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Analysis of the Galileo SAR Return Link Service using the GalileoSARlib open-source library

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Contents

What is Galileo SAR?

How are you parsing the data?

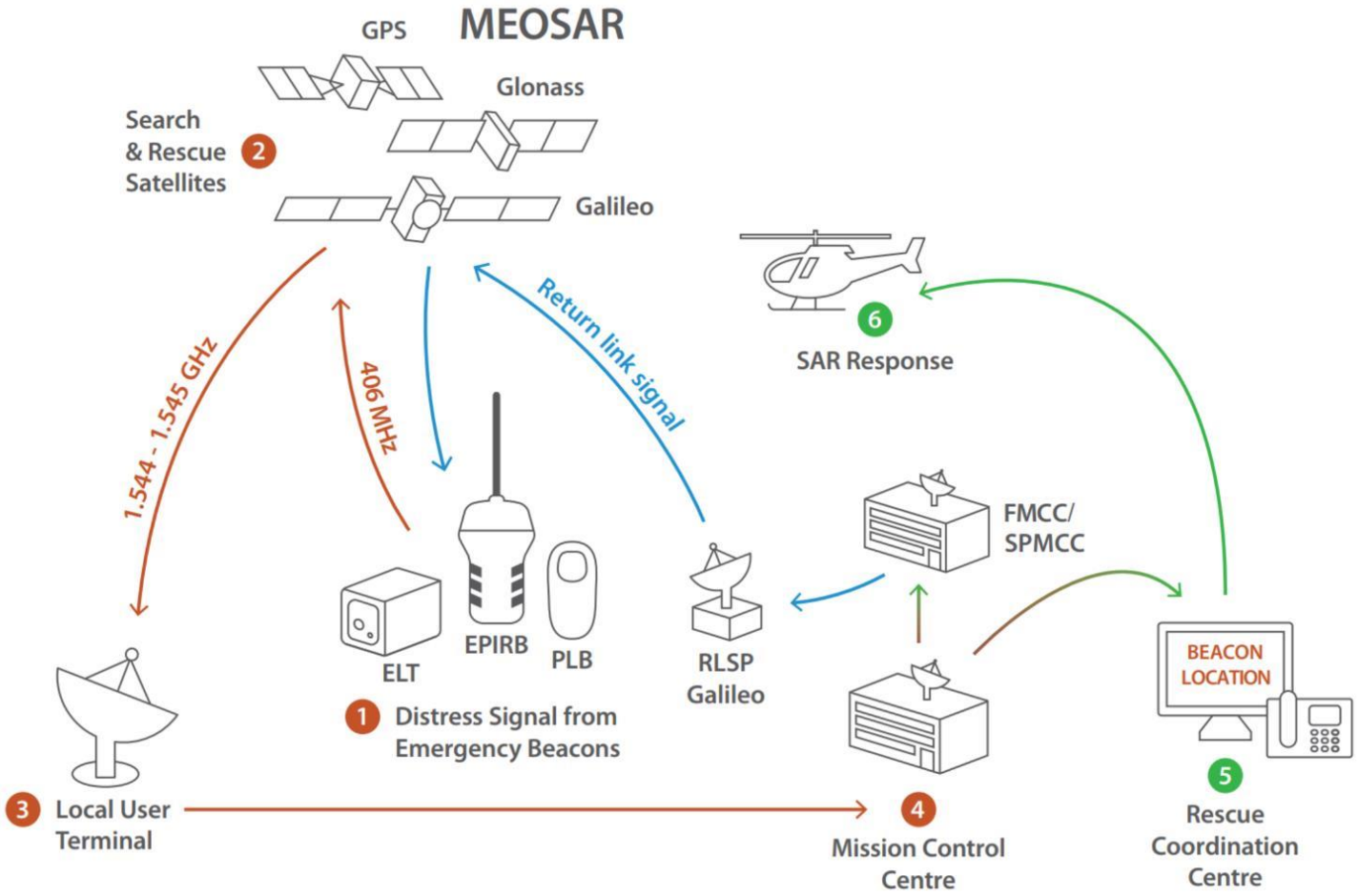
What did you find?

Cospas-Sarsat

Galileo Search and Rescue is the European contribution to the Cospas-Sarsat international programme.

The Cospas-Sarsat employs networks of satellites and ground infrastructure to detect and localize distress signals and alert the competent authorities.

Galileo SAR is unique in providing a Return Link Service to communicate back to the distress beacon.



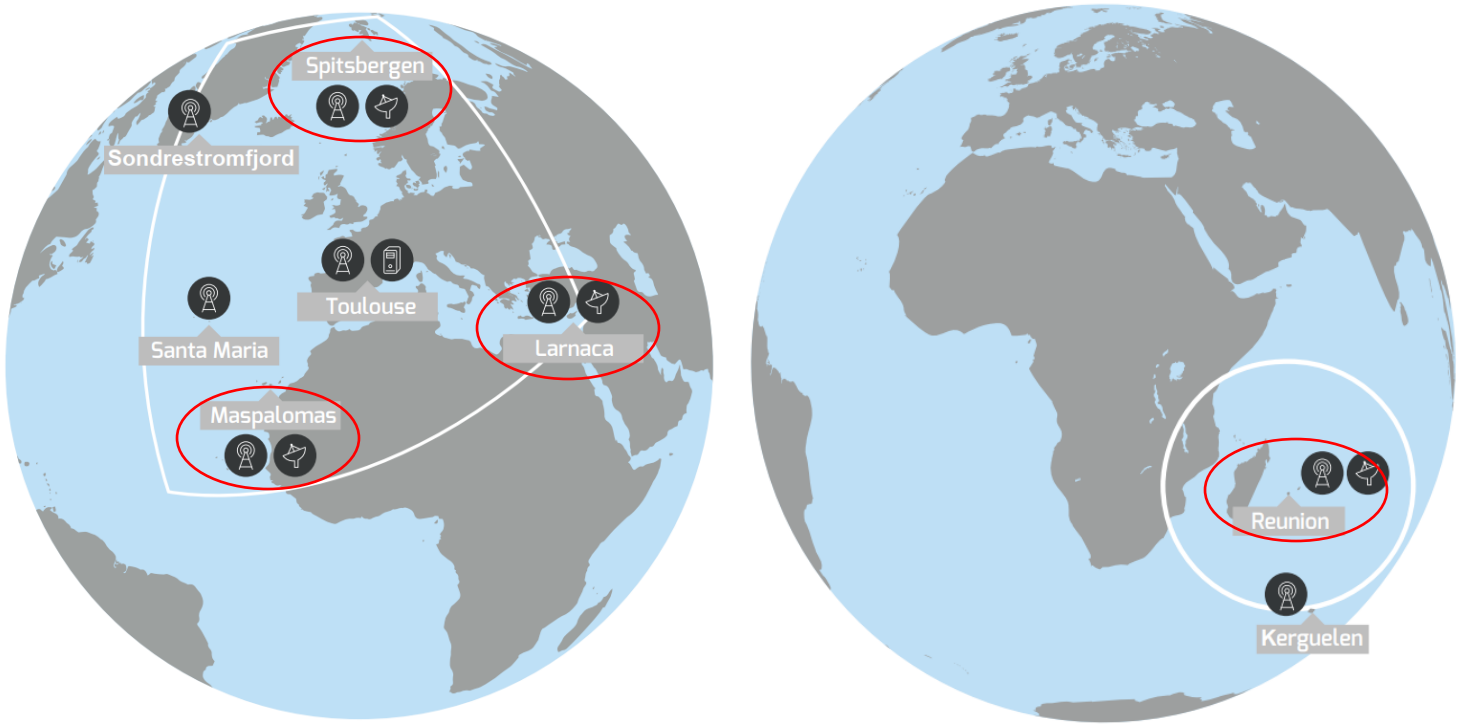
Source: Search and Rescue Galileo Service Definition Document, © European Union, 2024

