Navigation solutions powered by Europe

Galileo and SAR/Galileo Return Link Service

Beacons Manufacturers Workshop

Xavier Maufroid (European Commission)

Annapolis, 1st May 2014

Launch of 419 and 420 MEOSAR/Galileo satellites in 2012

Navigation solutions powered by Europe

- ★ Performance of SAR/Galileo Repeaters up to now has exceeded expectations.
- ★ Tested in different test campaigns including Cospas-Sarsat D&E
- ★ 4 additional satellites to be launched in 2014

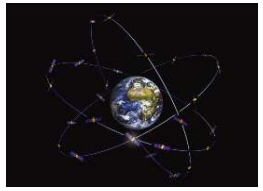
Galileo Status and Roadmap

Navigation solutions powered by Europe

Galileo implementation foresees the delivery of initial services (OS, PRS, SAR) as soon as 2014/2015.

Full Operational Capability
All services, 30 satellites
2018/2020

Initial Operational Capability
Early Services for OS, SAR, PRS
8-12 satellites
2014/2015



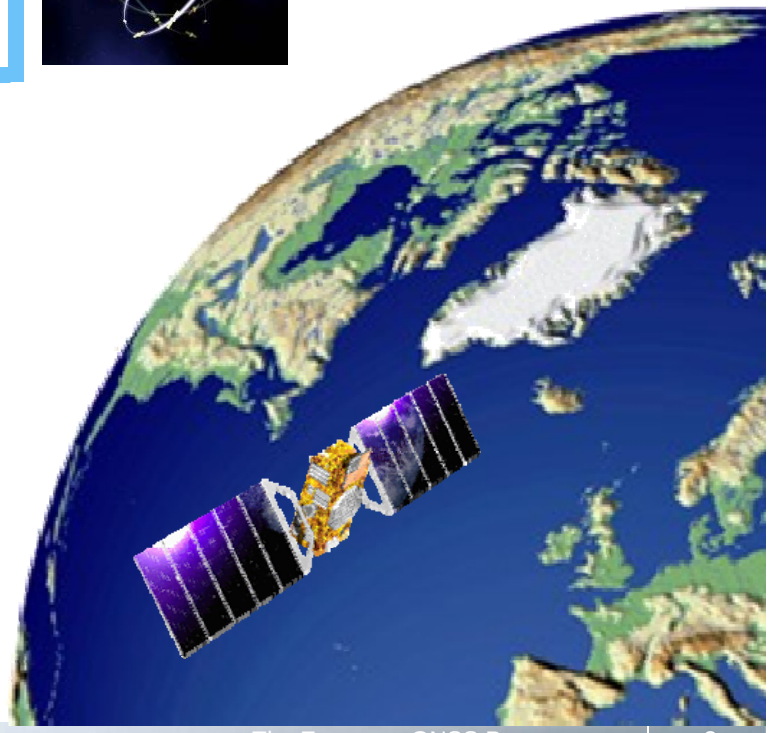
In-Orbit Validation
4 IOV satellites plus ground segment
2011-2012

