCCs.

5.2.13 Test O-5 SAR/Galileo Return Link Service

Test O-5 has been postponed to Phase III.

5.2.14 Test O-6 Evaluation of Direct and Indirect Benefits of the MEOSAR System

As only six countries provided results for Phase II of O-6, Cospas-Sarsat Participants should be encouraged to report incidents with MEOSAR data to develop a better understanding of MEOSAR across a broader range of RCCs.

Most the examples in test O-6 for Phase II concentrated on the time of detection and time of first location. More examples of incidents with known rescue location are needed in Phase III to allow for analysis of MEOSAR location data and the advantages and disadvantages to an RCC.

5.2.15 Test O-7 MEOSAR Alert Data Distribution –Impact on Independent Location Accuracy

Based on document JC-29/3/19 (USA), C/S operational and technical documents have been updated to distribute alerts based on a significant improvement in the Expected Horizontal Error and to provide the Expected Horizontal Error to RCCs. Per document C/S T.019 (section 5.10), the MEOLUT shall produce an Expected Horizontal Error for every independent location that contains the true location with a probability of 95 ± 2%. Further analysis of the Expected Horizontal Error should be performed for test O-7 in Phase III.

- END OF SECTION 5 -

ANNEX A

DETAILED LOG OF PHASE II TESTS

Week	Date Start (yyyy-mm-dd)	Test	Test Run	Time 1st Tx (yyyy-mm-dd UTC)	Time last Tx (yyyy-mm-dd UTC)	Beacon simulator	Comments
2015/25	2015-06-18	T-6	1	2015-06-18	2015-06-19	Maryland	Exact transmission slot to be provided by France
2015/25	2015-06-16	T-6	1	2015-06-16	2015-06-17	Toulouse	Exact transmission slot to be provided by France
2015/16 2015/19	2015-04-20	O-1 O-2 O-3 O-4 O-6 O-7		Not applicable	Not applicable	Not applicable	O-tests in MEOLUT network mode
2015/04 2015/15	2015-01-19	O-1 O-2 O-3 O-4 O-6 O-7		Not applicable	Not applicable	Not applicable	O-tests in MEOLUT stand-alone mode
2015/19	2015-05-07	T-4/T-7	1	2015-05-07 14:00:00	2015-05-08 14:00:00	Hawaii	
2015/19	2015-05-06	T-4/T-7	1	2015-05-06 14:00:00	2015-05-07 14:00:00	Florida	
2015/19	2015-05-05	T-4/T-7	1	2015-05-05 14:00:00	2015-05-06 14:00:00	Toulouse	
2015/19	2015-05-04	T-4/T-7	1	2015-05-04 14:00:00	2015-05-05 14:00:00	Maryland	
2015/17 2015/18	2015-04-20	T-5/T-7	1	2015-04-20 14:00:00	2015-05-01 14:00:00	Many locations	See details in the beacon transmission schedule available on the D&E FTP server
2015/14 2015/15	2015-03-30	T-5	1	2015-03-30 14:00:00	2015-04-10 14:00:00	Many locations	See details in the beacon transmission schedule available on the D&E FTP server
2015/14	2015-04-16	T-4	1	2015-04-16 14:00:00	2015-04-17 14:00:00	Florida	Confirmed
2015/14	2015-04-14	T-3	1	2015-04-14 14:00:00	2015-04-15 14:00:00	Florida	Confirmed
2015/14	2015-03-31	T-4/T-7	Dry run	2015-03-31 15:00:00	2015-03-31 21:00:00	Maryland	Dry run of the USA of the MEOLUT networking test T-4/T-7
2015/13	2015-03-26	T-4	1	2015-03-26 23:00:00	2015-03-27 23:00:00	Hawaii	Note: RESCHEDULED
2015/13	2015-03-25	T-4	1b	2015-03-25 12:00:00	2015-03-26 12:00:11	Maryland	Re-run of the Maryland transmission (see line below)
2015/13	2015-03-24	T-4	1a	2015-03-24 17:00:00	2015-03-25 06:00:00	Maryland	First part of transmission (early stop of the simulator at 06:00 UTC due to a simulator issue)
2015/12	2015-03-19	T-4	1	2015-03-19 14:00:00	2015-03-20 14:00:00	Toulouse	
2015/11	2015-03-17	T-4	1	2015-03-17 14:00:00	2015-03-18 14:00:00	Hawaii	CANCELLED

