SMOS ESA RFI MONITORING AND INFORMATION TOOL:

LESSONS LEARNED

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Outline

- SMOS description
- ERMIT description
- RFI problem in first SMOS measurements
- Branches of an RFI tracking system and their evolution
- Lessons learned and tips for new missions
- Examples of detected interfering equipment
- Conclusions

What is SMOS?

ESA's Soil Moisture and Ocean Salinity Earth Explorer Mission

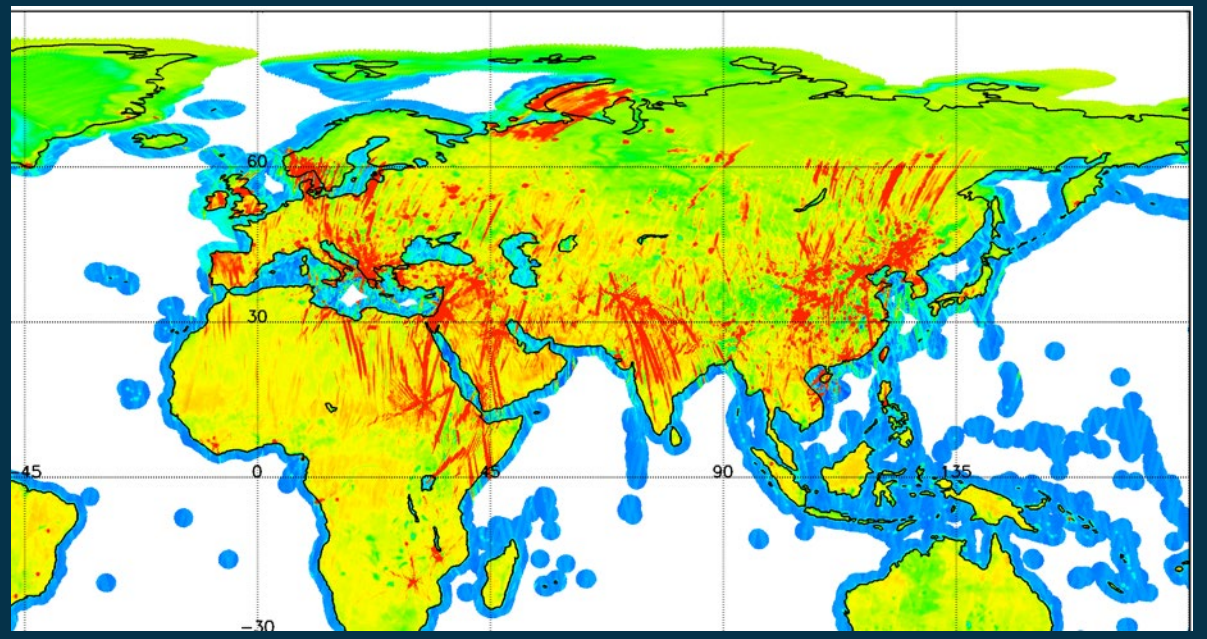
- Joint program led by ESA with participation of CNES in France and CDTI in Spain.
- Objective: To provide global maps of soil moisture and sea surface salinity.
- Launched on 2nd Nov 2009, currently in Operational Phase.
- FOS & DPGS at ESAC (ESA).
- Payload: MIRAS, 2D Interferometric Radiometer.

What is ERMIT?

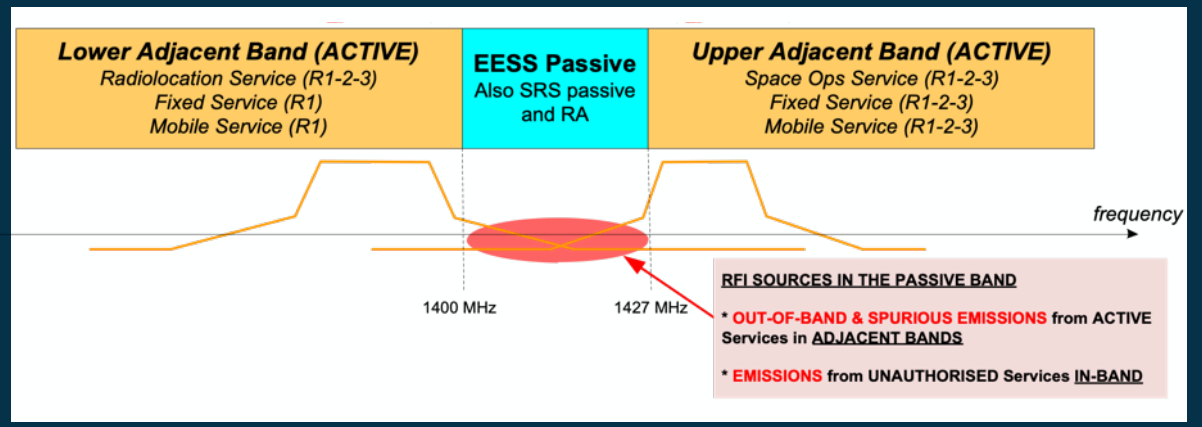
ESA RFI Monitoring and Information Tool

- Tool implemented by DPGS RFI team at ESAC with the purpose of handling and managing the information of Radio Frequency Interference or RFI collected by SMOS.
- Achieved after 12 years of continual improvements.
- In constant evolution.
- Continuous learning process due to the unexpected problems and challenges that have arisen.
- This presentation summarizes this process chronologically so that new missions can take advantage of this knowledge.
- Tips based on our experience, not definitive, but very useful.

RFI problem in first SMOS measurements



SMOS BT Map averaging 88 L1C products generated in December 2009



- The first SMOS data showed an unexpected worldwide problem of Harmful Radio Frequency Interference (RFI).
- SMOS radiometer operates in the 1400 – 1427 MHz band.
- This is a PURELY PASSIVE BAND, allocated only to passive services in the ITU Radio Regulations.
- ALL emissions are PROHIBITED in this band (RR No. 5.340).
- This band is also protected against UNWANTED EMISSIONS from active services in ADJACENTS bands (ITU-R RR Resolution 750).

Three branches of an RFI tracking system

Monitoring and Detection	Monitoring of the frequency-band. Detection of new interfering sources with their geolocation and signal characteristics. Follow-up of the evolution of the sources already detected.
Database	Log of all sources detected, sorted by country or region. All characteristics detected during the monitoring process are stored.
Reporting and operational coordination	Reporting procedure to the national authorities or other organizations in accordance with the ITU-R RR and Recommendations, with the aim of locating and mitigating (shutting down) the interfering equipment. Operational coordination with national authorities and tracking of all actions performed.