Galileo System Testbed v2
2 initial test satellites
2005

Galileo System Testbed v1
Validation of critical algorithms
2003

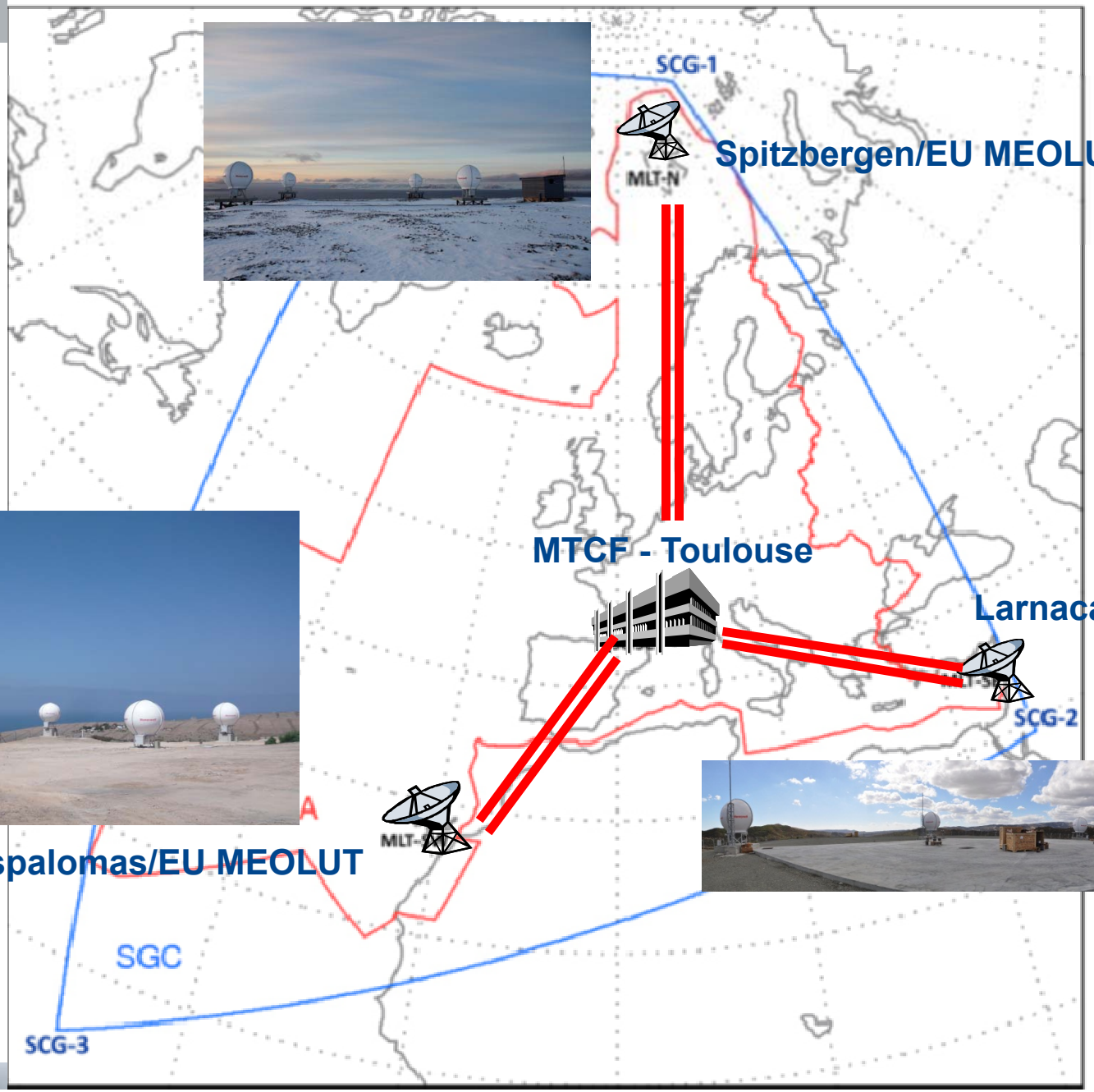
GALILEO GIOVE

GALILEO GSTB-V1

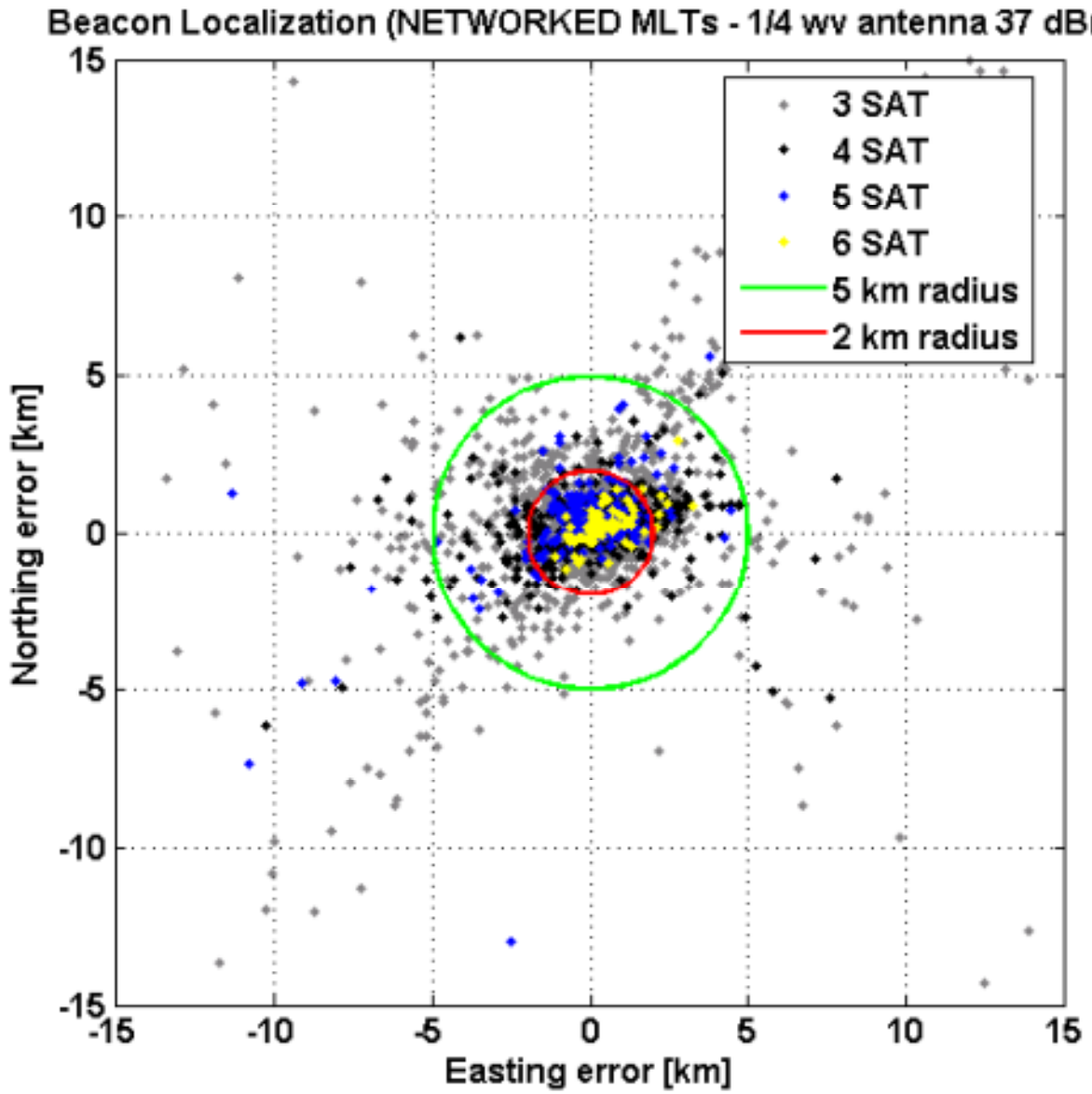


- **The Search and Rescue (SAR) Service of Galileo consists of:**
  - **The Forward Link Alert Service:** Contribution to the Cospas-Sarsat MEOSAR Programme:
    - Contributes to MEOSAR Global coverage by providing space (24 operational SAR Repeaters) and ground segment contribution (3 MEOLUTs)
    - Contributes to Cospas-Sarsat system by detection/localization data of 406MHz distress beacons
  - **The Return Link Alert Service:** it provides the users in distress a an acknowledgment message informing them that the alert has been detected and located

SAR/Galileo Ground Segment



Preliminary Results of Networked SAR/Galileo Ground Segment (test run 22 April with test beacons)



- **During the development process Two types of acknowledgments were considered in the Return Link Service:**

  - **Acknowledgment Type 1 (also called system acknowledgment):** in this case, the **Galileo system is the only responsible for the automatic transmission** of a Return Link Message (RLM) to the emitting beacon **once the alert has been detected and located**

