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SAR/GALILEO GROUND SEGMENT: AN EXAMPLE OF NETWORKING OF MEOLUTS TO IMPROVE LOCALIZATION PERFORMANCES

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Abstract

Since 2013, the French Space Agency (CNES) embodies the SAR/Galileo Data Service Provider (SGDSP), the SAR/Galileo Service Operator, for the European Union Agency for the Space Programme (EUSPA).

The SAR/Galileo Service is Europe's contribution to the international COSPAS-SARSAT MEOSAR System, which is a satellite-based Search and Rescue system allowing distress alerts detection and distribution. The service uses the protected 406 MHz frequency band and is available to maritime and aviation users or to other persons in distress situations carrying a distress beacon.

The SAR/Galileo Ground System (SGS) has been operational since 2016 and is currently constituted by three geographically distributed sites of 4-antennas MEOLUTs (MEO Local User Terminal). The operational concept of these MEOLUTs is based on their interconnectivity: the MEOLUTs exchange data continuously and work following an optimized tracking plan that takes into account the entire set of the 12 antennas. Then the MEOLUTs determine the position of the distress beacons by computing the frequency and time difference of arrival (FDOA and TDOA) of the same distress signals relayed through different SAR transponders on-board the Galileo and other GNSS satellites.

A fourth site is being deployed and starts its operations in November 2022. As of today, this new component operates as a stand-alone, i.e. without exchanging data with the other SGS MEOLUTs, but its integration into the current operational system is believed as of major importance.

This paper presents the architecture of the SGS focusing on the advantages of the operations in networked configurations in terms of localization performance that can be achieved in a shared-antennas system such as the SGS. The presentation of these advantages is supported by operational data and by simulation results, obtained through the CNES MEOSAR performance toolkit software.

The tool allows for simulating and estimating the performance of a stand-alone MEOLUT, a network of MEOLUTs or a combination of the two presenting its results in terms of coverage for the key performance criteria such as the location probability, location accuracy and estimating antenna coverage. Several configurations are studied in support of the advantages of networked MEOLUTs including stand-alone SGS MEOLUT performance compared with networked SGS MEOLUTs showcasing the localization performance and the coverage area differences. Along with it, particular attention is paid to other performance parameters such as the location accuracy better than 5 and 2 km.

The simulations show the improvements that could be achieved by networking the SGS with the forth MEOLUT being deployed in La Réunion. In conjunction with the simulations a detailed summary of the future SAR/Galileo networking configuration and the key challenges involving the fourth MEOLUT (i.e. four MEOLUT sites) connection such as the capacity, different antenna technologies or calibration issues will be provided.

Finally, the paper concludes with the information concerning the implementation plan and the roadmap of this networking. In particular, the paper presents the remediation solutions foreseen to minimize the impacts on the current SAR/Galileo operations.

Keywords: SAR/Galileo, MEOLUT, Network, SGS, performances

Acronyms/Abbreviations

CALBE :	*Calibration Beacon*
CNES:	*Centre National d'Etudes Spatiales*
C/S:	*Cospas-SARSAT*
EC:	*European Commission*
ECA:	*European Coverage Area*
EUSPA:	*European Union Agency for the Space Programme*
FLS:	*Forward Link Service*
GEO:	*Geostationary Earth Orbit*
IOCA:	*Indian Ocean Coverage Area*
KCP:	*KPI Collection Platform*
KPI:	*Key Performance Indicators*
LEO:	*Low-altitude Earth Orbit*
LUT:	*Local User Terminal*
MCC:	*Mission Control Center*
MEO:	*Medium-altitude Earth Orbit*
MEOSAR:	*Medium-altitude Earth Orbit Search And Rescue*
MTCF:	*MEOLUT Tracking & Coordination Facility*
REFBE:	*Reference Beacon*
RCC:	*Rescue Coordination Centre*
RLS:	*Return Link Service*
RLSP:	*Return Link Service Provider*
SAR:	*Search and Rescue*
SARN:	*SAR Network*
SGDSP:	*SAR/Galileo Data Service Provider*
SGS:	*SAR/Galileo Ground Segment*
SGSC:	*SAR/Galileo Service Centre*
SIT:	*Subject Indicator Type*
TOA/FOA:	*Time of Arrival / Frequency of Arrival*
T/F DOA:	*Time/Frequency Difference of Arrival*

1. Introduction

SAR/Galileo Service represents the European contribution to the international satellite-based Search And Rescue (SAR) program Cospas-Sarsat.

The service has been operational since 2016 and has undergone improvements and innovation since then. The major contributors to the SAR/Galileo Forward Link Service have been the three MEOLUT facilities spread over the European Coverage Area (ECA), in Maspalomas (Spain), Spitzbergen (Norway) and Larnaca (Cyprus).

Each facility hosts a four-dish-antenna MEOLUT and is interconnected with the two other sites, allowing the sharing of the Time of Arrival and Frequency of Arrival (TOA/FOA) measurements and thus resulting for each site to be equivalent to a twelve-antenna MEOLUT. This functioning represents the as-of-today main example of networking of MEOLUTs.

Thanks to this networked configuration, the ECA MEOLUTs have shown since the beginning outstanding performances, allowing in particular to improve the location accuracy of the distress alerts received at the antennas. In fact, more than 90% of computed locations have an accuracy below 2km, which represents a major advantage for SAR forces involved in the distress.