First approach to detect and report RFI sources

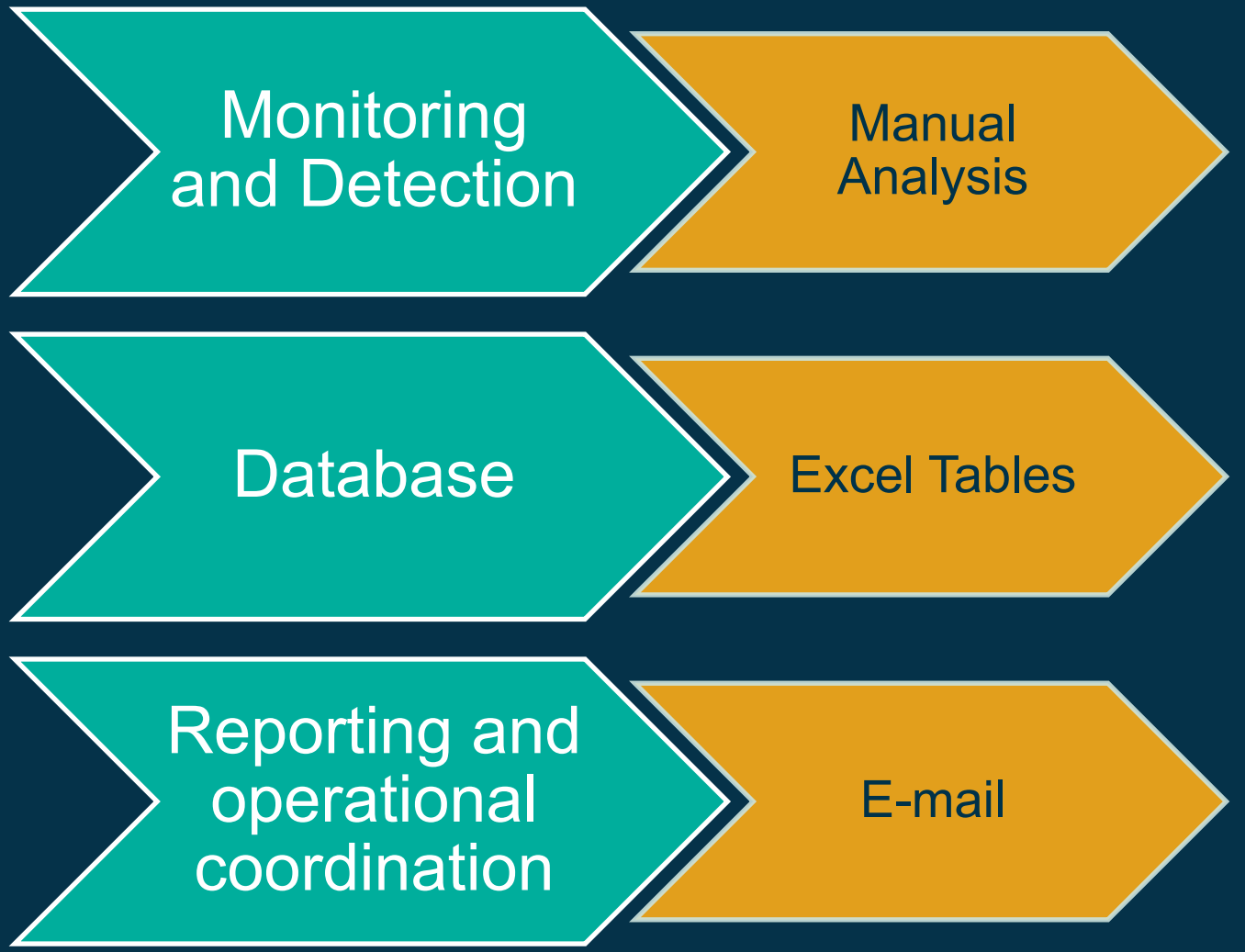
- Detection and Monitoring
  - Manual analysis of L1C products at ESAC
  - Using VISAT (SMOS product reader)
- Database
  - Manual tracking of persistent sources
  - Stored in Excel tables
- Reporting and Operational Coordination
  - Direct communications with the National Authorities via e-mail
  - Reports for specially problematic cases

RFI sources in Spain

Id	LON	LAT	BT in H pol (K)	BT in V pol (K)
Pin 1	5° 48' W	39° 07' N	3500	1066
Pin 2	~~1° 56' W~~	~~43° 11' N~~	2321	1250
Pin 3	0° 33' W	39° 19' N	1871	333
Pin 4	0° 38' W	38° 04' N	1764	286
Pin 5	2° 53' W	43° 16' N	1927	8007
Pin 6	6° 48' W	37° 15' N	958	2293
Pin 7	0° 11' W	39° 58' N	613	342
Pin 8	0° 03' W	38° 59' N	555	317
Pin 9	~~3° 44' W~~	~~40° 02' N~~	251	249
Pin 10	1° 50' E	41° 24' N	377	430
Pin 11	4° 34' W	36° 41' N	440	321