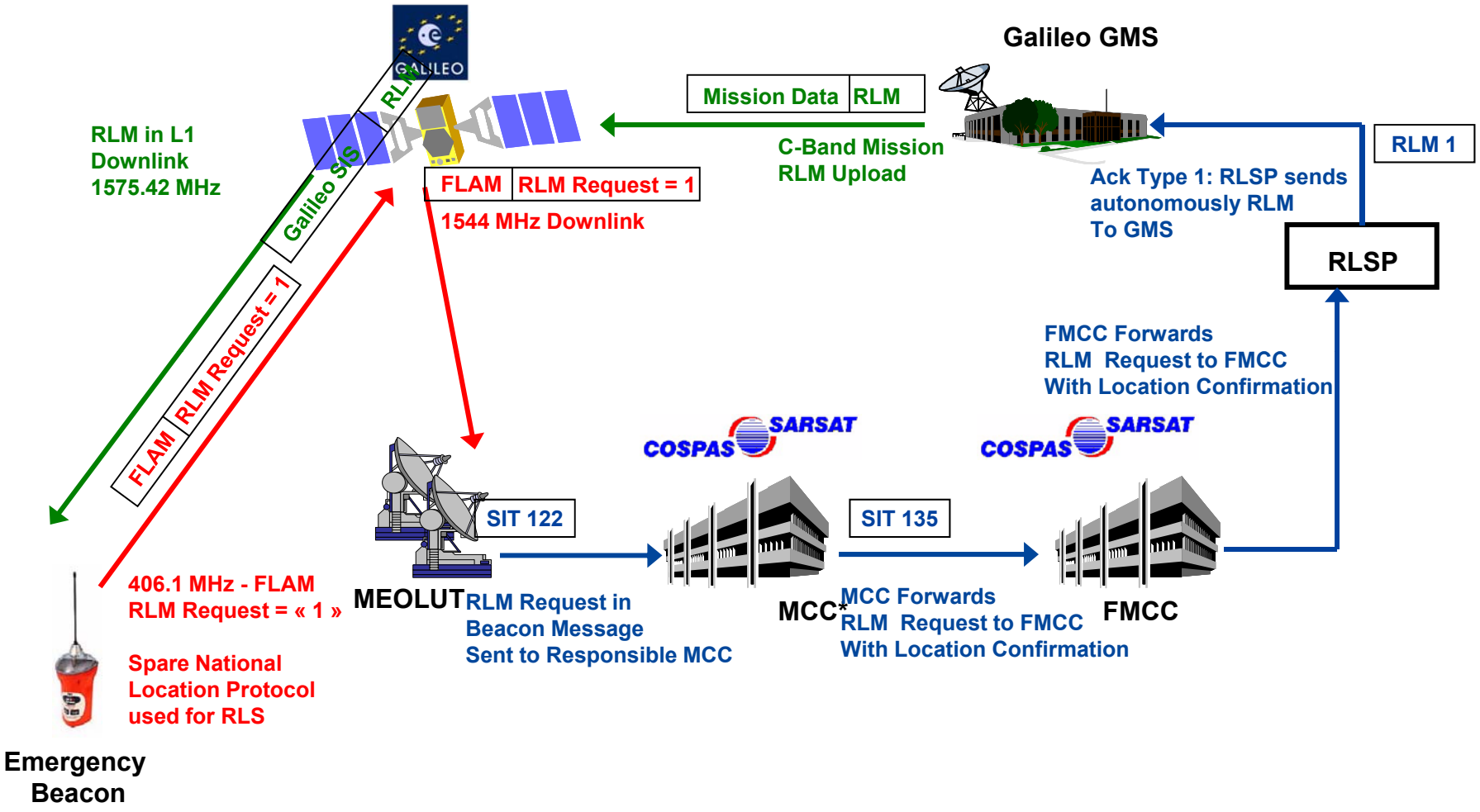
  - **Acknowledgment Type 2 (also called RCC acknowledgment):** in this case the Galileo system would send the RLM to the emitting beacon **once he has received the authorization of the RCC.** This acknowledgment would inform the user that the distress has been received by the RCC.

- **In March 2012, the European Commission participated to the COMSAR 16 and presented a paper on the Return Link Service**
  - **Outcome of COMSAR 16:**

> ***6.22 The Sub-Committee endorsed:***
>
> ...
>
> *.4 the acceptability of the Return Link Message (RLM) Type-1 including the optional inclusion of this particular functionality within distress beacons; and*
>
> *.5 the further consideration of the complex matter of RLM Type-2 messages by the ICAO/IMO Joint Working Group.*

