

# STATISTICS OF INTERFERENT SOURCES IN L-BAND OBSERVED BY SMOS

## DETECTION, REPORTING AND SHUTDOWN OF RFI

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15/02/2022

- Intro
  - SMOS mission overview
  - SMOS and the RFI problem worldwide
  - RFI lifecycle & SMOS RFI Team Tasks
- SMOS RFI
  - RFI in the detection & reporting chain
  - Global Statistics
  - Current Status
- SMOS RFI Reporting
  - Reporting Process
  - Administrations Contacted
  - Reporting Statistics
- Conclusions

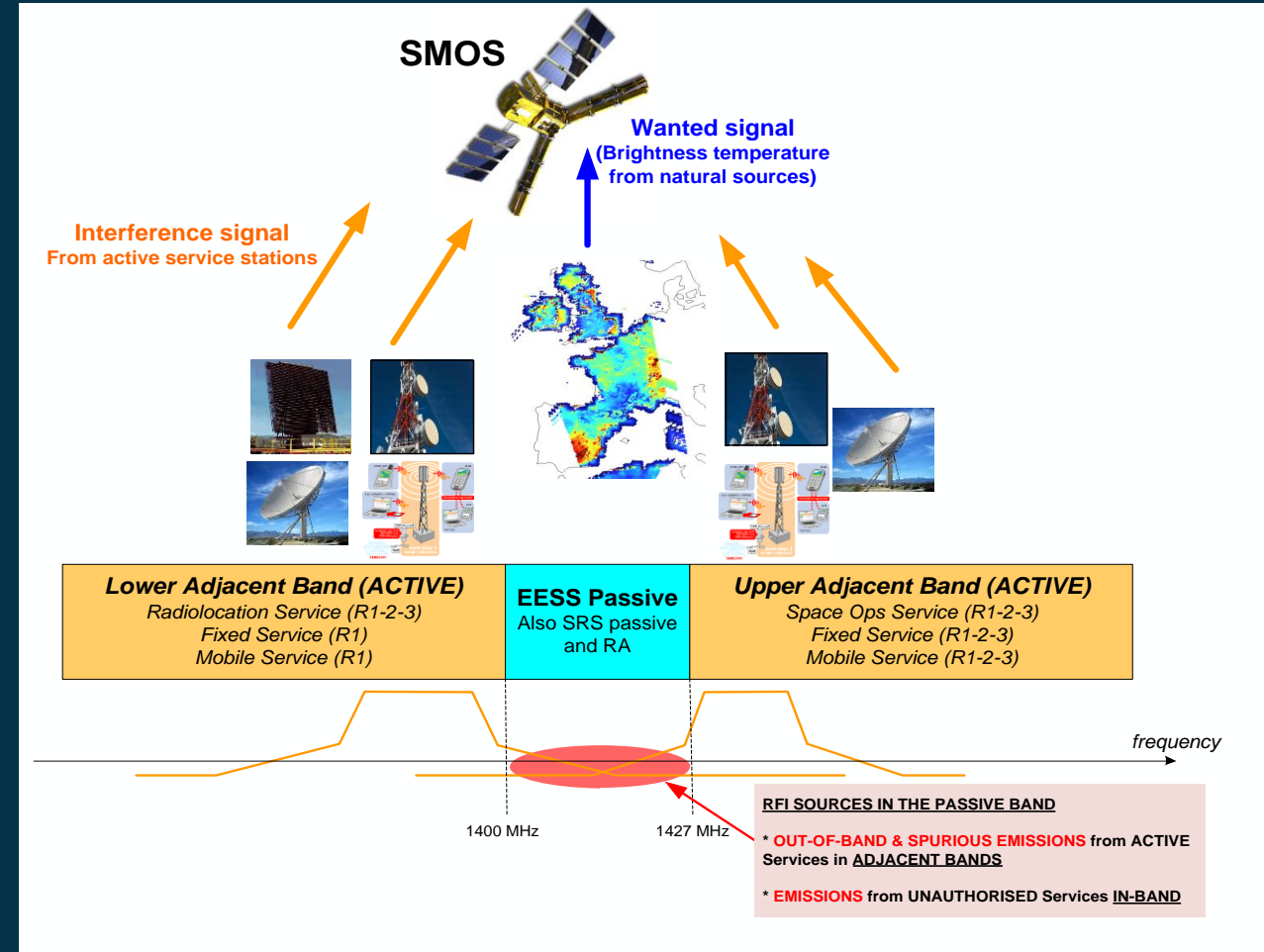
## ESA's Soil Moisture and Ocean Salinity Earth Explorer Mission