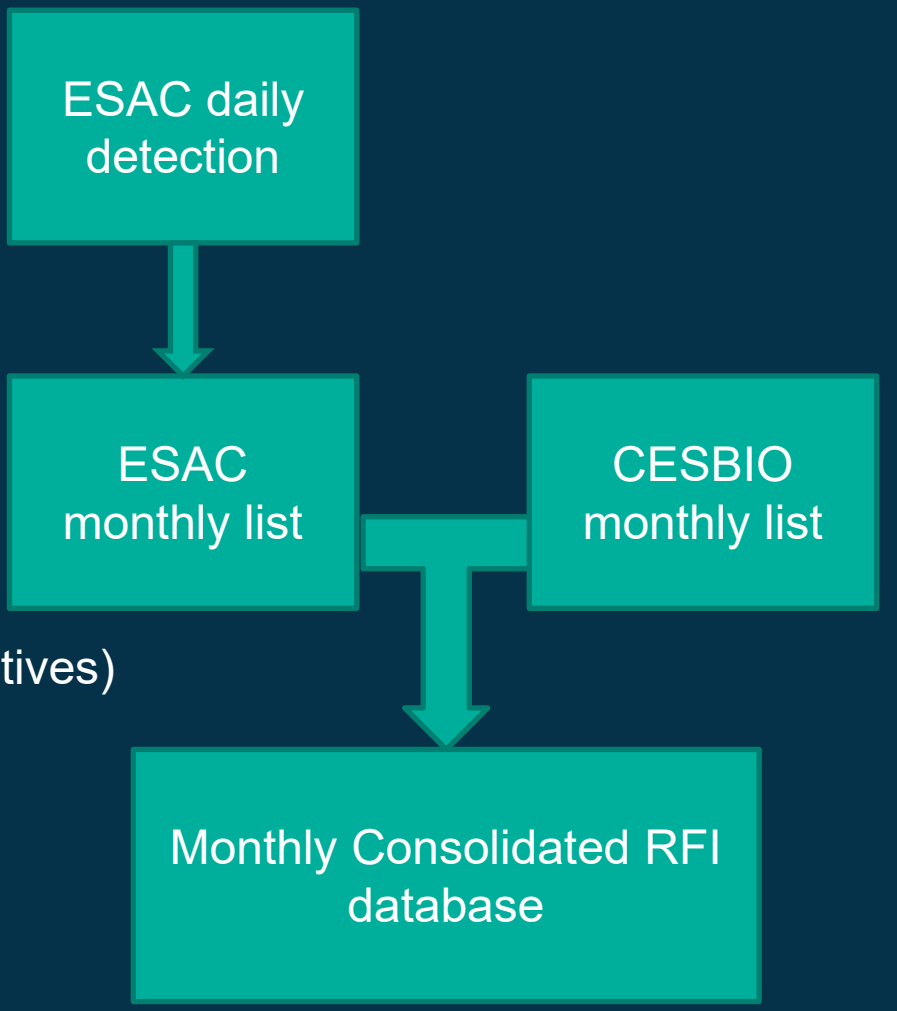
IMAGES

Three branches evolution (I)



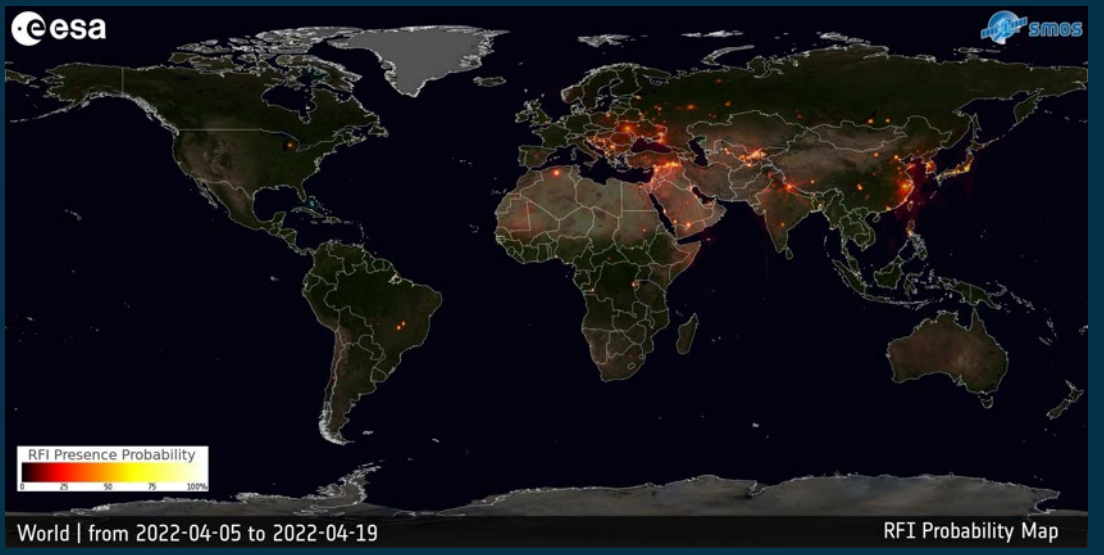
Monitoring and Detection automatization

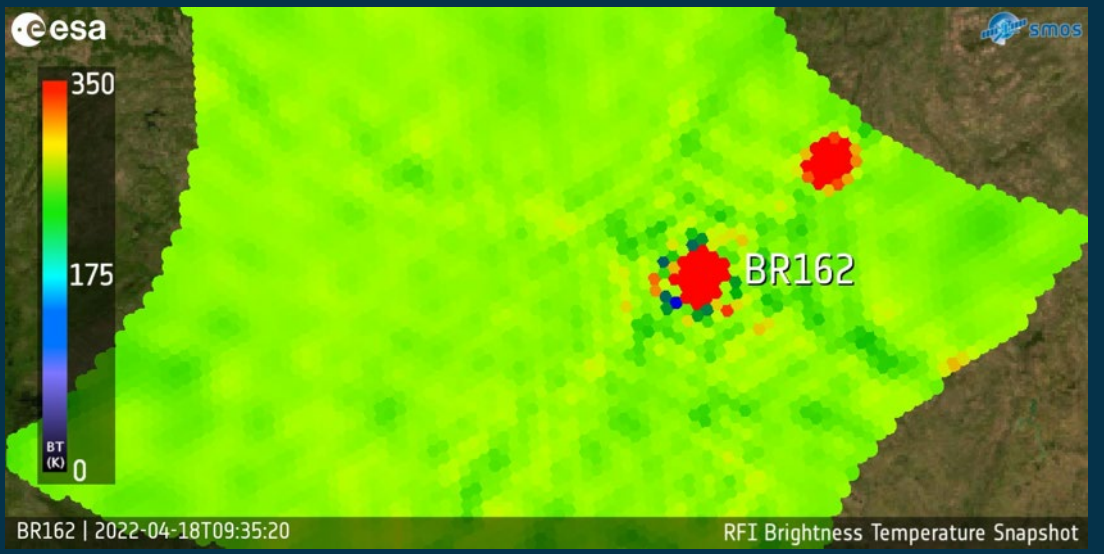
- ESAC RFI detection algorithm
  - Based in astronomical image processing
  - Daily L1C products processing
- CESBIO RFI List
  - Used in SMOS processing to flag RFI sources
  - Generated monthly from L1B products
- Monthly Consolidated RFI database
  - Based on ESAC detections
  - Consolidated with CESBIO RFI List (to discard false positives)



Monitoring and Detection automatization

- ESAC RFI detection algorithm
  - Based in astronomical image processing
  - Daily L1C products processing
- CESBIO RFI List
  - Used in SMOS processing to flag RFI sources
  - Generated monthly from L1B products
- Monthly Consolidated RFI database
  - Based on ESAC detections
  - Consolidated with CESBIO RFI List
- Automatic Maps generation
  - Global probability maps
  - Individual RFI BT maps
- Stored in a FTP server located at ESAC