To support this argument, the location performances improvement is underlined by comparing the configuration with four-dish antennas and the twelve-dish antennas via simulations and real data computation. Indeed, the simulations are performed via the CNES MEOSAR simulator and allow visualising the differences in coverage area if considering a single site or the three interconnected sites. These simulations are then validated thanks to the use of data from a real case during which the site of Larnaca was isolated from the other two. The computation shows the improvement in performances with the network configuration.

Since October 2022, a new SAR/Galileo MEOLUT installed in La Réunion (France) has entered into operations, with a coverage area over the Indian Ocean. This MEOLUT is currently working as a stand-alone, i.e. without exchanging TOA/FOA with the other ECA MEOLUTs. Indeed, its performances are currently slightly worse than for the networked configuration.

As supported by new simulations, SAR/Galileo program will work therefore on the networking of this new MEOLUT to the current ECA networked configuration. A step-by-step approach will be followed before achieving the networking of the whole SAR/Galileo Ground Segment.

The main driver of the approach is that the impact on operations has to be the minimum and the SAR/Galileo Service has not to be impacted.

2. SAR/Galileo Service

Since 2013, the European Union Agency for Space Program (EUSPA) has assigned CNES as SAR/Galileo Data Service Provider (SGDSP) for the implementation and operations provision of the SAR/Galileo Service, which has been designed as the European contribution to the Cospas-Sarsat (C/S) international satellite-based program for Search and Rescue (SAR).

The program was founded in 1982 with the aim of providing a free of charge SAR service without any discrimination to any user of a 406 MHz distress beacon and all over the world.

It was initially based on Low-altitude Earth Orbit (LEO) and Geostationary Earth Orbit (GEO) satellite constellations and has started a transition to MEOSAR (Medium Earth Orbit Search And Rescue) in 2000s following the engagement of USA, Russia and European Union to install SAR repeater payloads on their respective Medium-altitude Earth Orbit (MEO) navigation satellites.

Fig. 1 describes the functioning of the C/S system:

1) A distress beacons is activated transmitting a 406 MHz frequency signal
2) The space segment, including satellites in LEO, GEO and MEO, processes and/or relays the signals transmitted by beacons;
3) A geographically distributed set of receiving ground stations called Local User Terminals (e.g. MEOLUTs, for the MEOSAR service) provides the ground segment coverage with the capability to track the satellites, process the broadcast signals and generate independent location estimations of the user in distress;
4) The Mission Control Centres (MCCs) assure the distribution of Cospas-Sarsat distress alerts generated by the LUTs throughout the world via dedicated network connections and data distribution plan in order to the alert to arrive at the relevant Rescue Coordination Centre (RCC) in charge of the SAR mission.

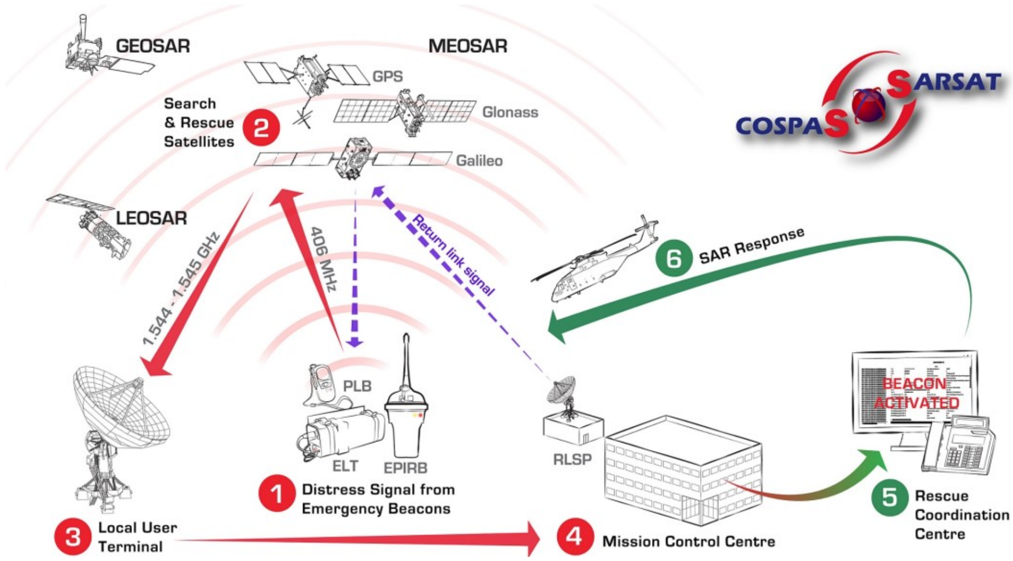

Fig. 1 : Cospas-Sarsat system overview

The SAR/Galileo Service has been operational since the declaration of Galileo Initial Services on December, 15th 2016, and has been incrementally improved, resulting in the SAR/Galileo Enhanced Service declaration on January, 19th 2020. The service is now currently undergoing the SAR/Galileo Full Operational Capability Service declaration process, which is foreseen to be completed by end of 2023.

SAR/Galileo is at present the major contributor to the C/S system by providing 25 SAR payloads available from the Galileo constellation and the SAR/Galileo Ground Segment (SGS), including 4 MEOLUTs facilities (and their annexed components) for the Forward Link Service (FLS) and the components to assure the Return Link Service (RLS).