Galileo SAR Contribution

Galileo supports the SAR with 4 local user terminals (MEOLUTs) that define de coverage area of the SAR services.

There are also 8 reference beacons used to continuously monitor the performance:

TLS-EU1	LNC-EU5
SBG-EU2	SON-EU6
SMR-EU3	REU-EU7
MSP-EU4	KLN-EU8



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Return Link Services

The RLS enables a **communication channel back to the user** and is requested by the beacon in distress by setting a bit in the alert signal.

When the signal origin is located, **two** Galileo satellites transmit in parallel several times a Return Link Message (RLM) to inform the beacon user.

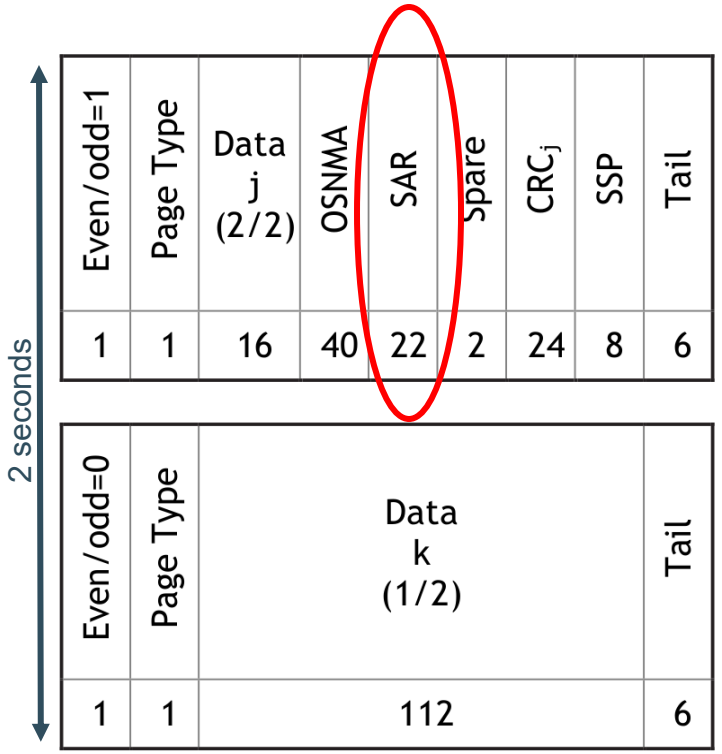
Currently, only 2 services are supported:

- **Test Service**: to test the acknowledgment service
- **Acknowledgment Service Type 1**: Automatic acknowledgment of the located signal

How is the RLM transmitted?

The RLMs are transmitted in the odd pages of the I/NAV message of the E1-B signal.

It takes 4 pages (8s) to transmit a short RLM, and 8 pages (16s) to transmit a long RLM.



Start Bit	Short /Long	SAR RLM Data
1 bit	1 bit	20 bits

concatenate

Short RLM	80 bits	8 seconds
Long RLM	160 bits	16 seconds

RLM content

Currently, there are only Message Codes for short RLM, all the long RLM are undefined.

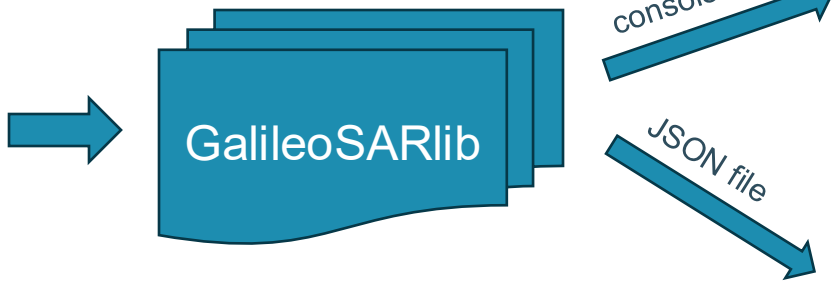
	Beacon ID	Message Code	RLM Parameters
	60	4	16 / 96
Test Service	15 hex ID	1 1 1 1	[reserved 15] [parity 1]
Ack Service	15 hex ID	0 0 0 1	1 0 [spare 13] [parity 1]

The **Beacon ID** is defined by Cospas-Sarsat, and is the **unique identifier of the beacon**. It encodes information such as the protocol used, the beacon type, the registration country, etc.

Parsing the data: GalileoSARlib

We developed **GalileoSARlib**, an open-source Python library to parse Galileo SAR.

Septentrio Binary Format




```
2024/05/08 01:03:55 - 2313 263053 - SVID 09
        RLM Identifier: SHORT_RLM (0)
        Beacon ID: 2ddb2de67f3fdff
        Message Code: ACK_SERVICE (0001)
        SRL Parameters: 1000000000000001
                Protocol Type: Standard or national...
                Country Code: United States of America (366)
```


```
{
 "metadata": {
  "wn": 2322,
  "tow": 445381,
  "utc": "2024/07/12 03:42:43",
  "svid": "31"
 },
 "rlm_id": {
  "name": "RLM Identifier",
  "value": "SHORT_RLM",
  "raw_value": 0
 }...
```


Other log files with navigation data possible (UBX, android data, etc)

Collecting the data: 90 days

We collected 90 days of continuous GNSS data: from **January 16th** to **April 16th** of 2025.