- Operated by ESA & CNES
- FOS & DPGS at ESAC (ESA)
- Launched in 2009
- Payload: MIRAS  
2D Interferometric Radiometer



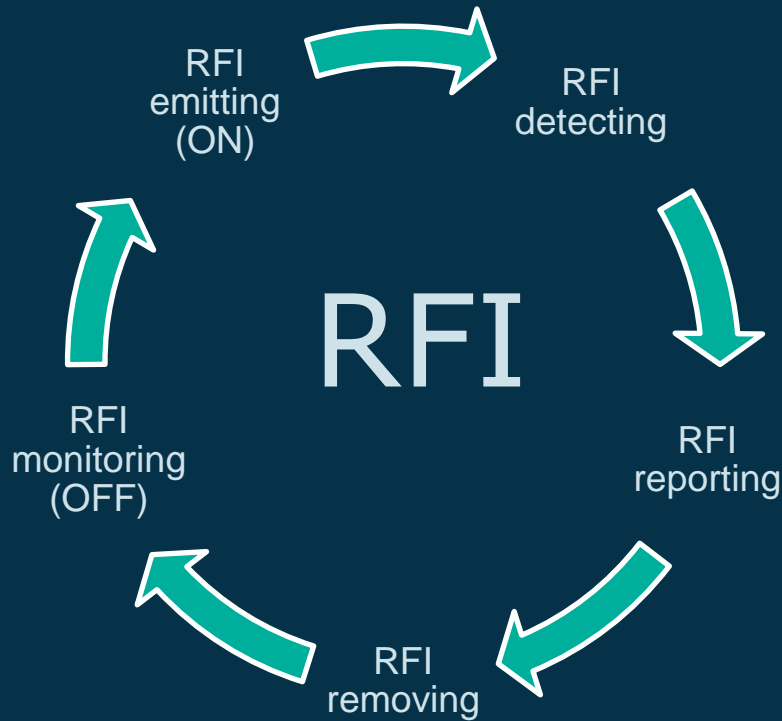
# SMOS and the RFI problem worldwide

- SMOS radiometer operates in the 1400 – 1427 MHz band
- This is a PURELY PASSIVE BAND allocated to the EESS by the ITU-R Radio-Regulations
- ALL emissions are PROHIBITED in this band (RR No. 5.340)
- ... and the maximum unwanted emissions levels from ACTIVE services in neighbouring bands are limited (Res.750)