Each MEOLUT has an assigned coverage area which is defined as the area where all the performance criteria defined by the C/S Program are met simultaneously, which are defined in [1]:

- Beacon probability of detection at 99% for any 10-minutes period
- Single burst location probability at 90%
- Multi-burst (after ten minutes) location probability at 98%
- Single burst location accuracy better than 5km at 90% for nearly-static beacons (beacons moving at a speed between 0 and 0.5 m/s)
- Multi-burst location accuracy better than 5km at 95% for nearly-static beacons
- Multi-burst location accuracy better than 10 km at 98% for nearly-static beacons
- Single burst location accuracy better than 10 km at 70% for low-speed slow moving beacons (beacons moving at a speed between 0.5 and 5 m/s)
- Single burst location accuracy better than 20 km at 95% for low-speed slow moving beacons
- Multi-burst location accuracy better than 5 km at 75% for low-speed slow moving beacons
- Multi-burst location accuracy better than 7 km at 95% for low-speed slow moving beacons

3. SAR/Galileo Ground Segment

The SAR/Galileo Ground Segment (SGS) represented in Fig. 2 can be grouped in two parts, the Forward Link and the Return Link associated infrastructure [2]:

- The SAR/Galileo Forward Link Ground Segment is a geographically distributed (refer to Table 1) segment consisting of three four-dish-antenna MEOLUTs over the European Coverage Area (ECA) and

one active phased-array antenna MEOLUT over the Indian Ocean Coverage Area (IOCA). The antennas are then completed by the MEOLUT Tracking Coordination Facility (MTCF), a set of distributed Reference Beacons (REFBE) and Calibration Beacons (CALBE) and a dedicated network (SARN) for communication purposes.
The aim of the Forward Link Service is to contribute to the C/S program and deliver the locations of the distress alert beacons to the MCC and the SAR forces.

- The SAR/Galileo Return Link Ground Segment is mainly composed by the Return Link Service Provider (RLSP), located in the SAR/Galileo Service Centre (SGSC), and it interfaces on one side with the Cospas-Sarsat network through the French Mission Control Centre (collocated with the RLSP) and on the other side to the Galileo Mission Segment.
The aim of the Return Link Service is to provide an acknowledgement message to the activated distress beacons following the reception of the alert signals and localization of the distress by the MEOSAR system.

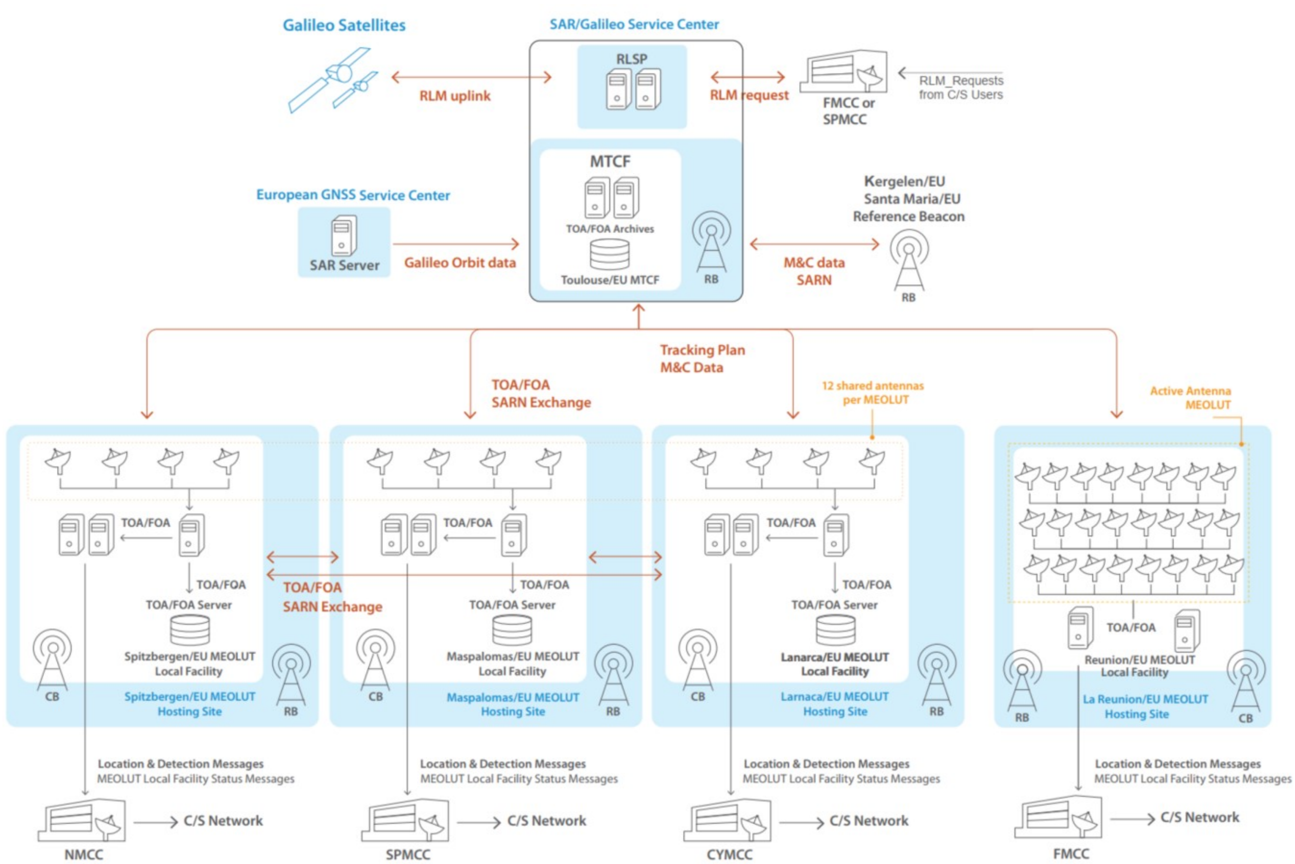

Fig. 2 : SAR/Galileo Ground Segment Architecture

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Table 1 SAR/Galileo European MEOLUT Locations