The antenna was at the top of a tower in the Electrical Engineering faculty of KU Leuven, Belgium.

Very good open-sky visibility, but it cannot track the whole Galileo constellation. Galmon could be an option, but its buggy.

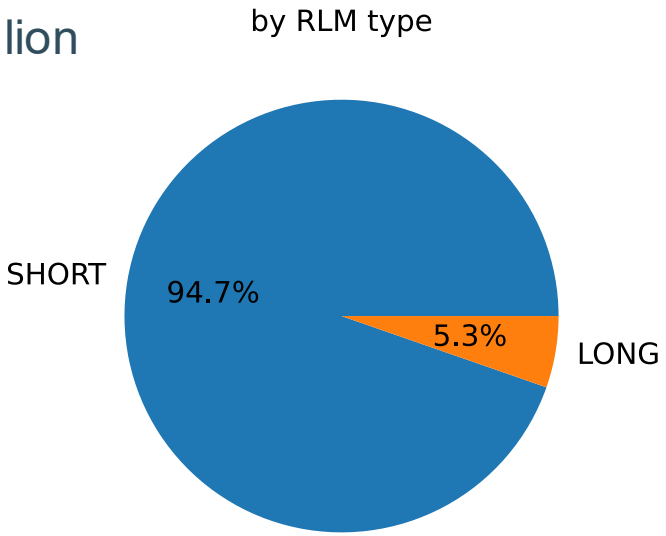
Galileo SAR Analysis

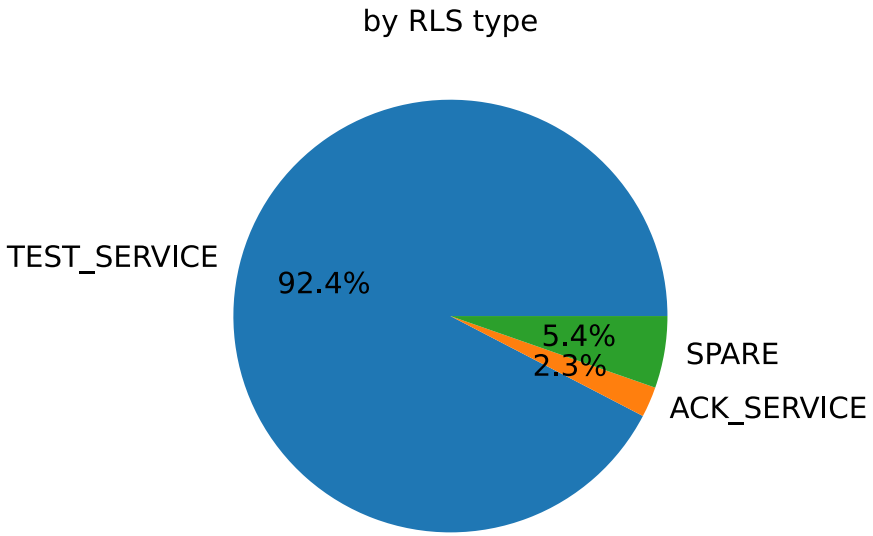
The Galileo SAR RLS usage was at **2.86%**

- Total I/NAV pages processed: ~40 million
- I/NAV pages used for RLS: ~1.1 million
  - Short RLM: ~260,000
  - Long RLM: ~14,000

Several Long RLM!

- No service defined





Galileo SAR Analysis

Some Short RLM also have an undefined service!

RLM Type	Test Service	Ack Service	Spare
Short RLM	253708	6249	68
Long RLM	0	0	14683

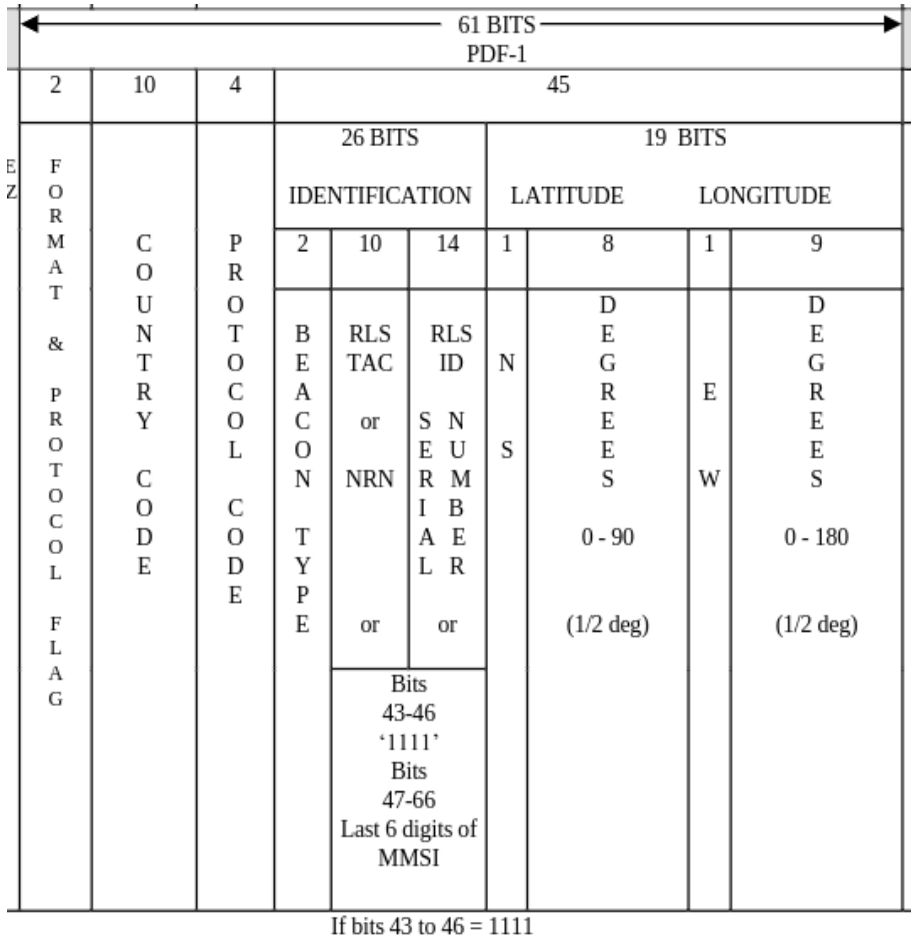
The next step is to analyze the Cospas-Sarsat beacon ID protocol, **only 2 protocols were recorded.**