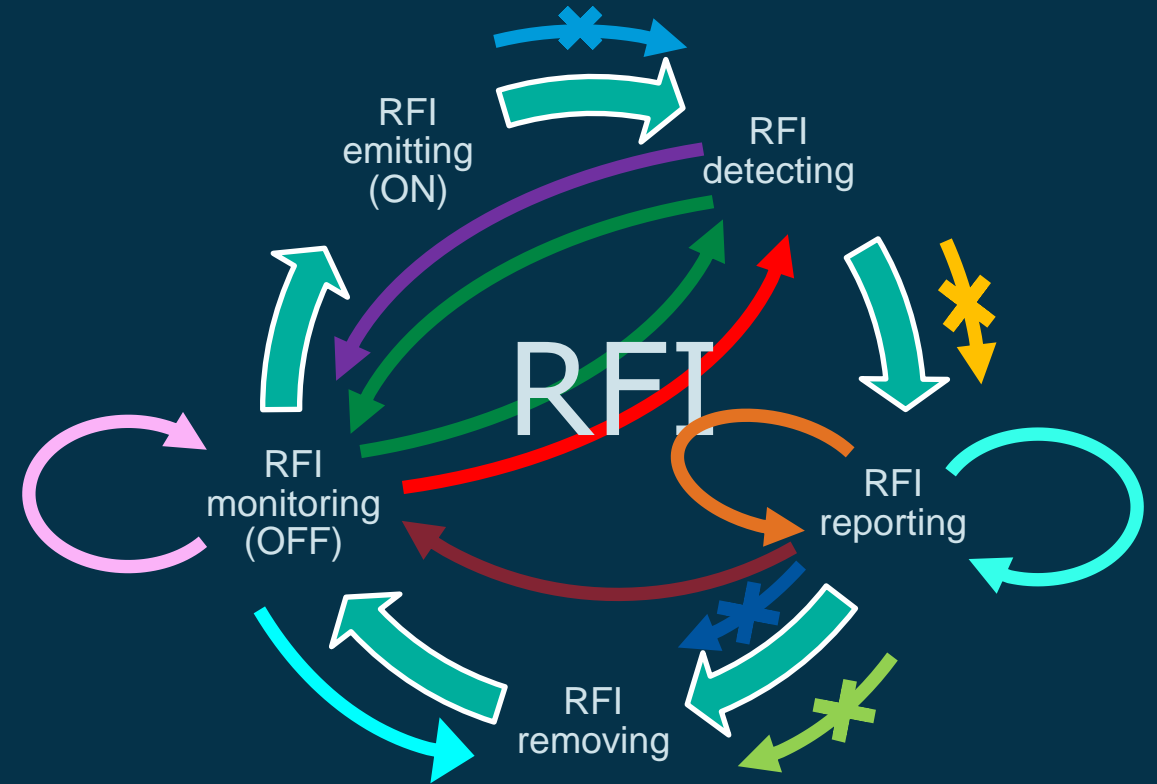


# RFI lifecycle & SMOS RFI Team Tasks

- Detecting
- Monitoring
- Reporting

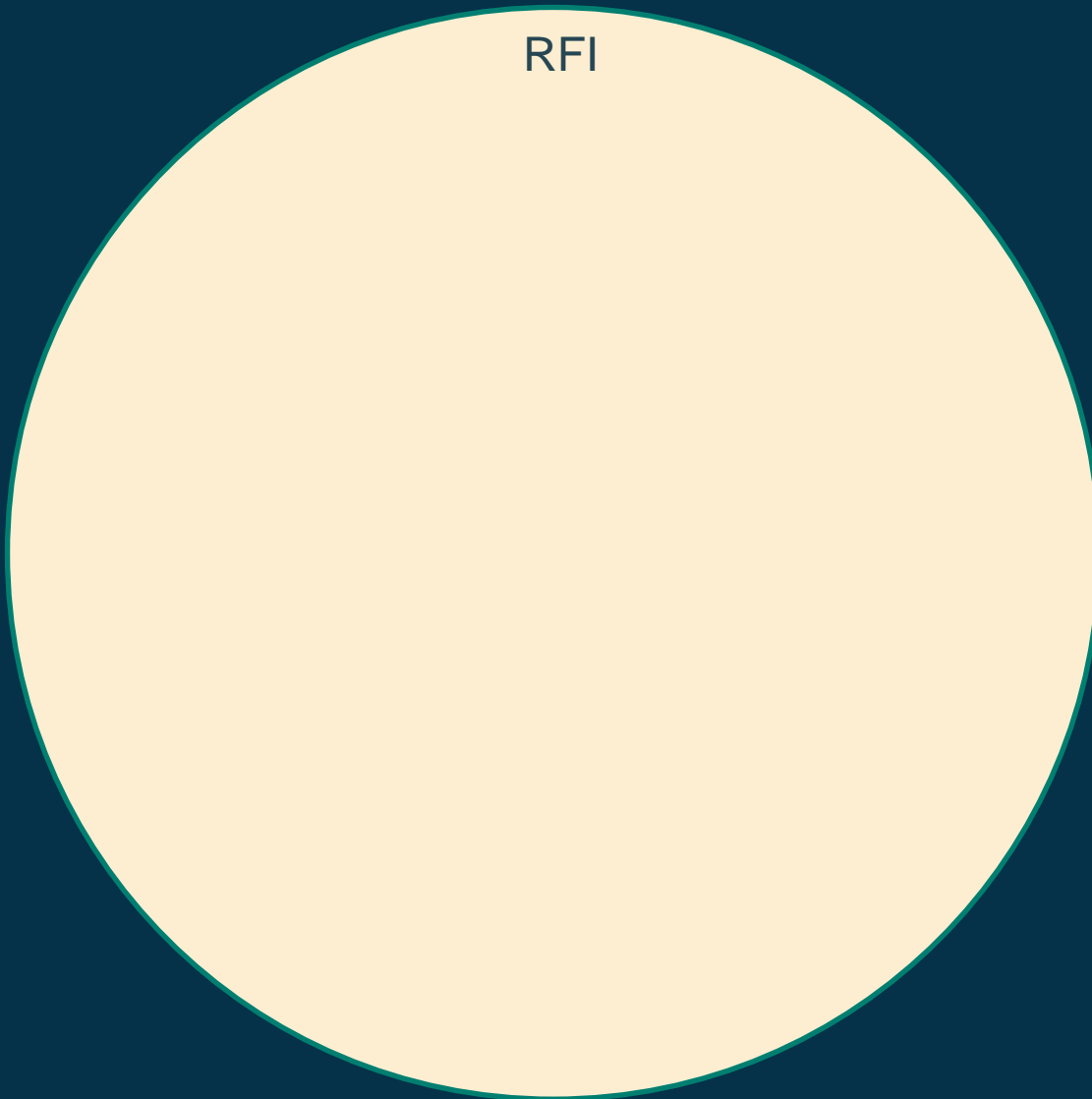


Naïve RFI Lifecycle