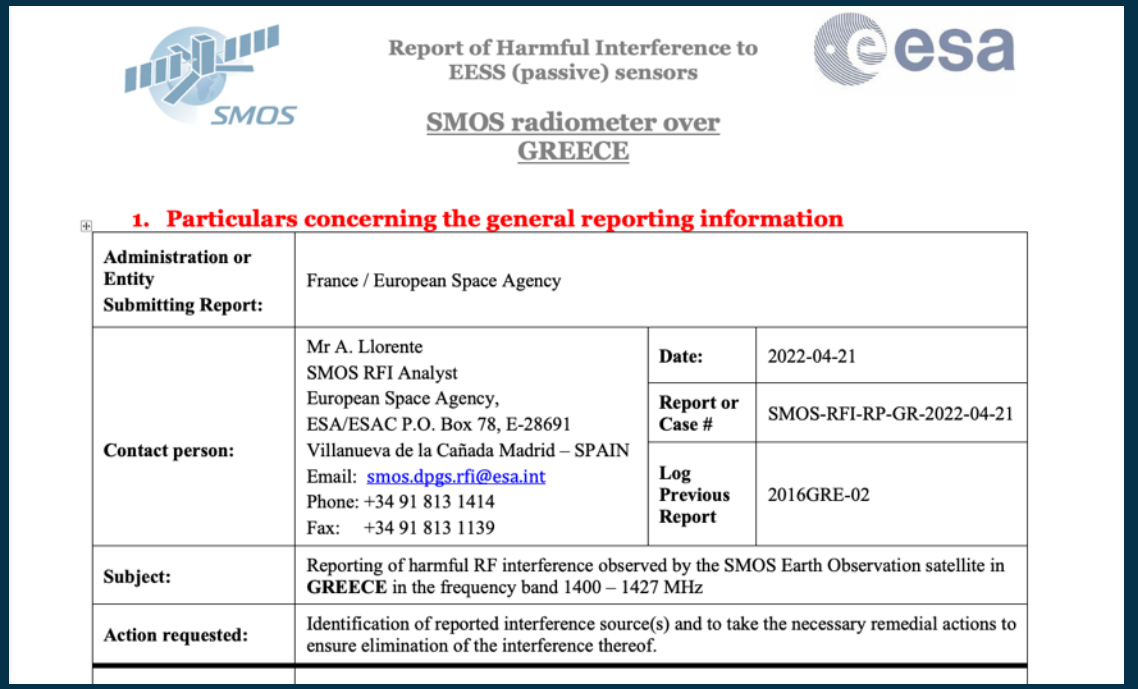




Reporting standarization

- Document template for reporting to National Authorities
- Quarterly summaries of the global RFI situation
- Reporting to the ITU-R SIRSS

(Satellite Interference Reporting and Resolution System)

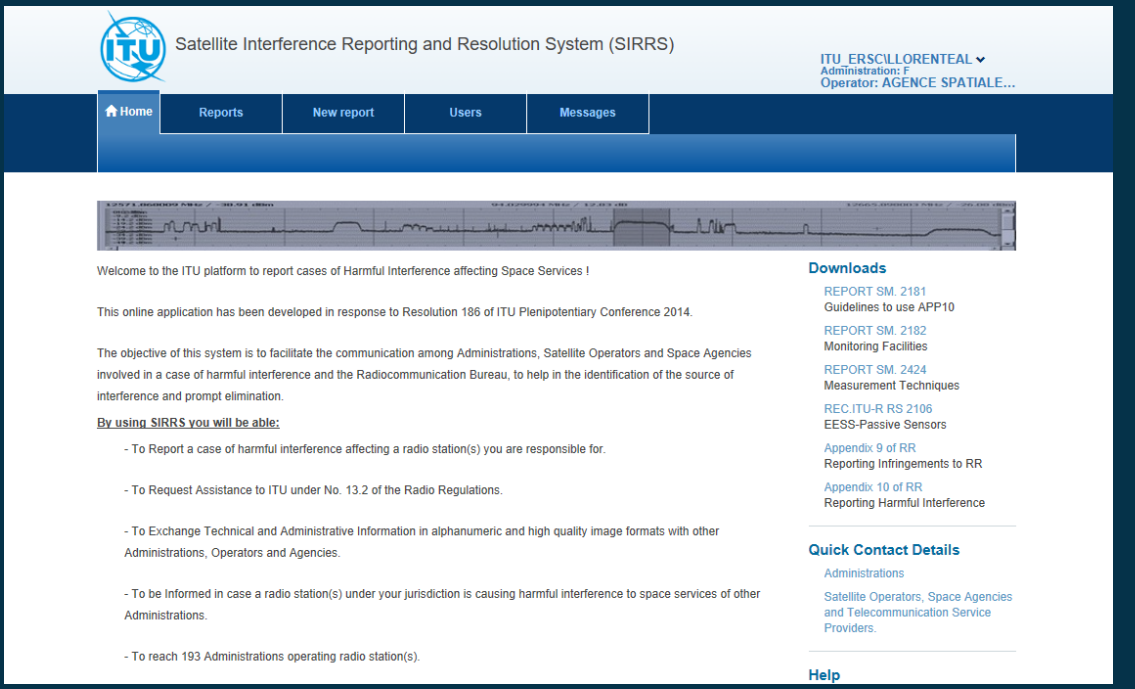


Report of Harmful Interference to EESS (passive) sensors

SMOS radiometer over GREECE

1. Particulars concerning the general reporting information

Administration or Entity Submitting Report:	France / European Space Agency		
Contact person:	Mr A. Llorente SMOS RFI Analyst European Space Agency, ESA/ESAC P.O. Box 78, E-28691 Villanueva de la Cañada Madrid – SPAIN Email: smos.dpgs.rfi@esa.int Phone: +34 91 813 1414 Fax: +34 91 813 1139	**Date:**	2022-04-21
		Report or Case #	SMOS-RFI-RP-GR-2022-04-21
		Log Previous Report	2016GRE-02
Subject:	Reporting of harmful RF interference observed by the SMOS Earth Observation satellite in **GREECE** in the frequency band 1400 – 1427 MHz		
Action requested:	Identification of reported interference source(s) and to take the necessary remedial actions to ensure elimination of the interference thereof.		



Satellite Interference Reporting and Resolution System (SIRRS)

ITU_ERSC\LLORENTEAL
Administration: F
Operator: AGENCE SPATIALE...

Home | Reports | New report | Users | Messages

Welcome to the ITU platform to report cases of Harmful Interference affecting Space Services !

This online application has been developed in response to Resolution 186 of ITU Plenipotentiary Conference 2014.