C/S Protocol	Test Service	Ack Service
Orbitography Protocol	252325	0
RLS Location Protocol	1383	6249

RLS Location Protocol

It contains information on:

- Registration country of the beacon
- Beacon type (ELT, PLB, EPIRB...)
- Beacon manufacturer, model and revision date
- Beacon serial number
- Coordinates with 30min resolution
  - Have default values in the RLM



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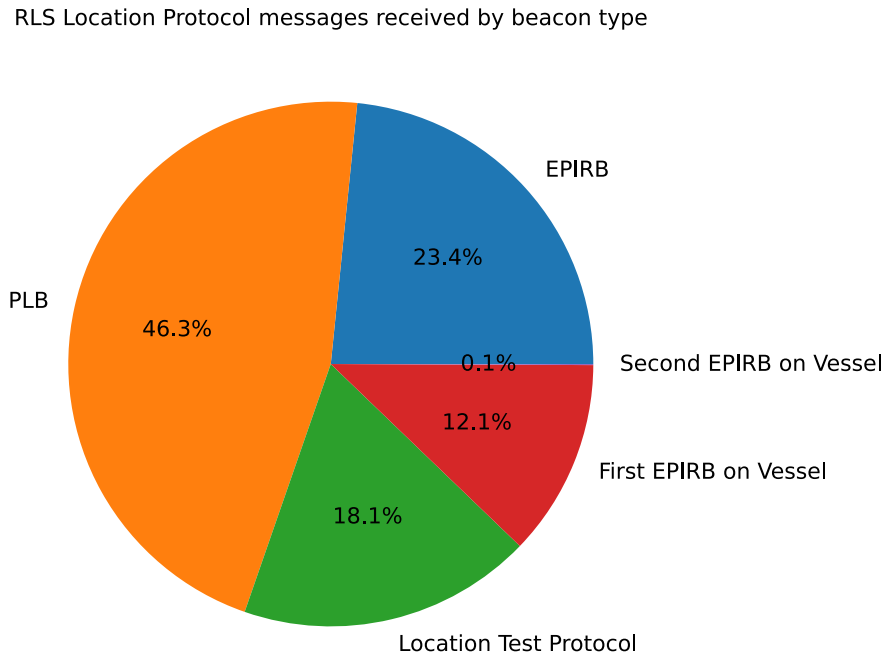
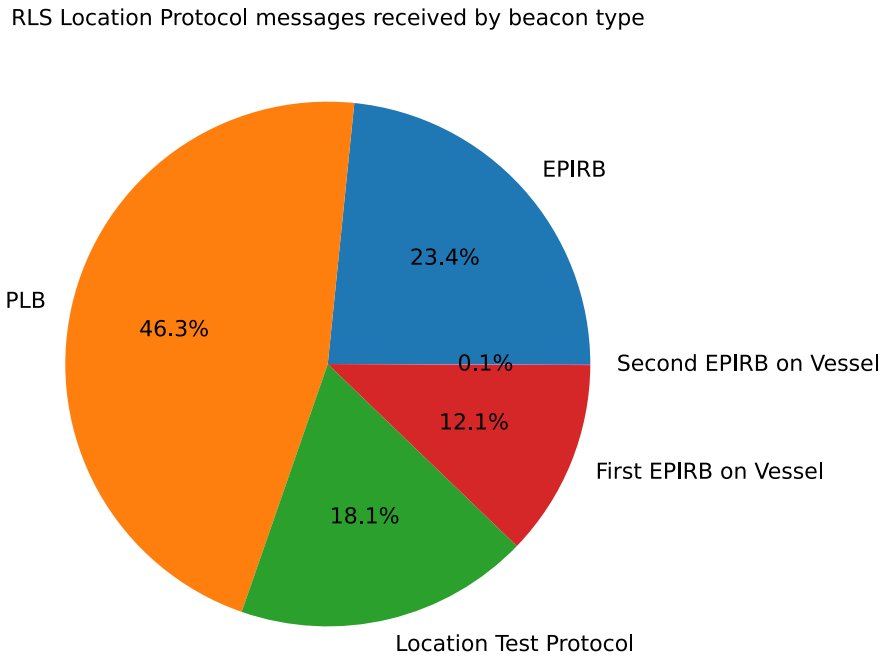
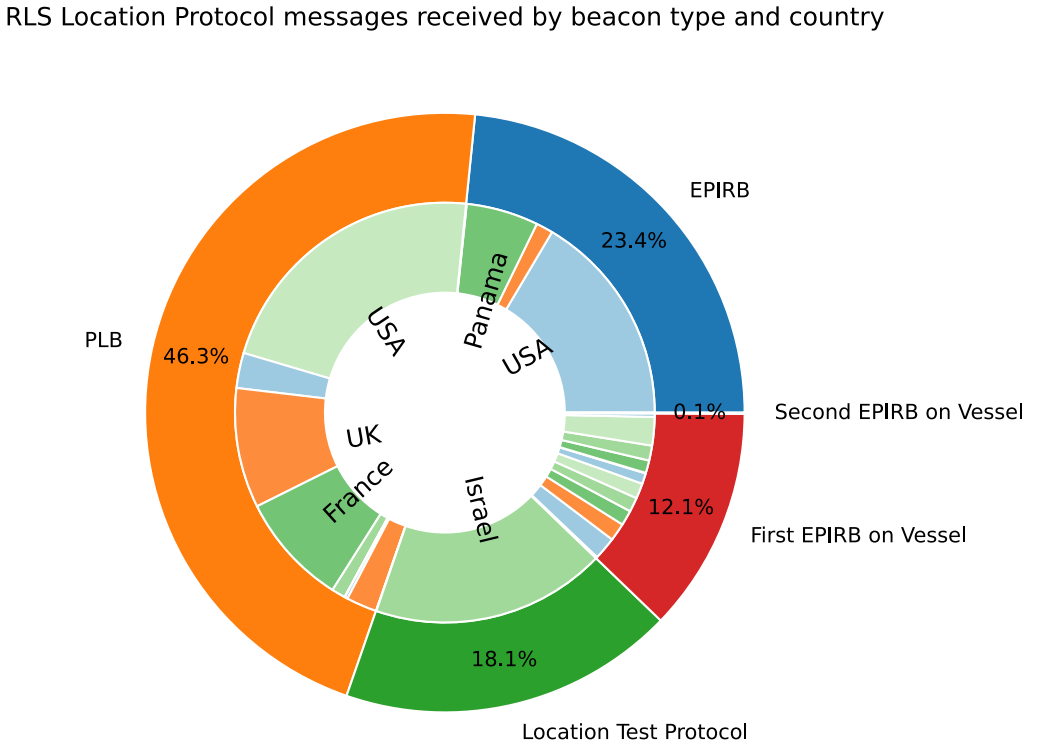
RLS Location Protocol