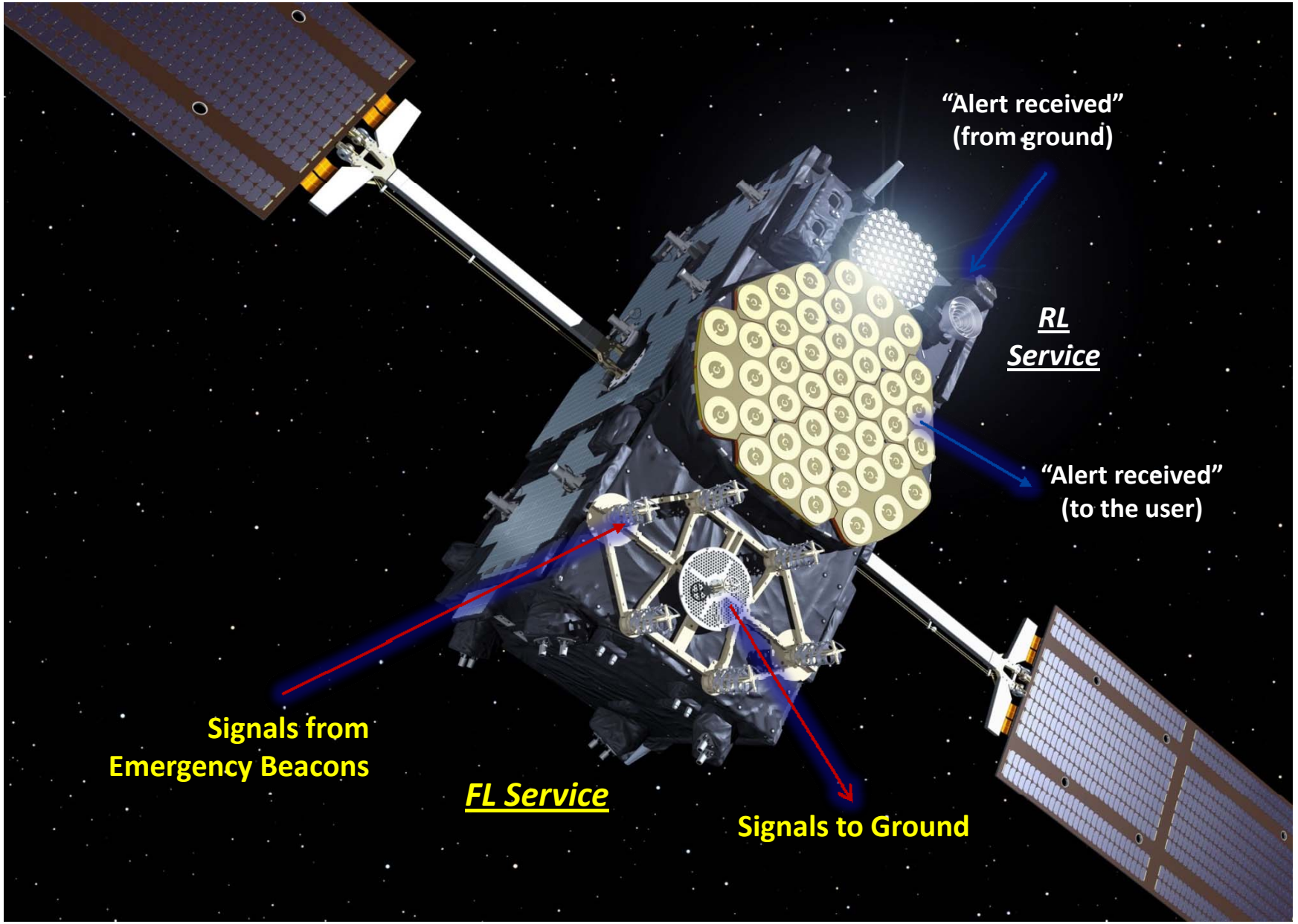
- **ICAO/IMO JWG in 2012 concluded that the RLS Type-2 and further applications of it (e.g. two-way messaging) should not be pursued for the time being**

Return Link Acknowledgment Service End-to-End Loop (RLM Type-1)



SAR/Galileo RLS Space Segment Component

Navigation solutions powered by Europe



SAR/Galileo RLS Ground Segment: Return Link Service Provider (RLSP)

Navigation solutions powered by Europe

- ★ **The RLSP is the Galileo Service Facility in charge of the generation of the Return Link Messages**
- ★ **Interface with the Galileo Ground System for uplinking of Return Link Message**
- ★ **Interface with the Cospas-Sarsat system (through FMCC) for receiving RLM requests (information of distress with RLM capability)**
- ★ **The facility is located in the SAR/Galileo Service Centre, Toulouse France**
- ★ **Operated by the SAR/Galileo Data Service Provider**