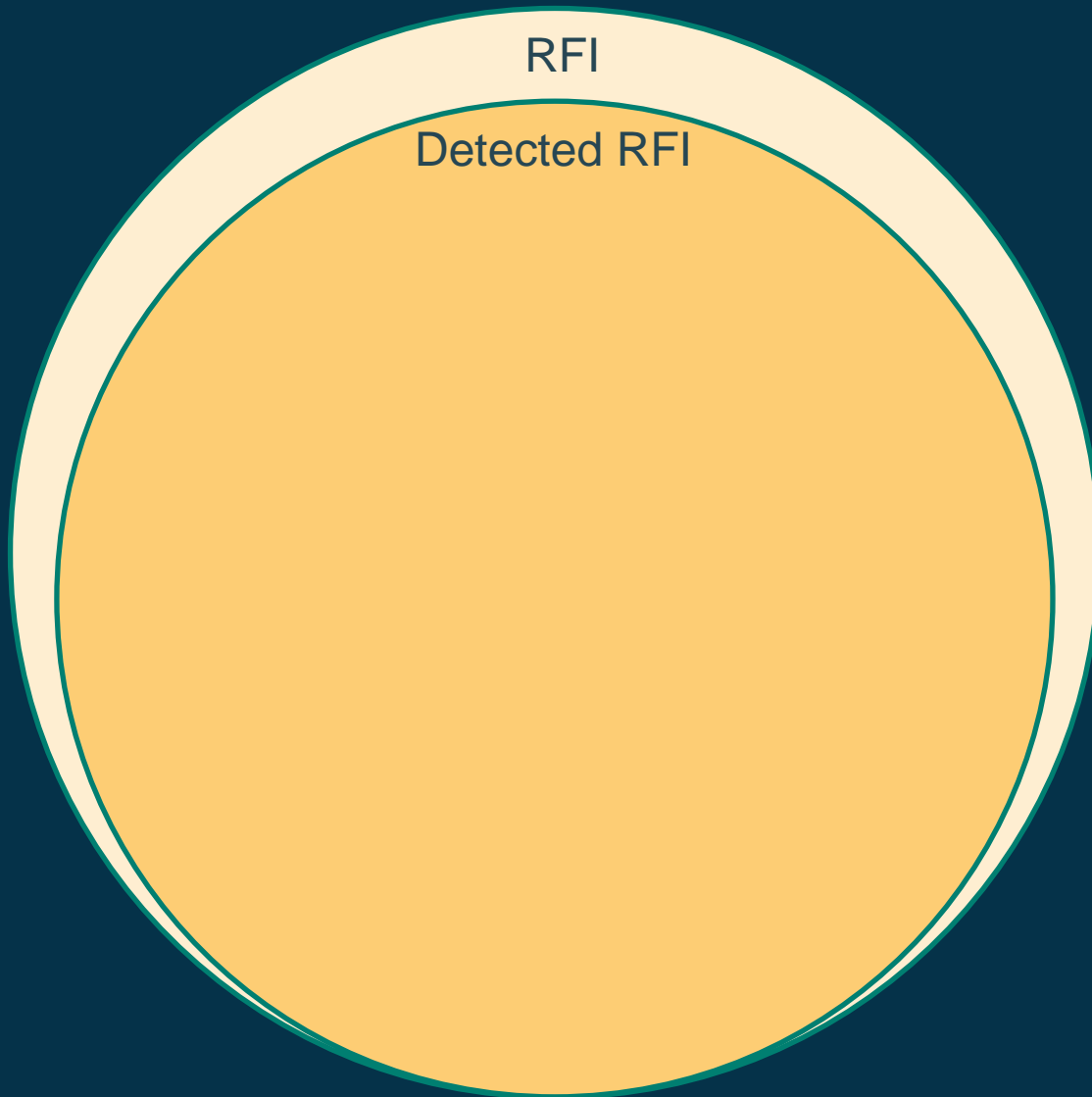


Actual RFI Lifecycle

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- **1400 – 1427 MHz band**
- **Detected and non detected by SMOS**
- **Undetermined and variable number**