RLS Location Protocol

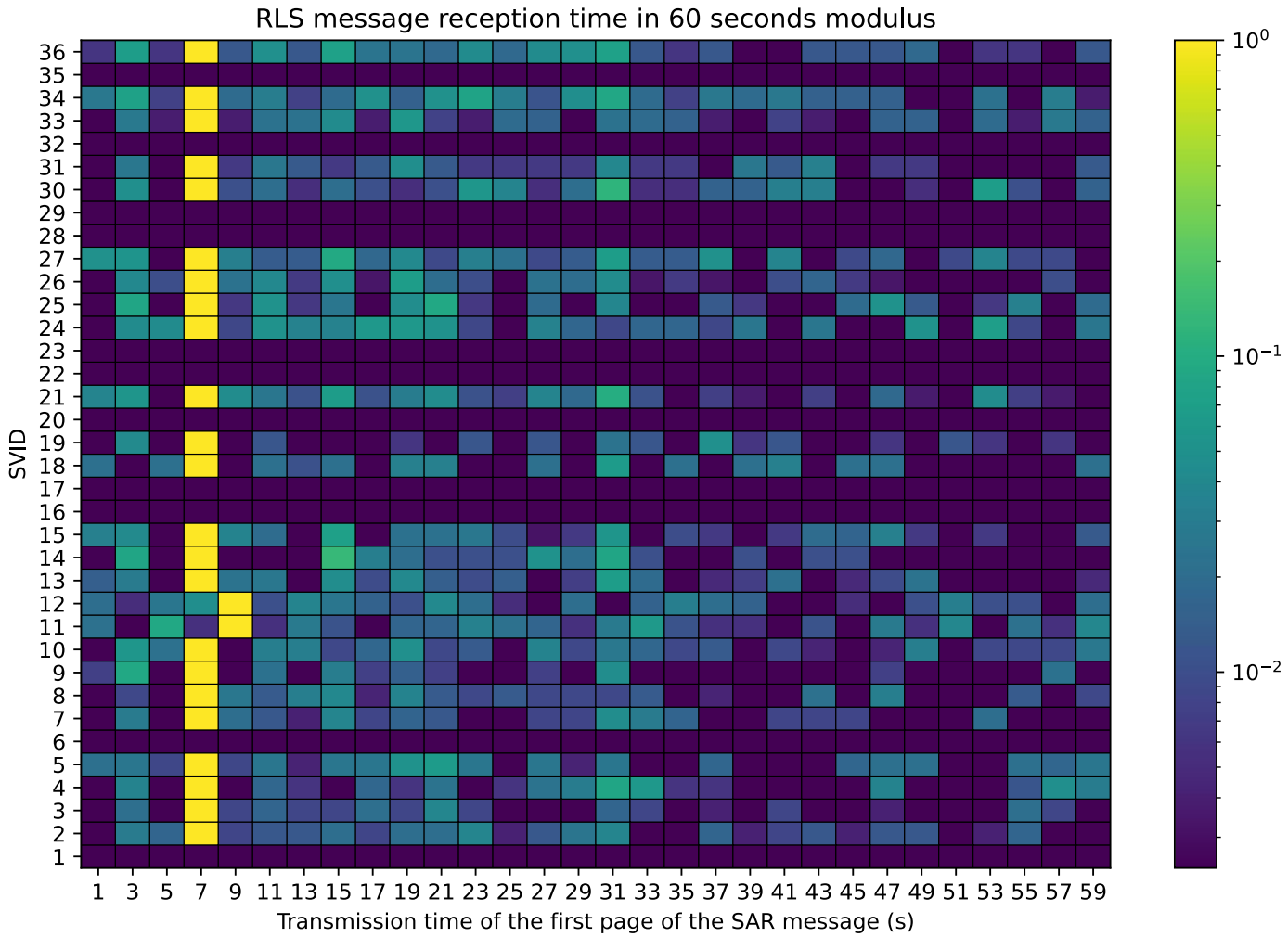




Transmission Offset – RLS Location Protocol

The satellites tend to prefer certain pages to transmit the RLM.

SVID 11 and 12 are offset by one page. Coincidentally, they are the oldest satellites in the constellation.



Orbitography Protocol

It is used to monitor the system performance by using beacons at accurately determined positions.