SAR/GALILEO MEOLUTS	C/S ID	ASSOCIATED MCC	LATITUDE [°]	LONGITUDE [°]	ALTITUDE [M]
SPITSBERGEN/EU MEOLUT (NORWAY)	2574	NMCC	78.2305	15.3707	430
MASPALOMAS/EU MEOLUT (SPAIN)	2244	SPMCC	27.7614	-15.6348	130
LARNACA/EU MEOLUT (CYPRUS)	2091	CYMCC	34.8651	33.3838	277
LA REUNION/EU MEOLUT (FRANCE)	6601	FMCC	-20.9089	55.5136	95

3.1 ECA SGS

The ECA SAR/Galileo Ground Segment, operational since 2016, is therefore constituted by three MEOLUTs, each of them hosting four-dish antennas and the associated processing servers. These MEOLUTs are currently deployed in Maspalomas (Spain), Spitzbergen (Norway) and Larnaca (Cyprus), representing a geographically distributed segment that allows a global coverage over the European Area.

The three sites are interconnected through the SARN allowing the sharing of the Time of Arrival and Frequency of Arrival (TOA/FOA) measurements made by each of these MEOLUT ground stations and thus resulting in the provision of outstanding performance in term of detection and location. Therefore, each site is considered as equivalent to a twelve-antenna MEOLUT.

In order to optimise the common coverage, represented in Fig. 3, the tracking plan of each antenna is coordinated by a common facility. Indeed, the MEOLUT Tracking Coordination Facility (MTCF) located at the SGSC in Toulouse and connected to the three sites via the SARN does the computation of their tracking plan.

Based on the exchange of the data, the location processor at each site computes the position of the COSPAS-SARSAT 406 MHz distress beacons by computing the frequency and time difference of arrival (FDOA and TDOA) of the same distress signals relayed through the different SAR transponders. The computed locations are then sent to the respective national MCC.

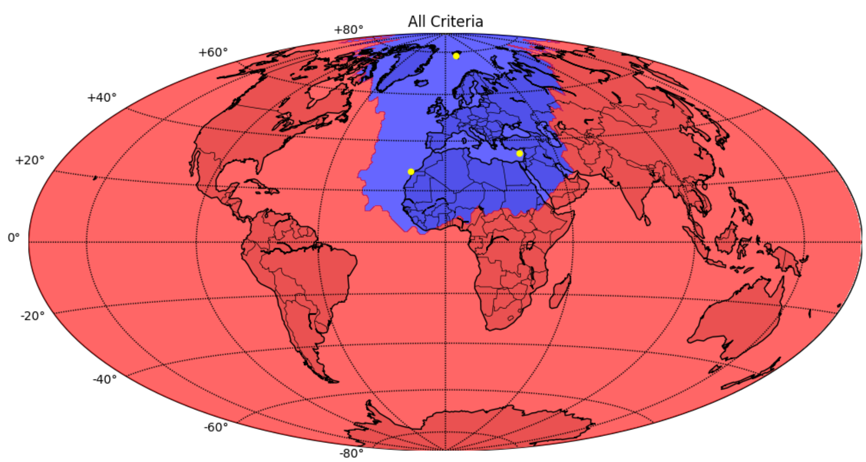

Fig. 3 : SAR/Galileo ECA MEOLUTs coverage area

3.2 IOCA SGS

Over the last few years, the European Commission (EC) has decided to improve the SGS and extend its facilities to provide a new coverage area over the Indian Ocean. Therefore, a new SAR/Galileo MEOLUT facility has been installed in La Réunion (France) and it has been validated against C/S requirements in summer 2022.

This MEOLUT is an active phased-array antenna MEOLUT with 64 L-band antenna receiver elements and associated processing component, connected to the SGSC and the MTCF via the SARN, for monitoring purpose. Its coverage area is represented in Fig. 4 and it is declared as the area of radius 2500 km centred at La Réunion/EU MEOLUT.

While the La Réunion MEOLUT is already operational in the C/S network since November 2022, providing distress alert locations to the SAR forces, the SAR/Galileo service validation is on-going and will be completed in the next months.