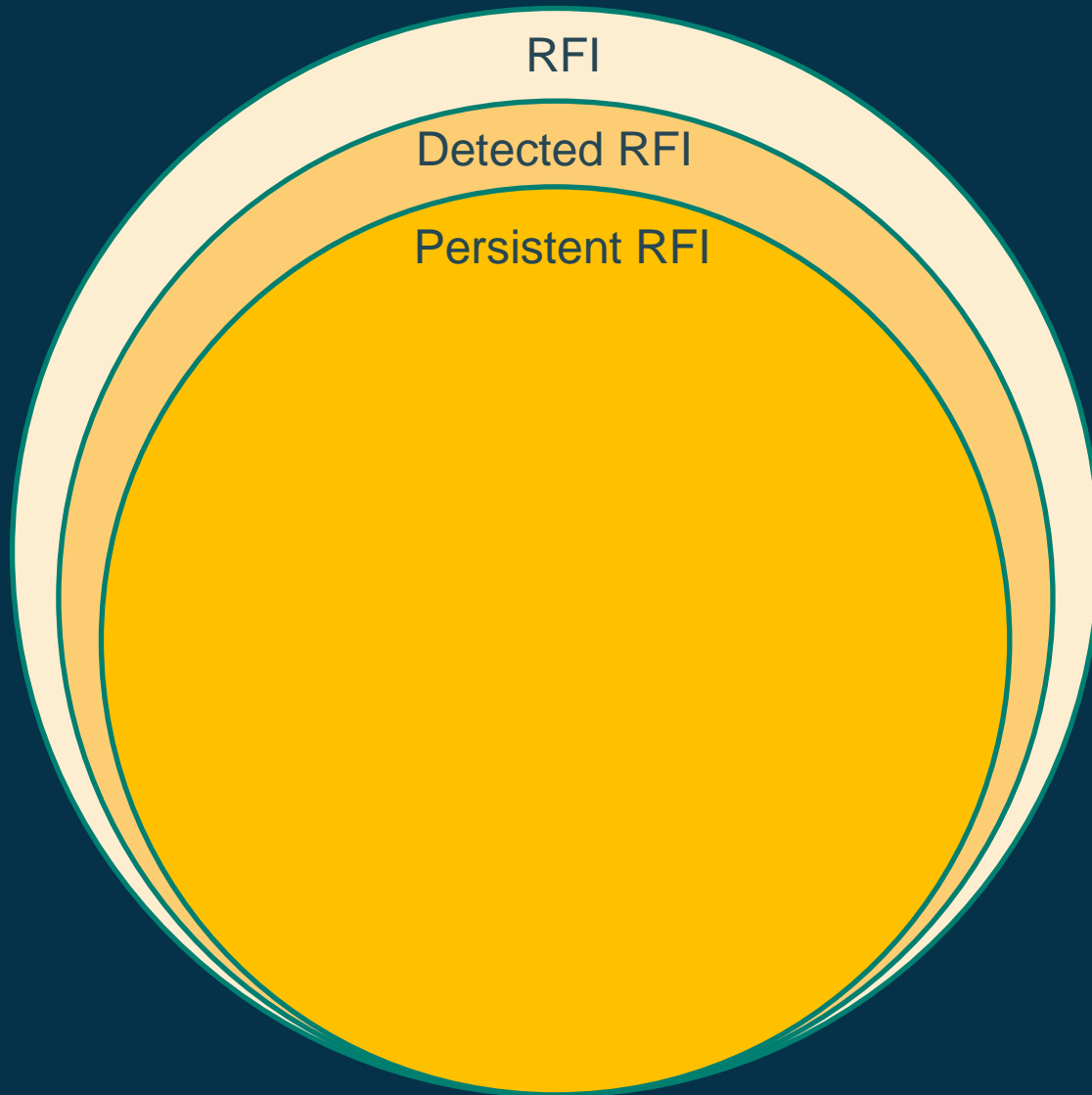
## SMOS ESAC RFI SW

- **BT detection Thresholds**

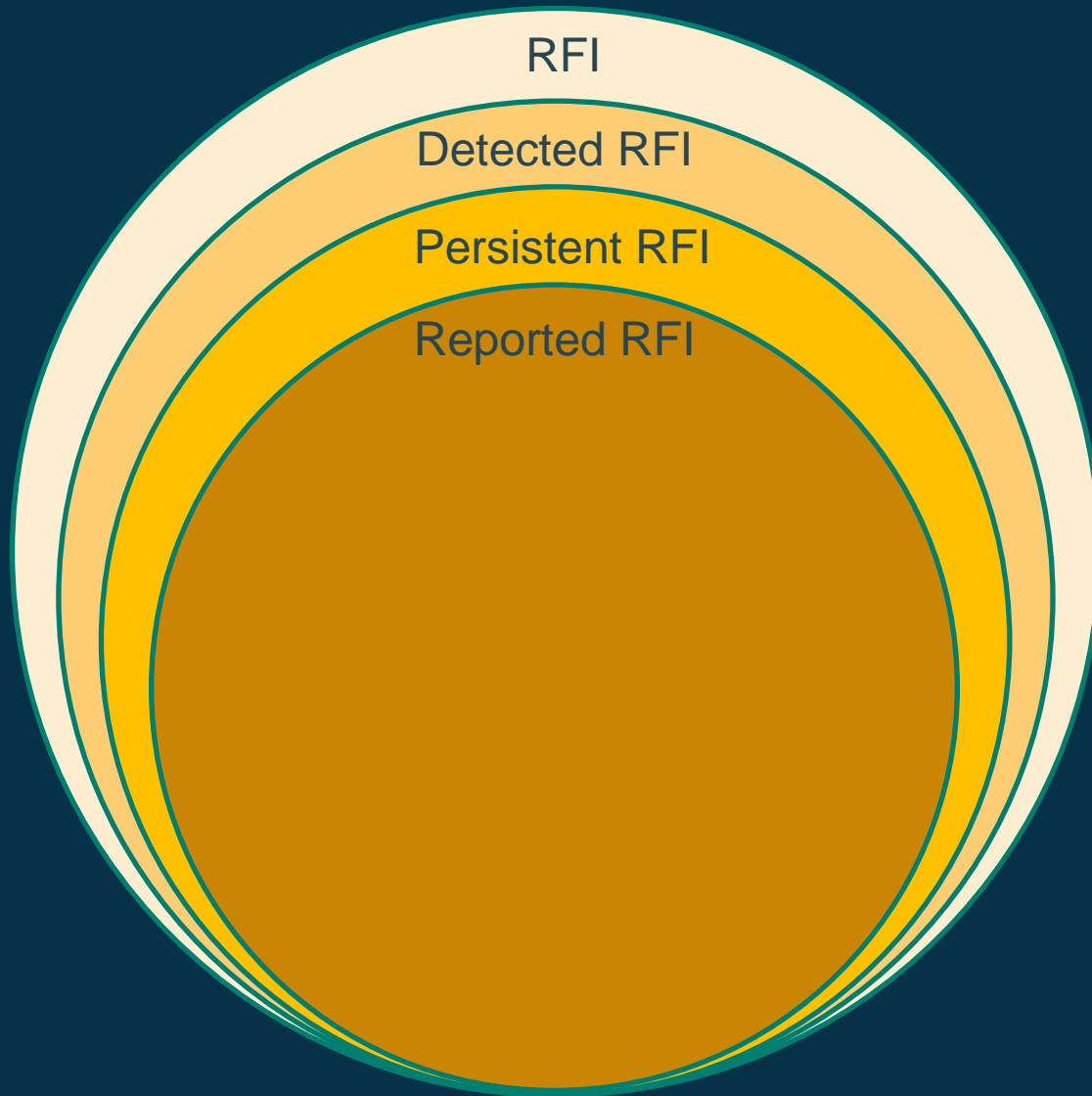
$BT_X > 350 \text{ K}$   
 $BT_Y > 350 \text{ K}$   
 $abs(RealBT_{XY}) > 50 \text{ K}$   
 $abs(ImBT_{XY}) > 50 \text{ K}$