Simplified Orbitography Protocol Description

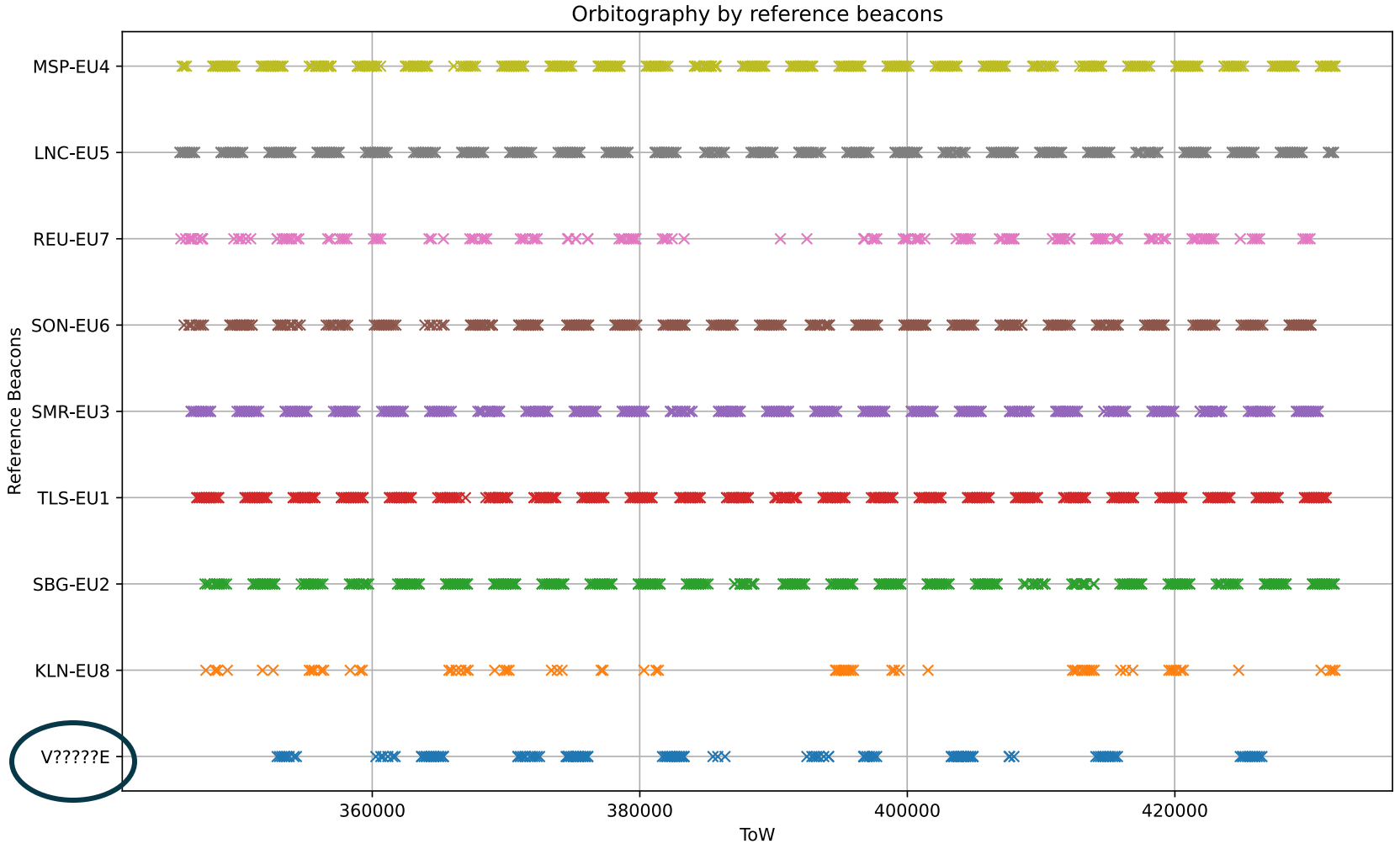
Country Code	Protocol Code	7 characters in Baudot Code	4 zeros

The 7 characters in Baudot code contain the 8 reference beacons described previously.

TLS-EU1	LNC-EU5
SBG-EU2	SON-EU6
SMR-EU3	REU-EU7
MSP-EU4	KLN-EU8

Orbitography Protocol

Example: April 10th



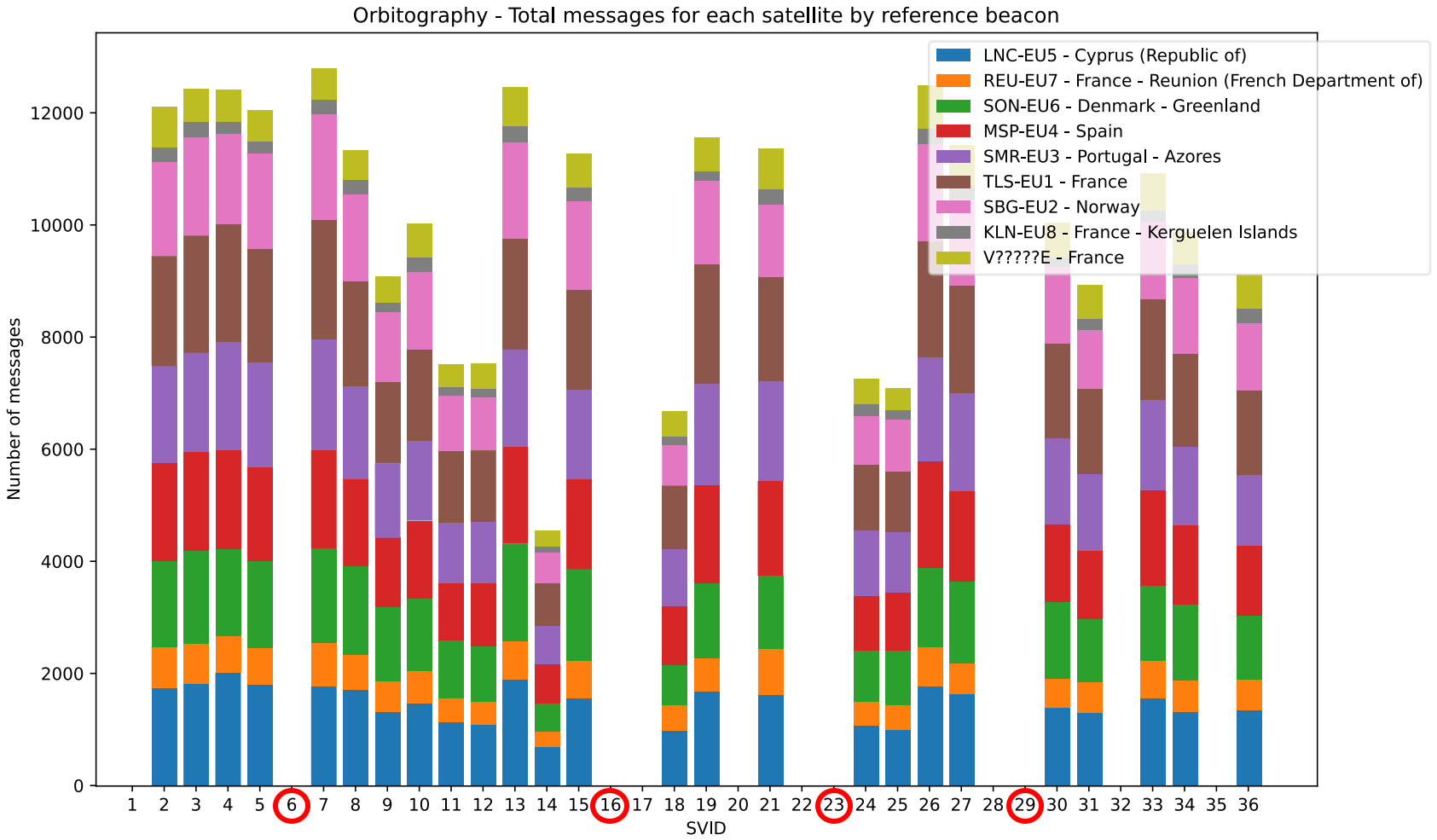
Country: France
Wrong 4 zeros

Orbitography Protocol

New Galileo satellites, they joined the SAR RLS on the 16th of April

```
E. AS OF (DAY-MONTH-YEAR): 16-04-2025

F. SAR PAYLOAD STATUS AT COMMISSIONING:
     -SART STATUS: ON
```