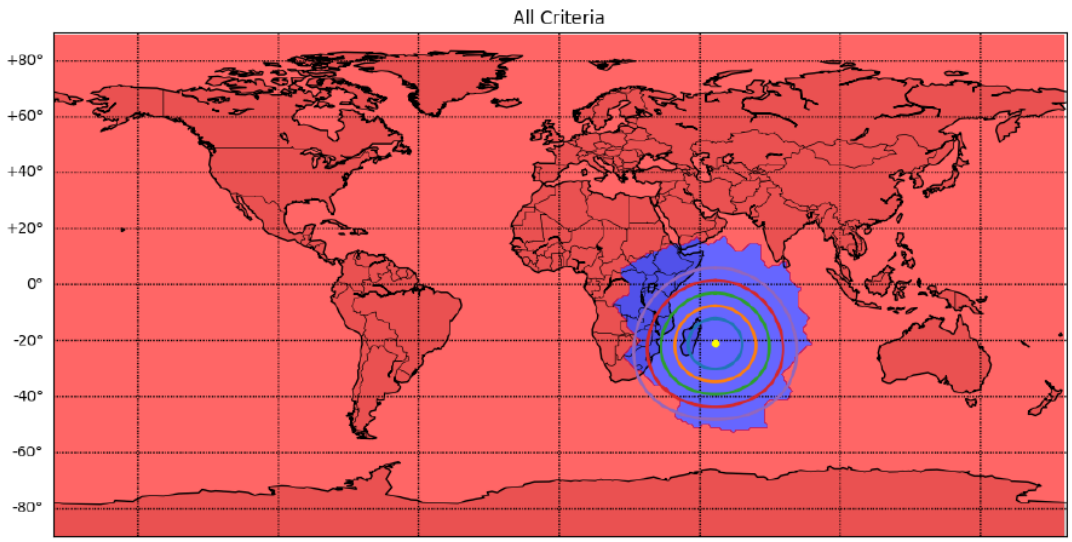

Fig. 4 : SAR/Galileo IOCA MEOLUT coverage area (red circle at 2500km radius)

3.3 RLS SGS

Besides the Forward Link, the SGS is completed with the Return Link Service Provider (RLSP) is the Galileo Service Facility deployed within the SAR/Galileo Service Centre (CNES Toulouse, France) which enables the provision of the SAR/Galileo RLS. The RLSP ensures the interface on one side with the Cospas-Sarsat system and on the other side, with the Galileo System (Ground Mission Segment) for return link messages uplink to the Galileo satellites.

4. SAR/Galileo Forward Link Service Performances

Since the declaration of the Galileo Initial service in 2016, the SGDSP has been monitoring on a continuous basis the Key Performances Indicators related to the performances of the service. This KPI monitoring and monthly reporting is performed through a KPI Collection Platform (KCP) deployed in the MTCF at the SAR/Galileo Service Centre.

This allows reporting the following monthly FLS KPI to the EUSPA, responsible of the Galileo Service:

- Single and Multi-burst Detection Probability
- Single and Multi-Burst Location Probability

- Probability of Location Accuracy below 5 km for multiple bursts
- Probability of Location Accuracy below 2 km for multiple bursts

The principle of the KPI collection mechanism is based on the use of several Reference Beacons (REFBE), five deployed over the SAR/Galileo ECA and one over the SAR/Galileo IOCA. For each of the REFBE, the position and transmission scheme are known exactly.

The detections and locations computed by the European MEOLUTs of each of the transmitted burst of the REFBEs are sent to the MTCF and assessed in the KCP in order to derive the performances.

The detection probability represents the ratio of between the received burst and the expected burst, described in (1), considering that a received burst is associated to the emitted one if the reception time is less than 3 seconds. For this computation, the KCP uses the detection archive files of each MEOLUT.

$$DetectionRate = \frac{ReceivedBursts}{ExpectedBursts} \qquad (1)$$

The location performances are instead computed based on the files that the MEOLUTs exchange with their respective MCCs to transmit the beacon distress alerts, called SITs (Subject Indicator Type), that are transmitted to the MTCF as well.

For each SIT received, the KCP extracts the timestamp to associate the alert to a single burst or to a multi-burst according to the difference with the expected transmission time.

For each REFBE and category, the location probability is then computed as follows:

$$LocationProbability = \frac{numberOfLocatedTransmissionSequences}{numberOfTransmissionSequences} \qquad (2)$$

For a given beacon, the probability of locating below X kilometers error is given by:

$$LocationProbabilityWithinXkm = \frac{NumberOfLocationsWithinXkm}{TotalNumberOfLocations} \qquad (3)$$

The ECA MEOLUT overall performances over 2022 are shown in Fig. 5 for the detection probability performance and Fig. 6 for the all location performances (location probability and location accuracy). For these figures, the average performance for all sites has been considered.

Both charts show excellent performances, well above the target, over the entire year. In particular, it is of major importance to notice that the location accuracy below 2km is a parameter not specified at C/S level (cf. with the requirements listed in Section 3), but this KPI has been introduced and monitored by SAR/Galileo program to show the outstanding performances of its ECA SGS. It is indeed remarkable that, for the entire year 2022, the probability of location accuracy below 2km has been higher than 95%.