- **Probability Threshold**

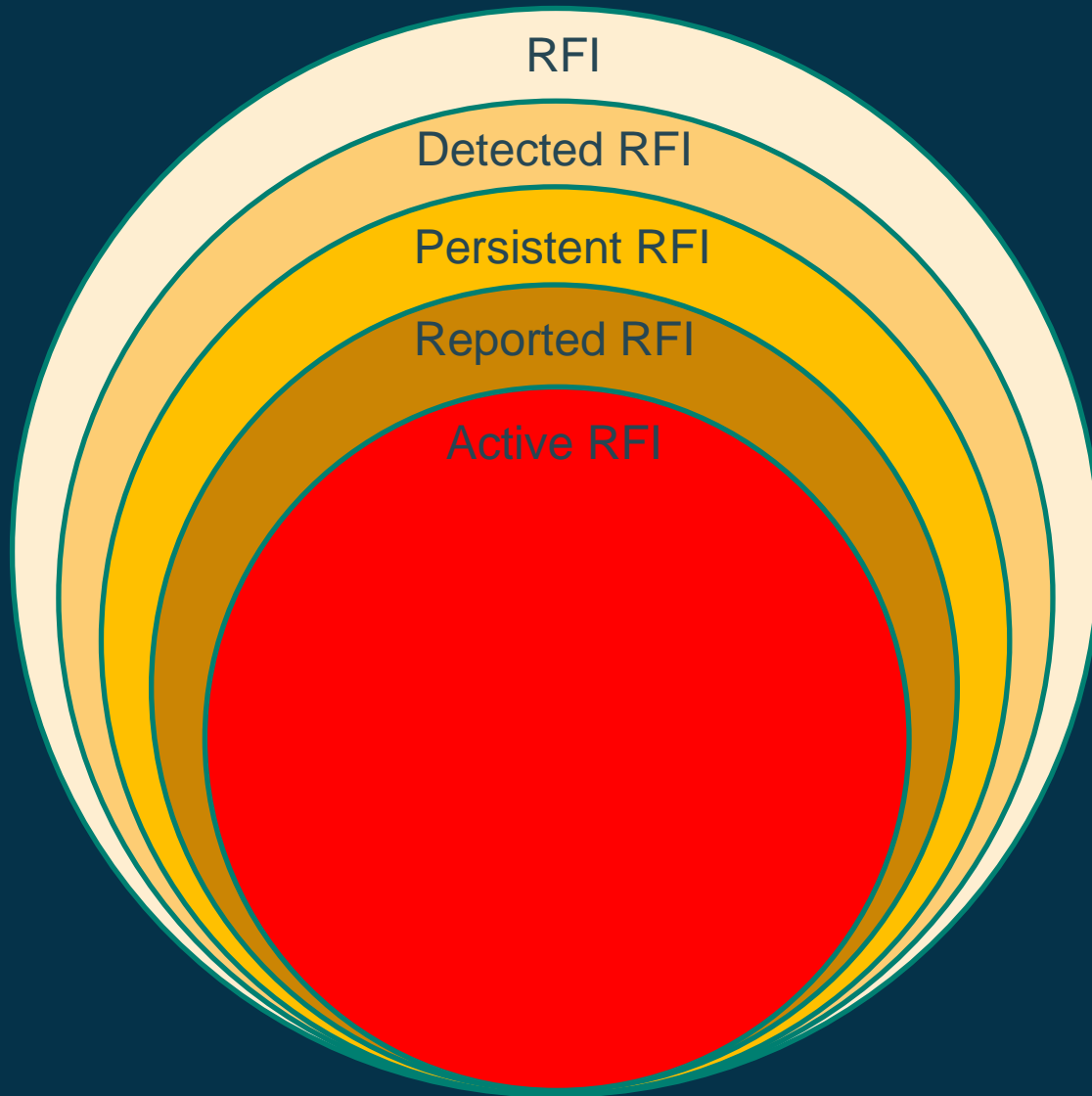
min prob. (%): 25