The objective of this system is to facilitate the communication among Administrations, Satellite Operators and Space Agencies involved in a case of harmful interference and the Radiocommunication Bureau, to help in the identification of the source of interference and prompt elimination.

By using SIRRS you will be able:

- To Report a case of harmful interference affecting a radio station(s) you are responsible for.
- To Request Assistance to ITU under No. 13.2 of the Radio Regulations.
- To Exchange Technical and Administrative Information in alphanumeric and high quality image formats with other Administrations, Operators and Agencies.
- To be Informed in case a radio station(s) under your jurisdiction is causing harmful interference to space services of other Administrations.
- To reach 193 Administrations operating radio station(s).

Downloads

REPORT SM. 2181
Guidelines to use APP10

REPORT SM. 2182
Monitoring Facilities

REPORT SM. 2424
Measurement Techniques

REC.ITU-R RS 2106
EESS-Passive Sensors

Appendix 9 of RR
Reporting Infringements to RR

Appendix 10 of RR
Reporting Harmful Interference

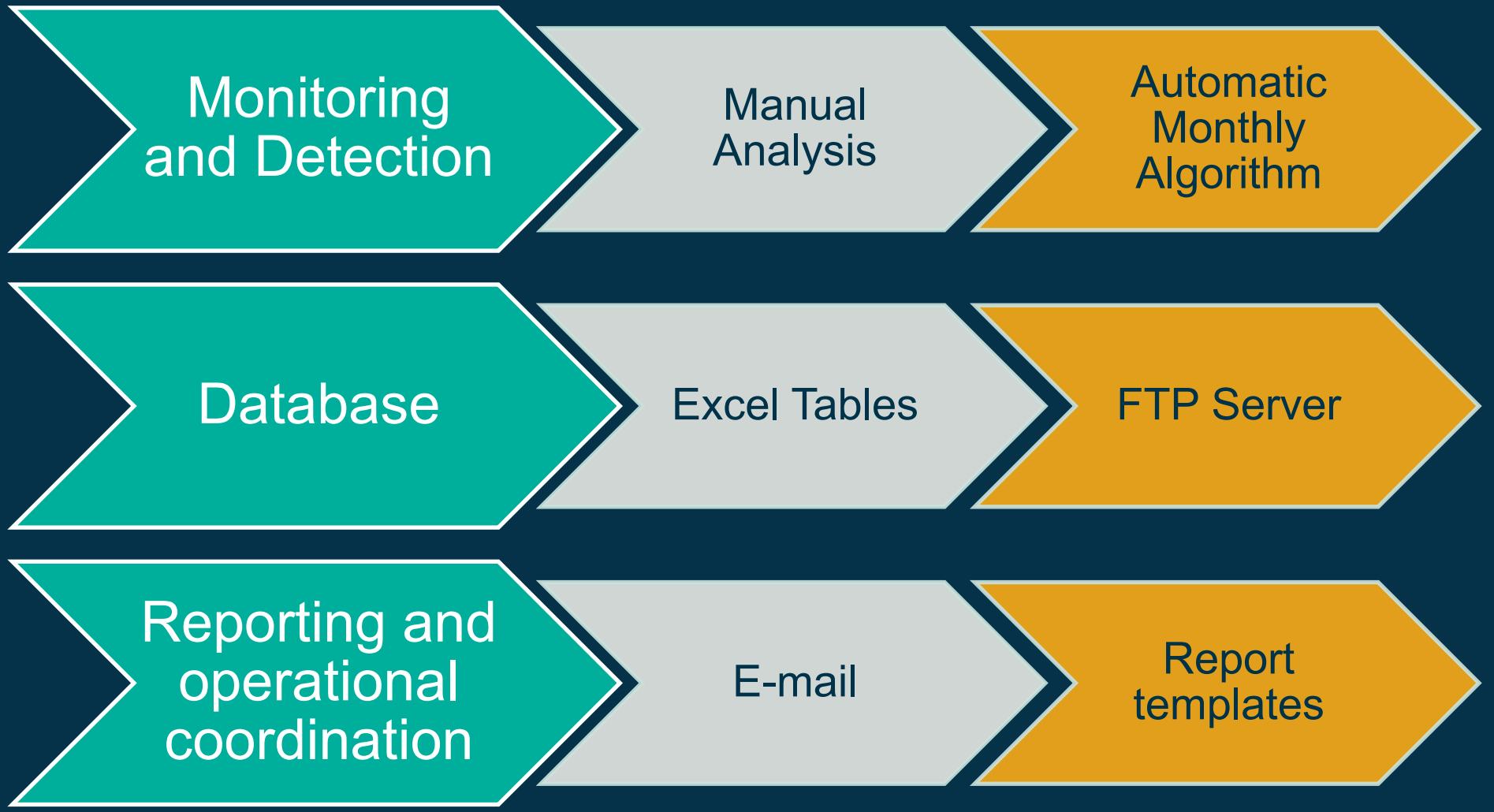
Quick Contact Details

Administrations

Satellite Operators, Space Agencies and Telecommunication Service Providers.

Help

Three branches evolution (II)



All mission data reprocessing

Once the daily automation of RFI detection achieved:

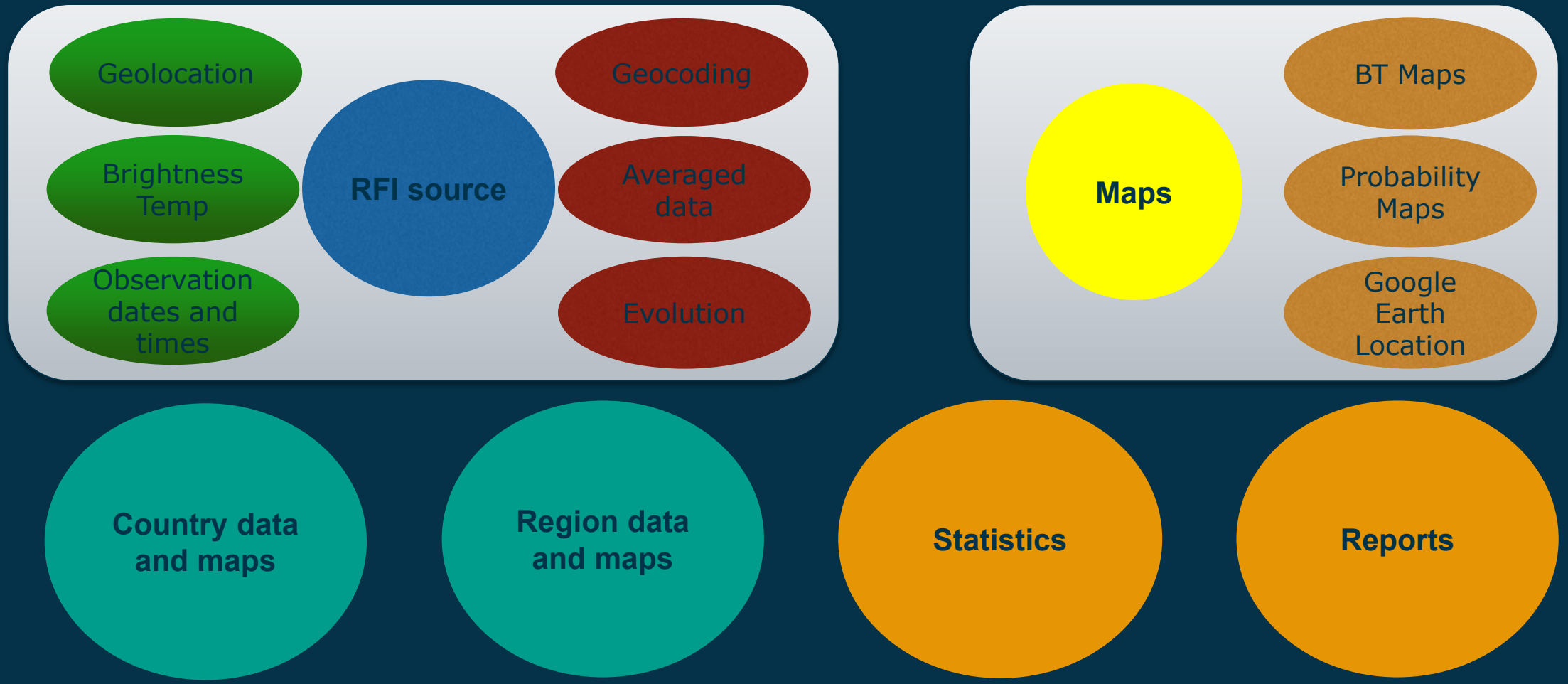
- Data from the beginning of the mission processed.
- Tracking of unique RFI sources to maintain consistency.
- BT and probability maps generation since 2010.
- Statistics recalculation.

HOMOGENEOUS DATA FROM THE BEGINNING OF THE MISSION

- ~8,000 Unique RFI sources
  - Location | Brightness Temperature | Geographical data | Orientation | Averaged data...
- ~800,000 observations
  - Timestamp | Location | Brightness Temperature | Brightness Temperature Map…
- ~4,500 global probability maps
- ~1,200,000 regional probability maps

MySQL Database

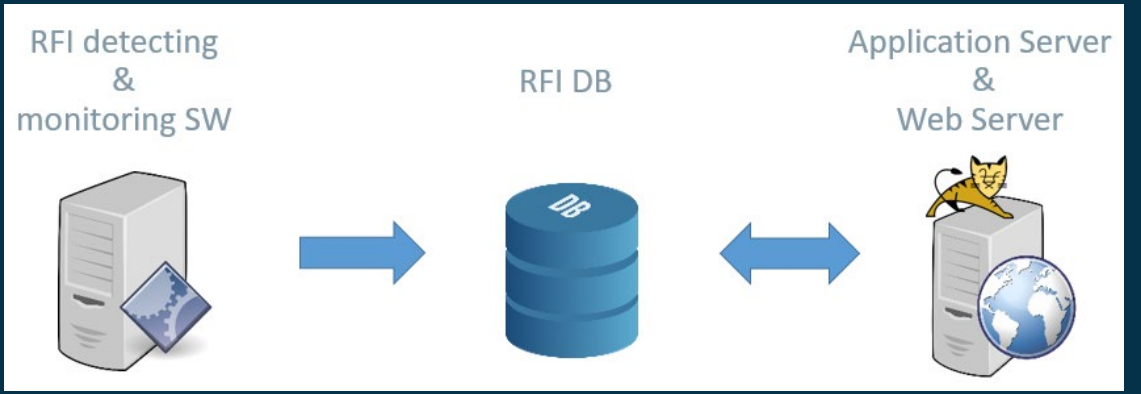
As the number of tools and data has increased, it has been necessary to create a database to store them efficiently.