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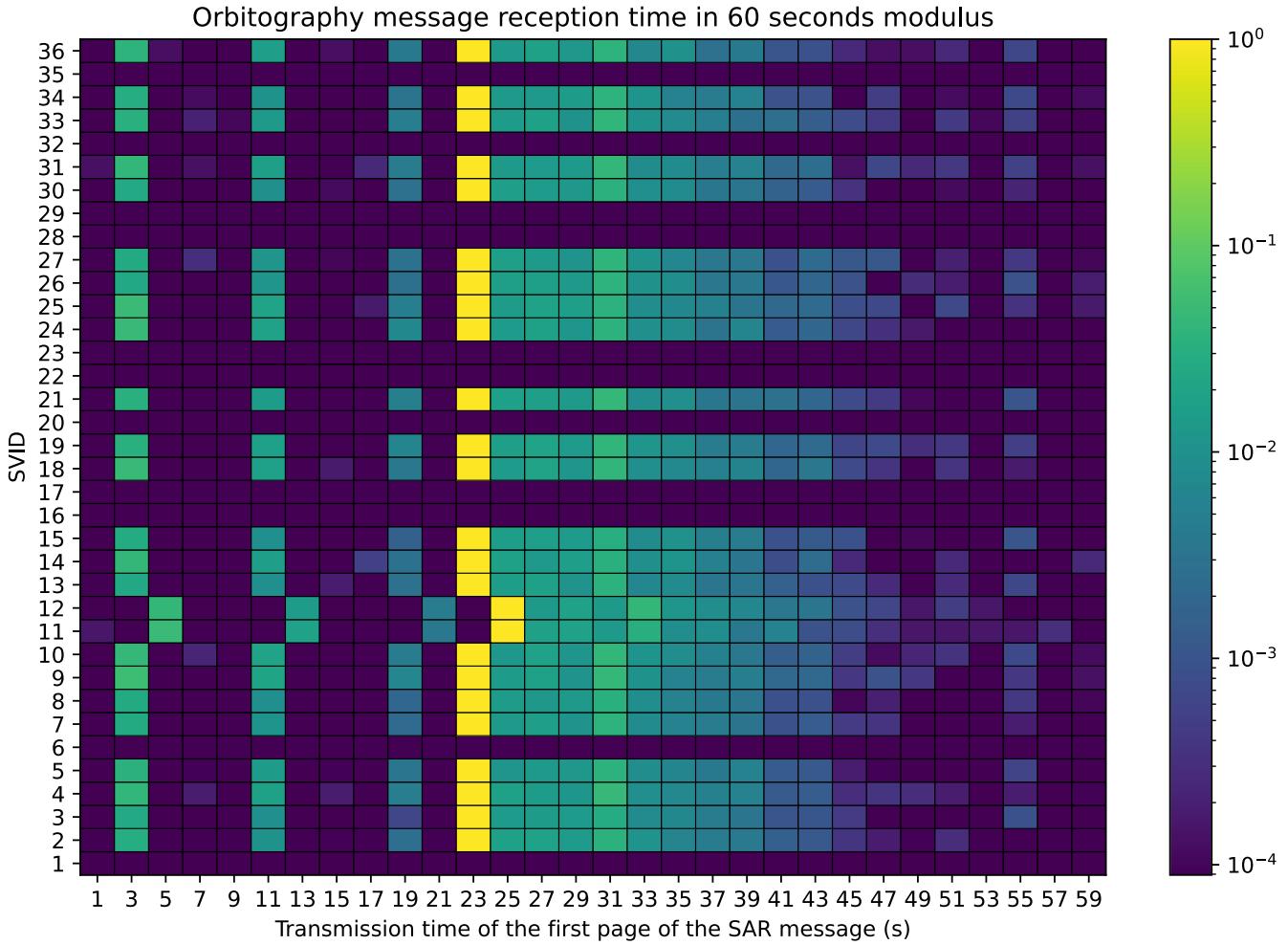
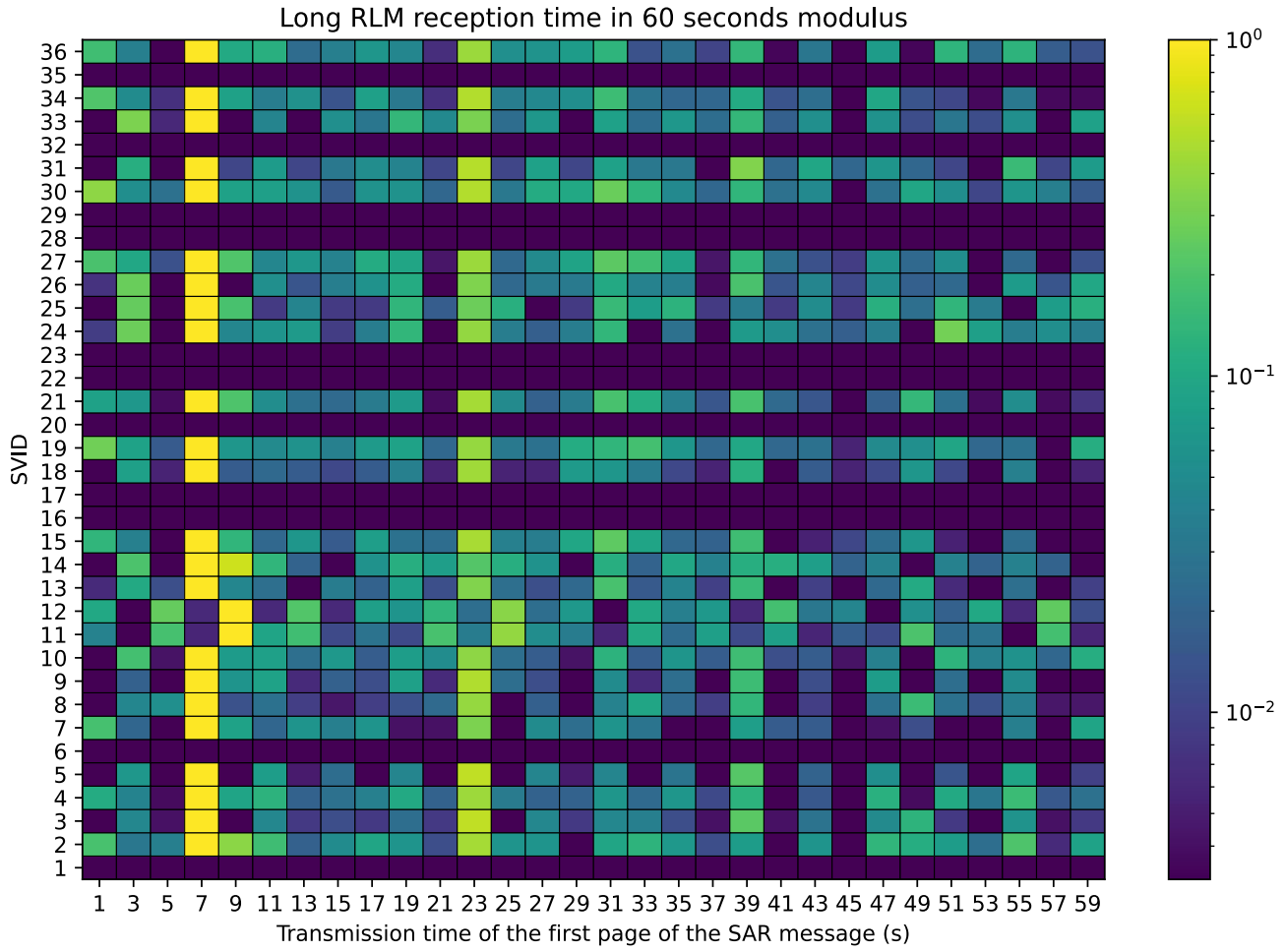