Return Link Message Request (RLM Request)

- Message sent by the distress beacon (specific RLS protocol on the 406 MHz uplink signal) to the Return Link Service Provider (RLSP) to indicate that it has a Return Link capability

- The protocol is defined for the current generation (T.001) of beacons and is being adapted for the next generation of Cospas-Sarsat beacons
  - Protocol Applicable as from November 2015

- The RLM request is received at the RLSP through the Cospas-Sarsat network
  - Is included as part of the SIT message (SIT135)
  - Follows a specific routing through the FMCC which interfaces with RLSP

★ Return Link Message (RLM)

- ★ Message sent by the Galileo system to the beacon through the Galileo L1 signal (1575.42 MHz)
- ★ Defined in Galileo Signal in Space ICD, version 1.2 (May 2014)
- ★ Two types of RLMs: short RLM (80 bits) and long RLM (160 bits)

Return Link Service	Beacon ID			Message Code				Short-RLM Parameters Field																
	60			4				16																
	Bit 1**	To..	Bit 60	Bit 61	Bit 62	Bit 63	Bit 64	Bit 65	Bit 66	Bit 67	Bit 68	Bit 69	Bit 70	Bit 71	Bit 72	Bit 73	Bit 74	Bit 75	Bit 76	Bit 77	Bit 78	Bit 79	Bit 80
Acknowledgment Service Type-1	15 HEX ID			0	0	0	1	1	0	Spares													Parity
Test Service	15 HEX ID			1	1	1	1	Spares															Parity	

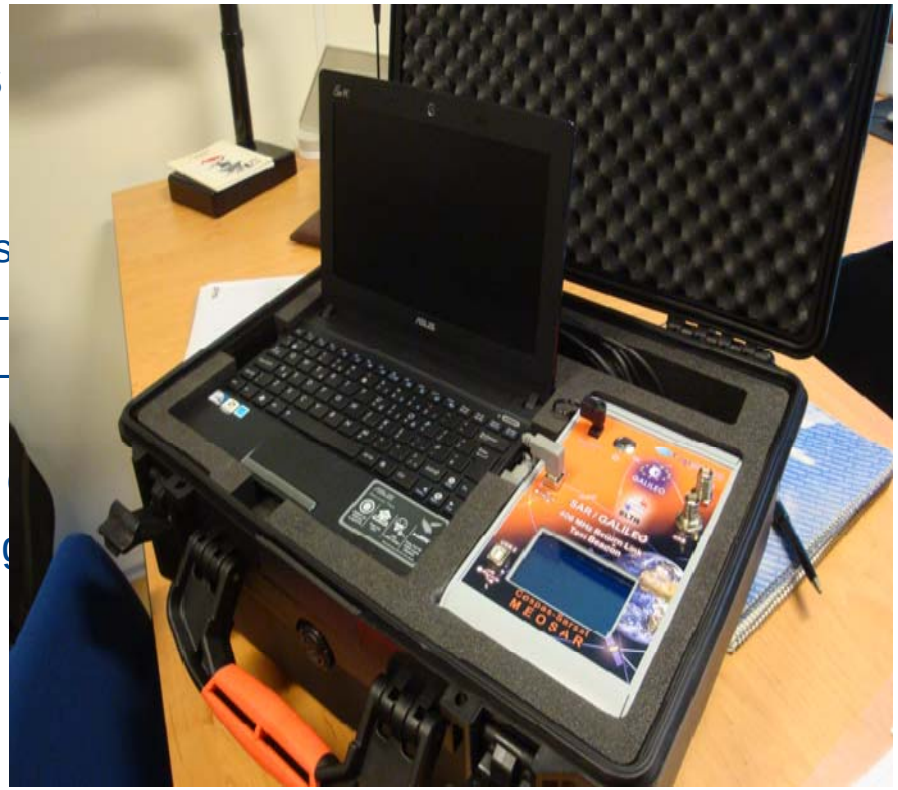
- ★ Interface between the GNSS receiver and distress beacon is being standardized: IEC TC80 WG6 has been requested to develop a new IEC 61162-1 sentence for the RLS message for consideration by next Cospas-Sarsat Council