ERMIT

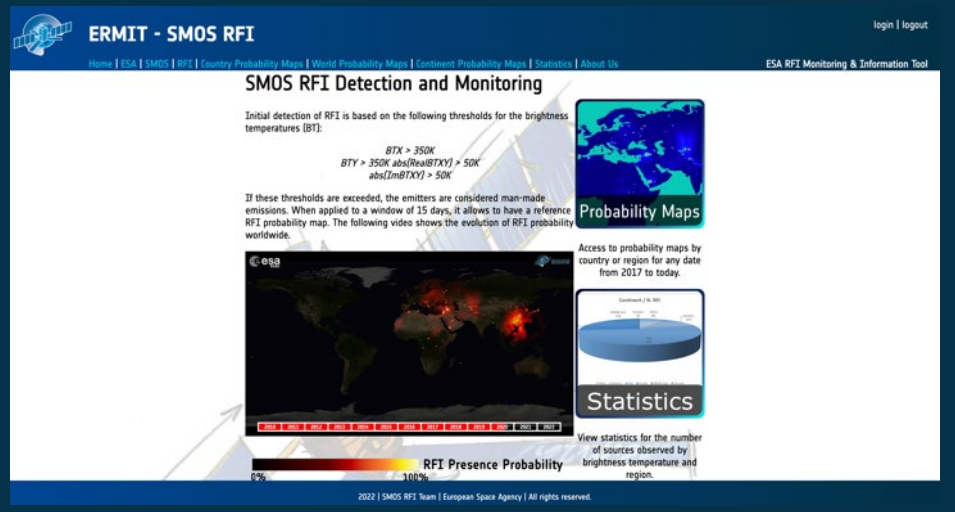
ESA RFI MONITORING AND INFORMATION TOOL

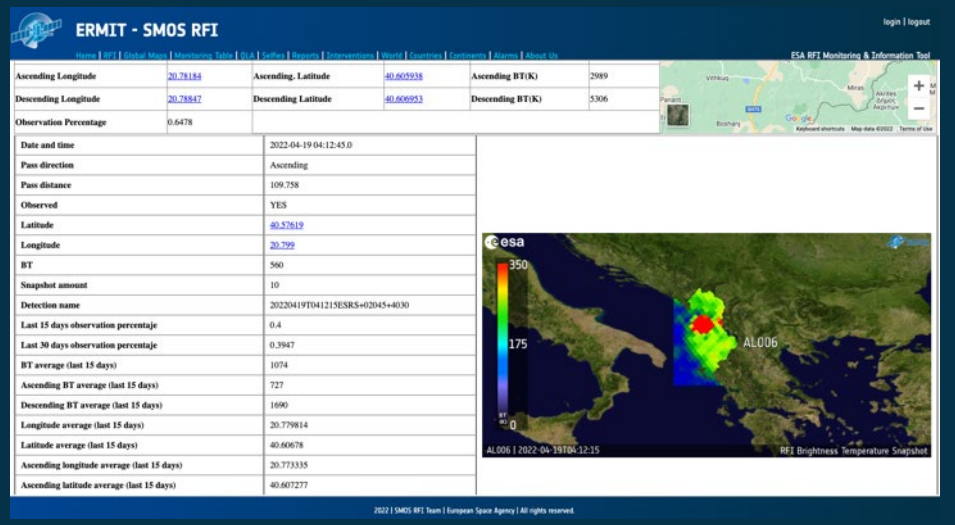
- Manage the information of RFI collected by SMOS
- Made up of 3 parts:
  - RFI detecting & monitoring SW
  - RFI Database
  - Application Server and Web Server
- Different user profiles
  - Public
  - Non-ESA agencies and international organisations
  - ESA/SMOS mission users
  - Admin

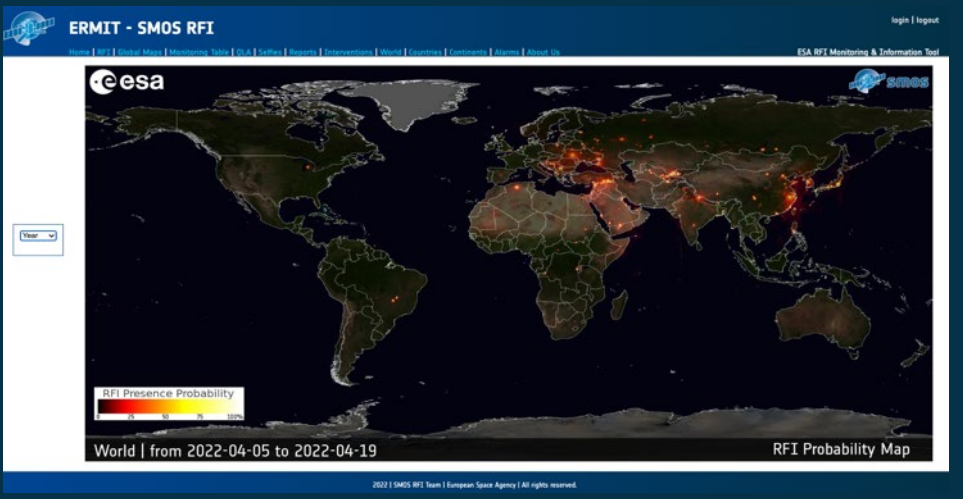


ERMIT website

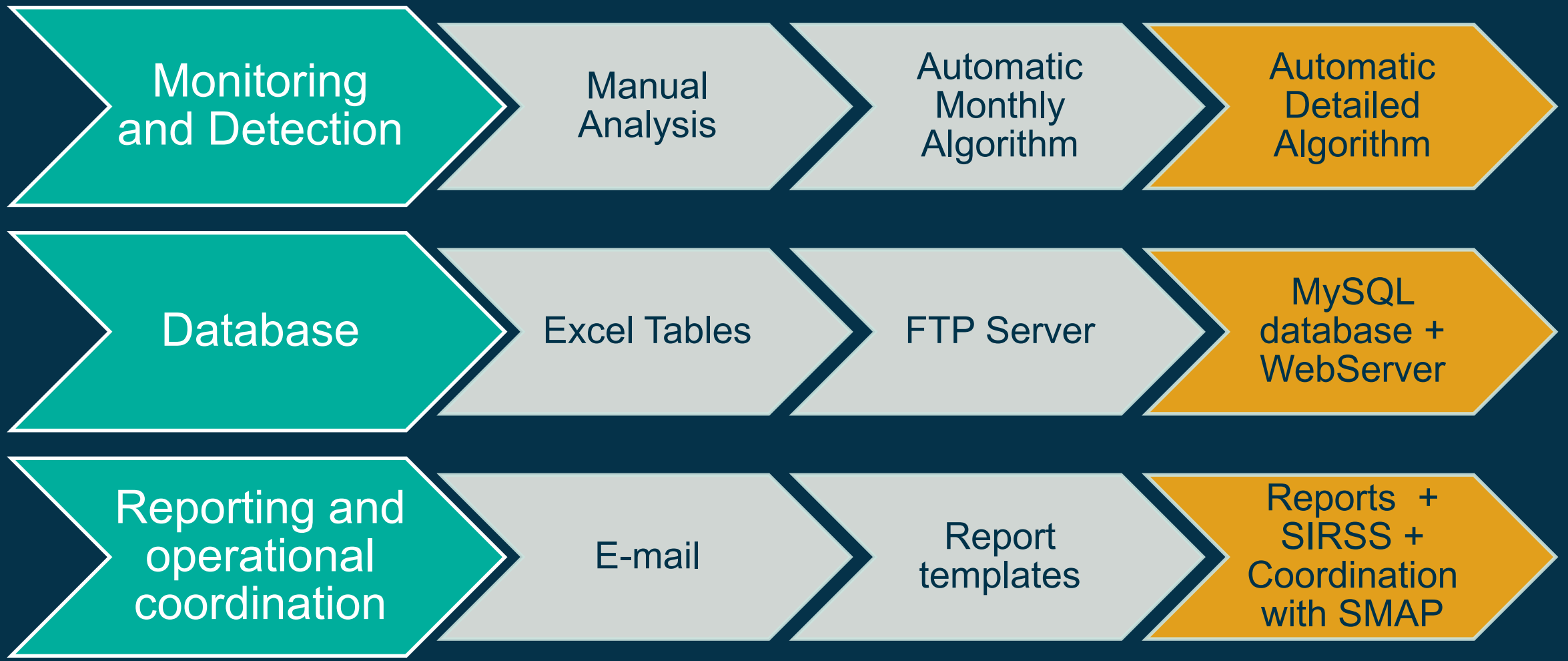
Hosted in a web server at ESAC: **https://rfi.smos.eo.esa.int**







Three branches evolution (III)



Lessons learned and tips for new missions

Minimum recommended requirements

- Systems:
  - 1 internal server for detecting and monitoring software and database
  - 1 internal server for development
  - 1 external server for web server
  - Scalable storage for all the data generated and access to input mission products
- SW:
  - RFI detection algorithm (for daily monitoring)
  - Second independent detection algorithm for checking (ideally should be developed externally)
  - Monthly basis merging algorithm (taking into account the data generated by the 2 algorithms)
  - BT or power maps extraction software
  - Probability maps generation algorithm
  - Other scripts (passes prediction, reverse geocoding, Google Earth pins creation, alarms…)

Lessons learned and tips for new missions

Minimum recommended requirements

- Web application:
  - Public webpage URL
  - Data policy
  - User profiles
- Reporting
  - ITU user for reporting at SIRSS system
  - Documentation templates
  - RFI team e-mail: maintain fluid communication with the National Administrations
- Manpower
  - Dedicated staff for :
    - Initial work to set up all systems and get tools up and running.
    - Software and systems maintenance and upgrades
  - Operations: ~1 FTE for monitoring, follow-up and reporting tasks.