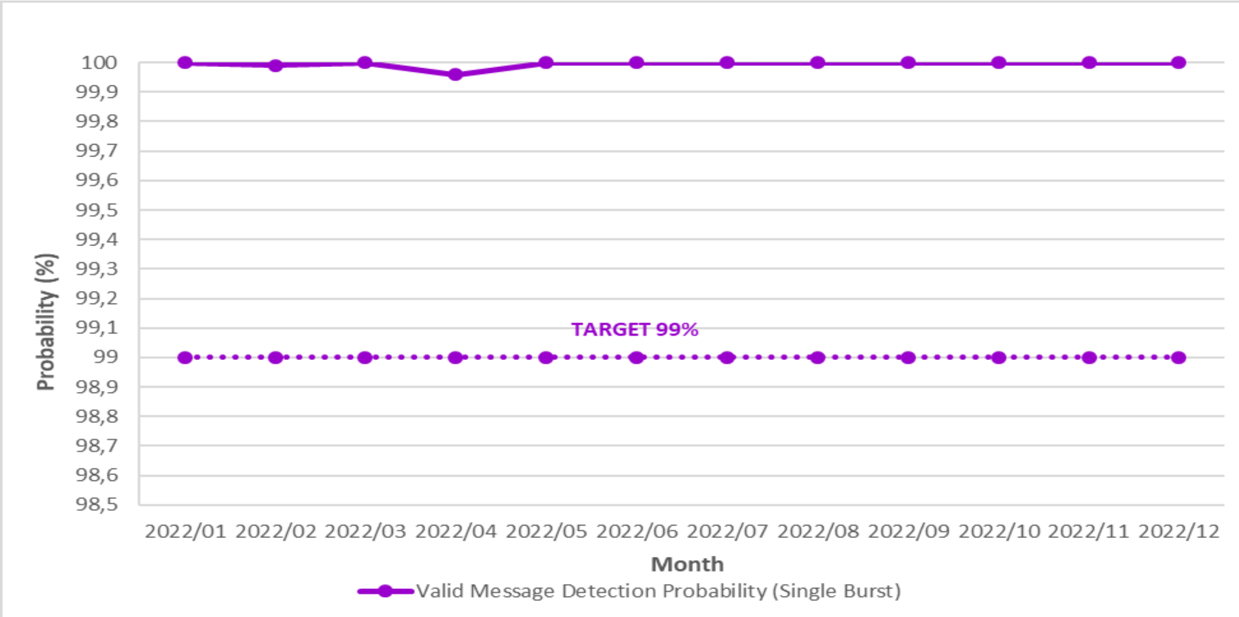

Fig. 5: ECA MEOLUTs 2022 Detection Probability Performance

Fig. 6 : ECA MEOLUTs 2022 Location Perfomances

Meanwhile, the IOCA MEOLUT entered its C/S operations on November 17th, 2022. Since then, it has started being monitored at KCP level for the performances on the REFBE placed in the IOCA.

The first monthly report for this MEOLUT, dated to December 2022, shows the following results:

Table 2 IOCA MEOLUT December 2022 Performances

KEY PERFORMANCE PARAMETER	RESULT	TARGET
VALID MESSAGE DETECTION PROBABILITY	99.91%	99%
MULTI-BURST LOCATION PROBABILITY	100%	98%
MULTI-BURST LOCATION ACCURACY <5KM	96.91%	95%
MULTI-BURST LOCATION ACCURACY <2KM	78.78%	90%

As it can be noticed, the detection and location performances are very good as well, but for the location accuracy below 2km, the result is less promising than for ECA MEOLUTs.

5. Networking advantages

The performances shown in Section 4 for the ECA MEOLUTs are indeed possible thanks to their networked configuration, i.e. the fact that the three sites are interconnected and the exchange of the TOA/FOA is continuous.

To support this statement, different simulations and computation analyses are presented in this section.

5.1 Simulations results

The simulations are performed via the CNES MEOSAR performance toolkit software. The tool has been developed by CNES teams over the years and allows for simulating and estimating the performances of a stand-alone MEOLUT, a network of MEOLUTs or a combination of the two presenting its results in terms of coverage of the key performance criteria described in Section 2.

The simulation principle is the following:

- A mesh grid (Long, Lat) is built with nodes uniformly spaced (distance wise) around the Earth. Each mesh node represents a beacon. In these simulations a total number of 2701 beacons is used.
- For each mesh node, the co-visibility node-satellite-MEOLUT is evaluated with some constraints:
  - Minimum MEOLUT-satellite elevation angle equal to 5°,
  - Minimum beacon-satellite elevation angle equal to 5°,
  - Maximum beacon-satellite elevation angle equal to 90°.
- The time step to compute a coverage is equal to 15 min.
- The simulation is executed using the tracking plans evaluated over a period of 10 days, to simulate a complete cycle of Galileo satellites, and following the real tracking capability of the MEOLUTs; i.e. Galileo and GPS constellation for the ECA MEOLUTs, Galileo-only for the IOCA MEOLUT.
- A calibration operation of the MEOSAR performance simulator is made prior to the computation of the performances. This operation consists in adjusting the simulator so that the calculated performances (detection, probability of location and location accuracies) are consistent with the observed MEOLUT performances, based on the data available from the SGS.
- The output of the simulation is a compliance map in which blue area represents the compliance status to all the mentioned criteria at the same time.

In order to compare the result of the coverage of a single MEOLUT facility and the coverage of the networking of the all ECA MEOLUTs, presented in Fig. 3, a simulation has been run only on the four-antenna channels of Larnaca MEOLUT. The result of the simulation is shown in Fig. 7.

Comparing the two Figures, it is remarkable the difference of the Earth surface covered only by four-antenna channels or using the twelve channels combined. Indeed, the networked configuration allows for the coverage of the entire Europe continent and the coverage extends up to Greenland, part of Atlantic Ocean, North Africa, part of Middle East and Russia, while the coverage area of the Larnaca-only configuration is restricted to part of the Middle East and North Arfrica.