2015/10	2015-03-04	T-3	1	2015-03-04 14:00:00	2015-03-05 14:00:00	Toulouse	
2015/10	2015-03-02	T-3	1	2015-03-02 14:00:00	2015-03-03 14:00:00	Hawaii	Two Frequencies transmitted (406.064 and 406.070 MHz instead of only one, 406.064MHz)
2015/10	2015-03-xx	T-3	1	-	-	Florida	CANCELLED
2015/09	2015-02-26	T-3	1	2015-02-26 14:00:00	2015-02-27 14:00:00	Maryland	
2015/07	2015-02-12	T-1	1	2015-02-12 14:00:00	2015-02-13 14:00:00	Florida	
2015/07	2015-02-10	T-1	1	2015-02-10 14:00:00	2015-02-11 14:00:00	Hawaii	
2015/06	2015-02-05	T-1	1	2015-02-05 14:00:00	2015-02-06 14:00:00	Maryland	
2015/06	2015-02-03	T-1	1	2015-02-03 16:00:00	2015-02-04 16:00:00	Toulouse	
2015/03	2015-01-13	Dry run T-4/T-7	-	2015-01-13 13:00:00	2015-01-13 15:00:00	Toulouse	Dry run using the script of test T-4
2014/15 2014/20	2014-04-07	O-1 O-2 O-3 O-4 O-6 O-7	1	2014-04-07 00:00:00	2014-05-12 00:00:00	Not applicable	O-tests only in MEOLUT stand-alone mode (no MEOLUT networking)

ANNEX B

LIST OF ACRONYMS FOR OPERATIONAL TESTS

B.1 Test O-1

TMANU	Time of first MEOSAR Alert Notification Unlocated
TMANE	Time of first MEOSAR Alert Notification Encoded
TMANL	Time of first MEOSAR Alert Notification Location
TMANC	Time of MEOSAR Position Confirmation (Ambiguity Resolution)
TLANU	Time of first LEOSAR Alert Notification Unlocated
TLANE	Time of first LEOSAR Alert Notification Encoded
TLANL	Time of first LEOSAR Alert Notification Location
TLANC	Time of LEOSAR/GEOSAR Alert Position Confirmation (Ambiguity Resolution)
TGANU	Time of first GEOSAR Alert Notification Unlocated (no encoded position)
TGANE	Time of first GEOSAR Alert Notification Encoded
Latitude	Based on encoded position, independent position or ground truth information
Longitude	Based on encoded position, independent position or ground truth information

B.2 Test O-2

LGST	LEO/GEO Start Time
LGET	LEO/GEO End Time
LGDT	LEO/GEO Data Type (U=Unlocated, E=Encoded, D=Doppler, C=Confirmed)
MST	MEO Start Time
MET	MEO End Time
MDT	MEO Data Type (U=Unlocated, E=Encoded, D=DOA, C=Confirmed)
Latitude	Based on encoded position, independent position or ground truth information
Longitude	Based on encoded position, independent position or ground truth information

B.3 Test O-3

MTT	MEO Transmission Time
MST	MEO SIT Type
LGTT	LEO/GEO Transmission Time
LGST	LEO/GEO SIT Type