Last but not least

- After a successful mitigation of an interference device by a National Administration, the work is not finished.
- It is very important to try to get the type and model of the interfering equipment.
- Sometimes is provided…. Other times it is not.
- The positive cases have shown us how unexpected and variable are the devices that interfere with SMOS in L band: CCTV camera transmitters, TV amplifiers, CDMA cellular networks, Broadcasting stations…

- Knowing the type of equipment that interferes with our satellite is important to:
  - Assess and report to the national regulator possible illegal market trends that need to be mitigated.
  - Give clues to technicians in the field of other administrations so that they know what type of equipment they are looking for.

Last but not least

For this, we include in all our reports the following simple form:

Annex 1: Information about interference sources after geo-location by National Administration

RFI Identifier: _____

Actual RFI Location (latitude, longitude): _____

Intervention date: _____

Interfering equipment device: _____

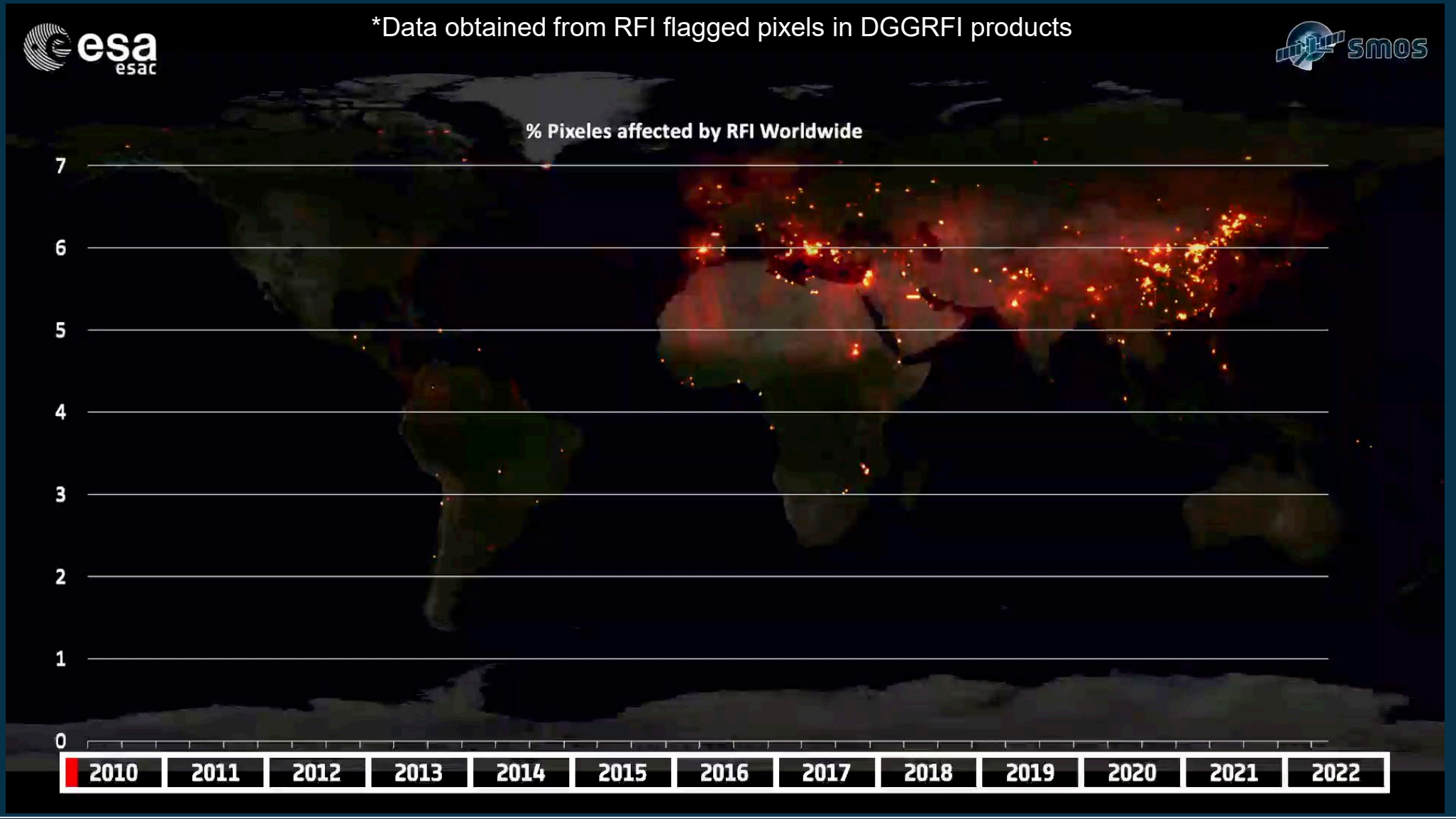
Interfering equipment manufacturer: _____

Interfering equipment model: _____

Any other info: _____

_____

Evolution of the Worldwide RFI scenario



Conclusions

- The experience of SMOS with harmful radio frequency interference these 12 years shows that it is **essential to protect the passive band 1400–1427 MHz** from both in-band and excessive unwanted emissions.

- ESA and the SMOS RFI teams have devoted **considerable resources** to the detection and reporting of interference cases worldwide, with the associated impact in cost, manpower and definition of RFI processes.

- The efficiency of reporting and monitoring of interference has improved remarkably with the development of the tools shown.

- Knowledge of the RFI environment is very important in the design phase of a mission. RFI environment in L-band was unknown before SMOS, but now we have lots of information.

- The lessons learned and the work done with the SMOS mission in the L-band interference issue are fully adaptable and useful for present and **future missions** and applications in **other frequency bands**.

Produced by

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