- **RLM reception at the distress beacon**
  - The GNSS receiver must have the capability to receive Galileo signals in L1
  - The GNSS receiver must be switched on after the beacon activation to allow the reception of the RLM
  - The RLMs message will be sent through 2 satellites in visibility of the beacon. The choice of the satellite is made by the RLSP based on the beacon location information and perceived link quality
  - The beacon does not which satellites will be used for RLM transmission → needs to track all Galileo satellite in view
  - The GNSS receiver in the beacon must be maintained ON during 30 minutes to guarantee the reception of the RLM in the beacon
    - The Galileo system commits to 15 minutes delivery time upon confirmation from MCC at the RLSP
    - The time required to get a location confirmation by Cospas-Sarsat may affect the end-to-end delivery time

On-Going Standardization Activities

- Complete Cospas-Sarsat Beacon Standad T.001 for inclusion of all requirements specific to the RLM function implementation:
  - Protocol
  - Beacon GNSS Receiver activation sequence
  - Beacon behaviour in case of RLM reception
- Complete Cospas-Sarsat Beacon Testing Standard T.007 to allow verification of the RLS functionality as part of the RLS enabled beacon Type Approval process
- Proposal for standard modification to be presented at JC-28 in June 2014
- Interface between GNSS receiver and beacon is being standardized (new IEC sentence)

- **IOV Test Campaign executed from October 2013 to March 2014**
  - Test set-up:
    - 4 GALILEO satellites for Return Link Message dissemination
    - 2 GALILEO satellites + DASS-GPS for end-to-end tests
    - SARVTB MEOLUT and French MEOLUT - for end to end test
    - FMCC-Test - for end to end test
    - pre-Operational RLSP
    - Several Test Beacons with RLS
  - Tests:
    - RLS Capacity (GMS + Satellites
    - RLM delivery time by the GALIL
    - End-to-end (Forward + Return L
- **Cospas-Sarsat MEOSAR D&E Test**
  - Large scale test campaign involvin
  - Beacon spread globally
  - Q4 2014



Test Results (1/3): RLS Capacity

Navigation solutions powered by Europe

- ★ **Delivery of short RLM (80 bits) takes 8s (20 bits per half-frame)**
- ★ **When the Galileo system is not saturated, delivery takes 10-15 seconds**
- ★ **System tested generating simulated RLM requests with repetition rate ≤ 8 sec**

CSID	TIMESTAMP (UTC)	START BIT	RLM TYPE BIT	RLM HEX
420	2013-Dec-04 21:31:53	1	0	1C9A8
420	2013-Dec-04 21:31:55	0	0	01415
420	2013-Dec-04 21:31:57	0	0	C402E
420	2013-Dec-04 21:31:59	0	0	18000
420	2013-Dec-04 21:32:01	1	0	1C9A8
420	2013-Dec-04 21:32:03	0	0	01515
420	2013-Dec-04 21:32:05	0	0	C402E
420	2013-Dec-04 21:32:07	0	0	18001
420	2013-Dec-04 21:32:09	1	0	AAAAA
420	2013-Dec-04 21:32:11	1	0	1C9A8
420	2013-Dec-04 21:32:13	0	0	01615
420	2013-Dec-04 21:32:15	0	0	C402E

Test Results (2/3): RLS Delivery Time & Coverage

Navigation solutions powered by Europe

- ★ RLS Delivery time test performed with RLM disseminated to Toulouse simulated beacon
- ★ RLS Coverage test performed with RLM disseminated to Galileo Sensor Stations worldwide
- ★ Delivery Time is defined from reception by GMS to dissemination by satellites