B.4 O-4

FA UNL	First Alert, no location
FA ENC	First Alert with location, encoded position only
FA DOA	First Alert with location, DOA position only
FA DOA ENC CFM	First Alert with location, DOA/encoded Position Confirmation (dependent event)
FA DOA ENC DIF	First Alert with location, DOA/encoded Position Conflict (dependent event)
NC DOA DOA DIF	position Not Confirmed, DOA/DOA position conflict
NC DOA ENC DIF	position Not Confirmed, DOA/encoded position conflict
NC ENC ENC DIF	position Not Confirmed, encoded/encoded position conflict/update
CA DOA DOA CFM	Confirmation Alert, new DOA to previous DOA
CA ENC DOA CFM	Confirmation Alert14, new DOA to previous/new encoded
CA DOA ENC CFM	Confirmation Alert, new encoded to previous DOA
CT CFM	Continued Transmission15 event, DOA and/or Encoded positions, no position conflict
CT DOA DIF	Continued Transmission event, DOA position conflict
CT ENC DIF	Continued Transmission event, encoded position conflict/update
RD DOA ENC	Redundant data (DOA/Encoded dependent beacon event and none of the above)
RD UNL	Redundant data (Unlocated dependent beacon event and none of the above)

B.5 O-6

Type of Analysis (Real-time/Retrospective)	The report could be based on a distress where MEOSAR System played a role in the Search and Rescue Mission in Real-Time (**Real-Time**), or could be based on a LEOSAR/GEOSAR case that has been analysed later trying to assess the benefits/deficits that MEOSAR data would have provided to the Search and Rescue Mission retrospectively (**Retrospective**), as if that MEOSAR data would have been available at that time.
Date and Time	Date and Time in UTC
Location	Name of the Location of the Incident.
Incident Type	Situation of the vehicle/person in distress (sinking vessel, road accident, walker injured…)
Beacon Type	EPIRB/ELT/PLB
Beacon Environment (land/sea/cliff/forest/dessert…)	Geographical environment of the vehicle/person in distress.
Beacon Speed (static/moving/drifting…)	Speed of the beacon.
Local Time	Local Time. This information could be complemented with the lighting conditions (Get dark/Night)
Local Weather Conditions (winds, ice, hot, cold…)	Weather conditions endanger not only the persons in distress but also the Search and Rescue personnel.
Resources moved (Helicopter/Vessel/Aircraft…)	Resources or means used in the rescue.
People Involved	People involved in the incident
People Rescued	People rescued

C/S MEOSAR Alert (Only/First/Other)	The MEOSAR alert received by the RCC from Cospas-Sarsat could be the **Only** alert received or the **First** alert received. Other situations are possible, as for example, the alert was first detected by MEOSAR but first located by LEOSAR, in such cases, a short description could be provided here.
Detection Time (Advantage/No Advantage)	Here the Advantage or No Advantage can be indicated for Detection Time. Between parenthesis the difference in minutes can be expressed.
Location Time (Advantage/No Advantage)	Here the Advantage or No Advantage can be indicated for Location Time. Between parenthesis the difference in minutes can be expressed.
Location Accuracy (Advantage/No Advantage)	Here the Advantage or No Advantage can be indicated for Location Accuracy. Between parenthesis the observed error in Nautical Miles/Kilometres can be expressed.

B.6 O-7

Status	Status of the alert site (beacon activation) when redundant condition occurred - **FA** = First Alert with DOA location; - **CA** = Confirmation Alert (confirmed but no data beyond); - **NC** = Not Confirmed (but beyond first alert with DOA location); - **CT** = Continued Transmission; - **PC** = Position Conflict.; - – – – = (Not recorded).
ActLat	the actual latitude as determined from external information
ActLon	the actual longitude as determined from external information
NewSolId	internal reference to the new solution record (if not available, use 0)
NewLat	the latitude for the redundant solution
NewLon	the longitude for the redundant solution
NewQF	the quality factor for the redundant solution
ExistSolId	internal reference to the existing solution record (if not available, use 0)
ExistLat	the latitude for the existing solution (which the redundant one matches)
ExistLon	the longitude for the existing solution
ExistQF	the quality factor for the existing solution

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