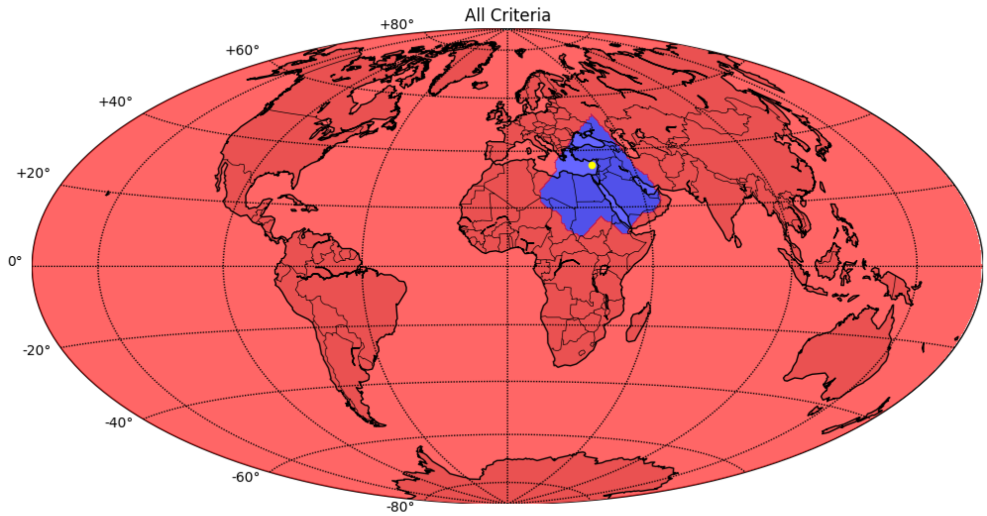

Fig. 7 Larnaca MEOLUT-only coverage area

5.2 Computed data

To validate the simulations, real data analyses have been done in order to compare the performances of a single MEOLUT site and the overall ECA performances.

On August 25th, 2022, Larnaca MEOLUT lost the connection to the other ECA MEOLUTs for about 9 hours, fault of a minor network issue. Therefore, during this time, the Larnaca MEOLUT worked as a stand-alone MEOLUT, only relying on the TOA/FOA obtained by the four-dish antennas co-located with the processing server. The connection was retrieved in the morning of August 26th, 2022.

This case has been analysed fully and the detection and location performances over this period are presented in Table 3, in comparison with a similar time period over the same day when all the sites were connected. In this case, the computation has not been done with the KCP but with an external toolkit, called SARLAB, developed in-house at CNES, that allows to verify several performances (not only the KPIs) offline by using MEOLUT computation data.

Table 3 presents therefore the location performances computed by Larnaca MEOLUT over the two periods for each of the five ECA REFBEs.

Table 3 Comparison of performances between Larnaca-only MEOLUT and networked ECA SGS

REFBE	VALID MESSAGE DETECTION PROBABILITY		MULTI-BURST LOCATION PROBABILITY		MULTI-BURST LOCATION ACCURACY < 5KM		MULTI-BURST LOCATION ACCURACY <2KM	
	Larnaca only	ECA SGS	Larnaca only	ECA SGS	Larnaca only	ECA SGS	Larnaca only	ECA SGS
LARNACA (CYPRUS)	100	100	100	100	**98.77**	100	**91.36**	97.86
MASPALOMAS (SPAIN)	100	100	83.33	100	**77.87**	99.47	**54.96**	95.21
TOULOUSE (FRANCE)	100	100	100	100	**92.2**	99.5	**62.3**	98.4
SPITSBERGEN (NORWAY)	100	100	83.33	100	**86.26**	100	**60.3**	97
SANTA MARIA (PORTUGAL)	100	100	83.34	100	**85.22**	100	**60.87**	97.8

As it can be observed, the location performances and in particular the location accuracy, dropped drastically while only four reception channels were available. It is notably, how the performance results change as well based on the distance of the beacon to the MEOLUT, for the Larnaca MEOLUT-only configuration: in fact, the major drops are remarked on the more distant beacons, while for the REFBE in Larnaca, the values stay in the requirement thresholds. This actually validates the simulation shown in Fig. 7.

The overall ECA SGS networked configuration at twelve antennas allows for outstanding performances for all the five beacons, without the position impact that we can see for the first configuration.

6. Future developments

6.1 Networking advantages for the entire SGS

Considering the findings in Section 5, it is clear that the MEOLUT configuration in networking with the sharing of the TOA/FOA is very advantageous and allows for outstanding performances in terms of location accuracy. Moreover, that would allow to improve the current SAR/Galileo performances presented in Section 4 and in particular improve the IOCA results.

Therefore, all parties of SAR/Galileo program agree on the fact that the SAR/Galileo MEOLUT Facilities should profit at maximum of these advantages and that all four MEOLUTs should be networked to extend the SAR/Galileo global coverage area and improve the performances.

Indeed, the simulation run in the CNES MEOSAR performance toolkit and presented in Fig. 8 represents what the coverage area would be in the case of the networking of the ECA MEOLUTs and the IOCA MEOLUT.