Number of delivered RLMs	Mean Delivery time [s]
4,462	57

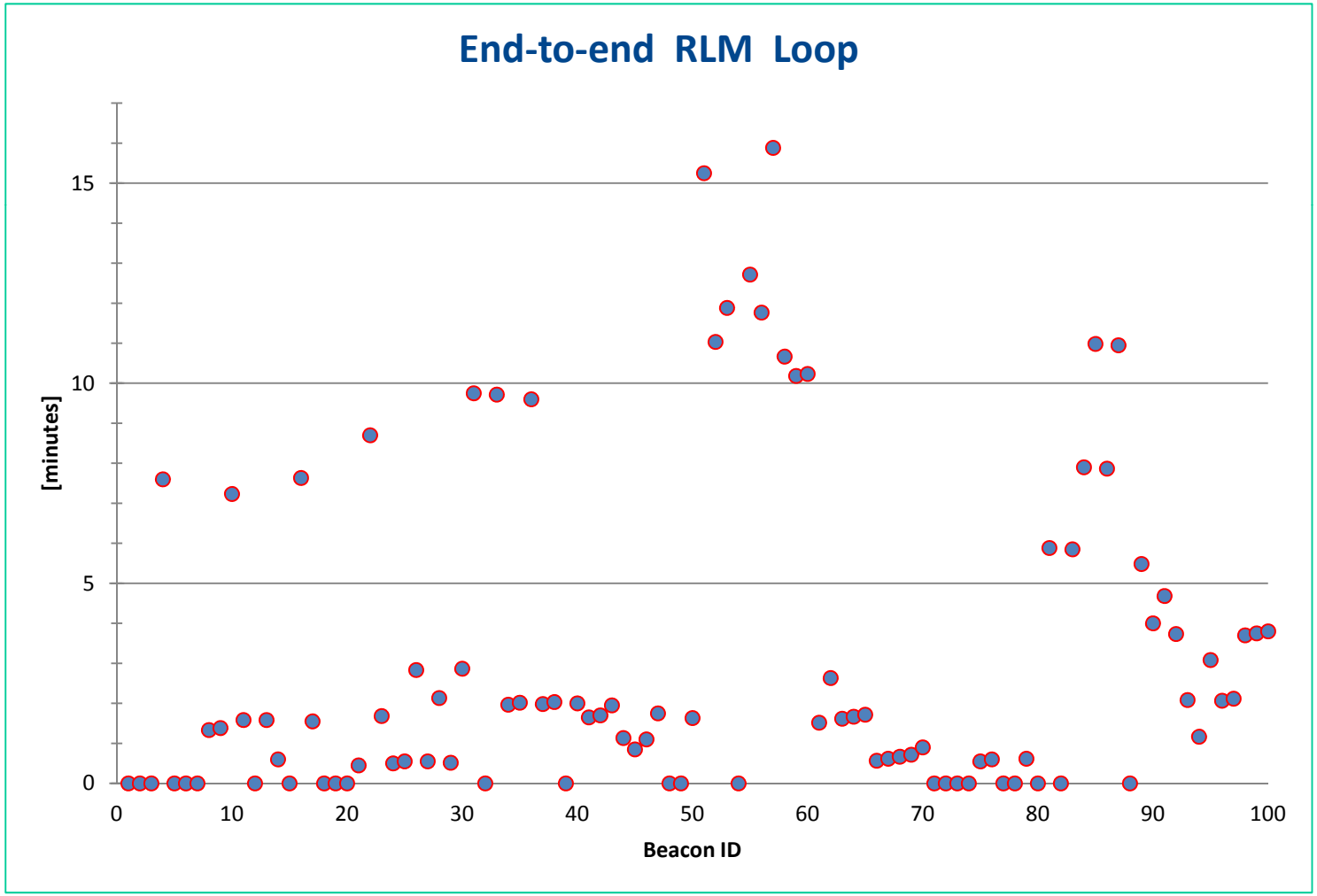
- ★ GALILEO system requirement is 15 minutes (900s)
- ★ Differences are due to limited availability of Galileo uplink stations (ULS) at this stage.

GSS	Number of RLM delivered	Mean Delivery time [s]
Falklands	1,690	137
Fucino	1,599	127
Kerguelen	1,694	129
Kourou	1,593	34
Noumea	1,395	14
La Reunion	1,883	254
Svalbard	1,587	40
Troll	1,490	14

Navigation solutions powered by Europe

★ **Forward-return link loop: from beacon activation to RLM reception at beacon.**

(Note: for this particular test the beacon has been in the same region as RLSP, so only FMCC involved)



- ★ Initial Return Link Service Tests have demonstrated that the system works properly with delivery times and reception probabilities within the expected range
- ★ Further large scale testing will be performed at the end of 2014 in the context of Cospas-Sarsat D&E
- ★ IMO has provided its support for the implementation of the RLS as additional optional function into distgress beacons
- ★ Standardization work is on-going and progressing well (IEC, T.001, T.007)
- ★ By the end of 2014, beacon manufacturers will have all required information to build up RLS capable beacons
- ★ EC expects to announce start of the RLS service by the beginning of 2016