Curiosity 1: What about long RLM?

Behaves similarly to the RLS Location Protocol.

But accounting for 8 pages of transmission.



Curiosity 2: Strange messages

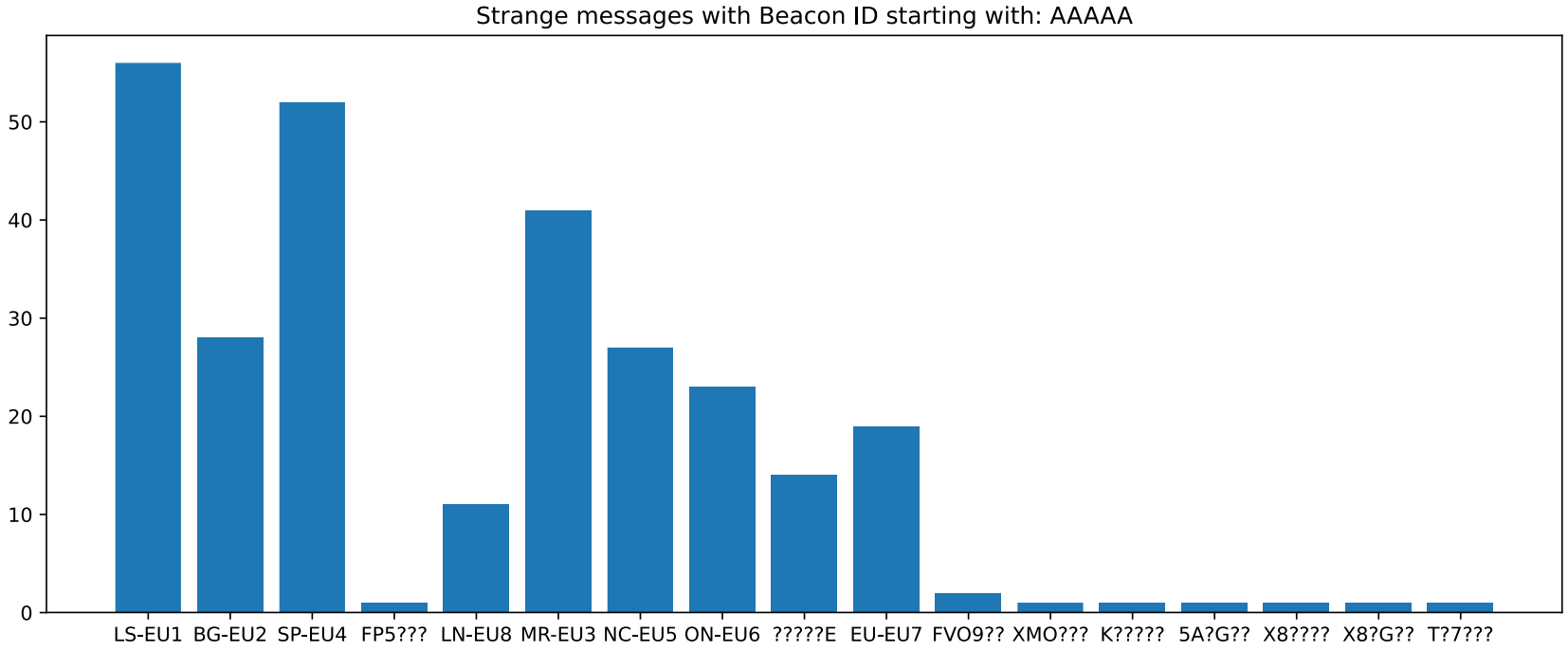
There are some RLM where the BeaconID does not seem to follow any protocol.

All of them start with a bunch of "a" values in hex:

`aaaaaa74630f1d0`

Discarding the "a" and decoding as Baudot code, we nearly get the reference beacons names

LS-EU1 instead of TLS-EU1



Conclusion and Future Work

We presented the results of monitoring for 90 days the Galileo SAR RLS.

The GalileoSARlib library, the plotting scripts, and the data are openly available on GitHub:

https://github.com/Algafix/GalileoSARlib

In the future, Galileo SAR may be used to transmit the Emergency Warning Message. This message will most likely need to be authenticated using OSNMA.

Since I have an open OSNMA library, I wanted to get familiar with this part of Galileo before the transmission of the warning message.

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