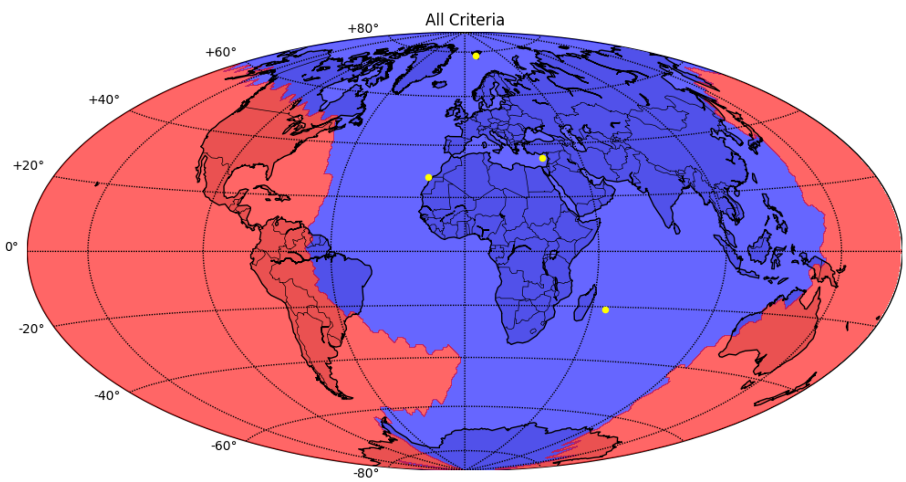

Fig. 8 : SAR/Galileo Coverage Area in the case of the networking of ECA MEOLUTs and IOCA MEOLUT

Comparing this result to the current ECA and IOCA Figures in Section 3 it is clear how the C/S Program could profit of such a network: the four European MEOLUTs would allow to cover almost entirely three continents (Africa, Europe and Asia), part of the Atlantic Ocean and practically the entire Indian Ocean, without the need of any other ground segment provider.

On the operational side, the advantages of the networking of several MEOLUTs would be beneficial as well: in fact, with the extension of the coverage as shown in the above figure, other MEOLUTs present in the region would only work as a back-up, allowing for reducing the number of antennas and their related operational and maintenance costs.

6.2 Future step-by-step approach

Several studies have already been performed to implement this new networked configuration, following the service validation of the IOCA MEOLUT.

In particular, the feasibility of this new network is being studied addressing all the SGS components and their maintainers that would be implicated in it: ECA MEOLUTs, IOCA MEOLUT, MTCF, and SARN.

One main point of attention is the capacity of the system, considering the increase of the data flow that would derive from the network of the entire SGS.
MTCF and SARN maintainers have confirmed that no blocking point exists at moment, as the equipment used are already scaled to support this amount of traffic. MEOLUT manufacturers have been addressed as well and they have assured that the operational hardware would not have problem to increase the volume of data and the computational capacity would not be impacted either.

In order to minimize the impacts on the operational system, SGDSP is considering performing this networking following different phases:

1) *Exchange of TOA/FOA data offline between ECA MEOLUTs and IOCA MEOLUTs.*
As the SGS MEOLUTs present different antenna technologies and are maintained by different manufacturers, the first phase of the networking concerns the validation that the format of the TOA/FOA files produced by the MEOLUTs can be used as they are by the other processor and that locations are produced using them.
This SW feasibility study is already on-going and is performed offline at manufacturers' premises by using a TOA/FOA file produced by the other MEOLUT.

2) *Release and validation of the new SW implemented.*
In the case of new software implementation will be needed by one and/or the other manufacturer to correctly process the TOA/FOA files to compute the localization, a new SW release will be fully validated in factory and site before implementation in the operational SGS.

3) *Dataflow exchange from the IOCA MEOLUT to ECA MEOLUT VAL chain*
With the new software implemented, the networking of the entire SGS will be tested by using the ECA MEOLUTs VALidation (VAL) chain. The chain is currently being deployed in Maspalomas and it represents exactly the operational chain, connected to the four-dish antenna and receiving the TOA/FOA files from the Spitsbergen and Larnaca MEOLUTs.
While implementing the networking, the dataflow will be open from the IOCA MEOLUT to this VAL chain. Performance of the VAL chain will therefore be monitored to assure the correct functioning of the new configuration and compared to the operational chain to check for non-regression.

4) *Dataflow exchange from ECA MEOLUT VAL chain to IOCA MEOLUT*
If the integration of the IOCA MEOLUT TOA/FOA to the ECA VAL chain will be proven to be reliable, the networking in the other sense will be tested. Therefore the dataflow from ECA VAL chain to the IOCA MEOLUT will be activated and the performances of the new network will be monitored at KCP.

5) *Network of the ECA MEOLUTs OPE chain and the IOCA MEOLUT*
At the end of all validation steps before, the network towards the ECA MEOLUT will be switched to the Maspalomas OPE chain and the networking configuration will be operational over the two areas.

7. Conclusions

As of today, the ECA SGS, composed by Larnaca, Maspalomas and Spitsbergen MEOLUTs, represents the main and only example of networked MEOLUTs. Each site can be described as a twelve-channel antenna MEOLUT and shows outstanding performances that SGDSP reports monthly to EUSPA.

This argument is supported by continuous data collection, specific real case, as well as simulations performances that represent how the networked MEOLUT configuration are a gain in terms of location performances in order to support SAR forces in the processing of the distress alert.

Mostly, comparing the ECA MEOLUTs and IOCA MEOLUTs performance, it is undeniable the enhancements allowed for the networked configuration in terms of location accuracy below 2km.

That is why all the parties of the SAR/Galileo program are currently involved in the work to network the ECA MEOLUTs to the most recent IOCA MEOLUT. This configuration will allow to extend the SAR/Galileo coverage over a wide area, including almost entirely three continents (Africa, Europe and Asia), part of the Atlantic Ocean and practically the entire Indian Ocean, without the need of any other ground segment provider.

This work is focussing on reducing the impacts on the operational SGS and will therefore be done following a step-by-step approach. This approach includes working offline at the MEOLUT manufacturers' premises, as well as integrating new software release after full validation campaigns and evaluating the networking performances at validation chains, before integrating the new configuration into the operational system.

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