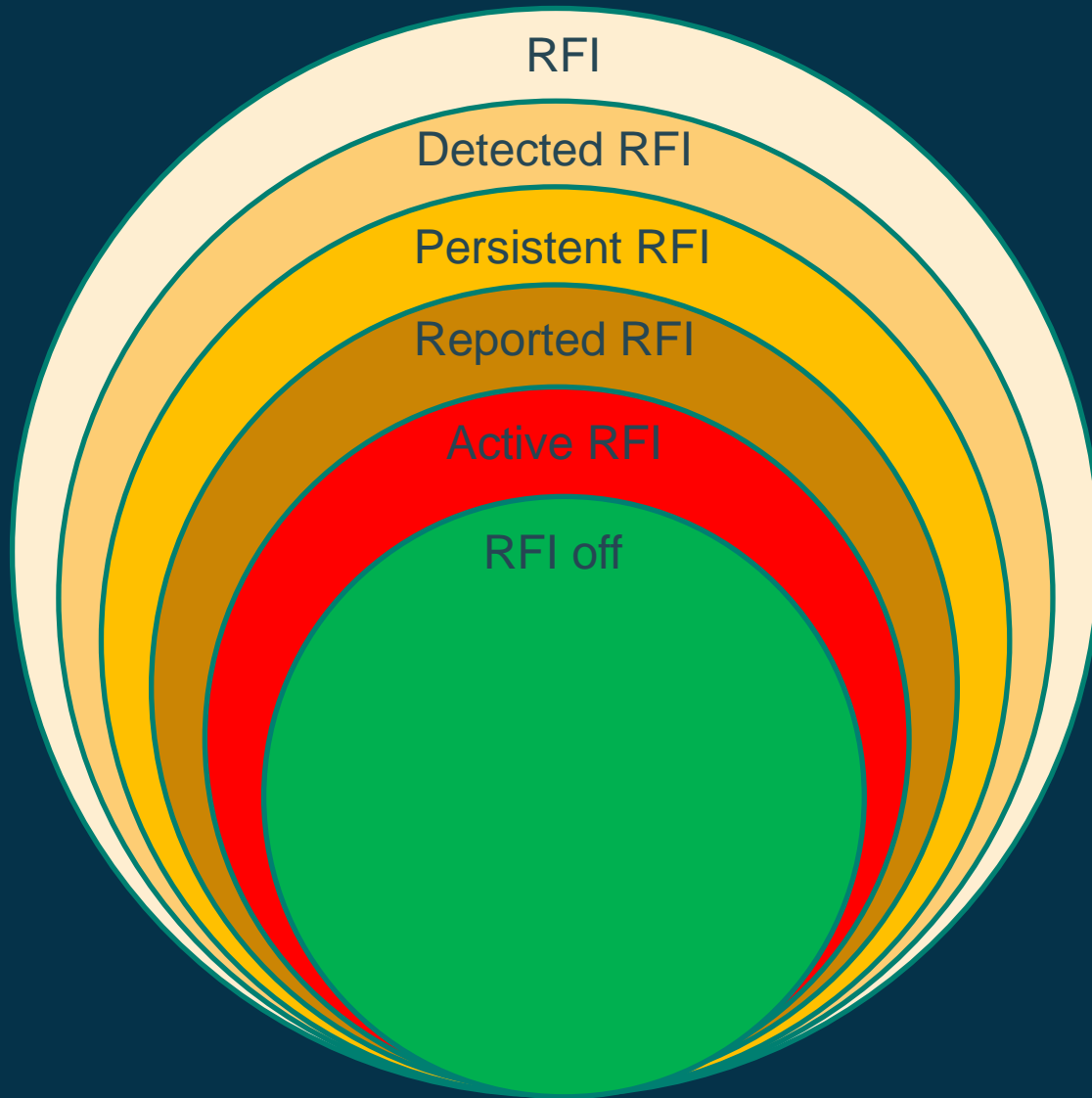
- **Transient RFI**
- **Persistent RFI**



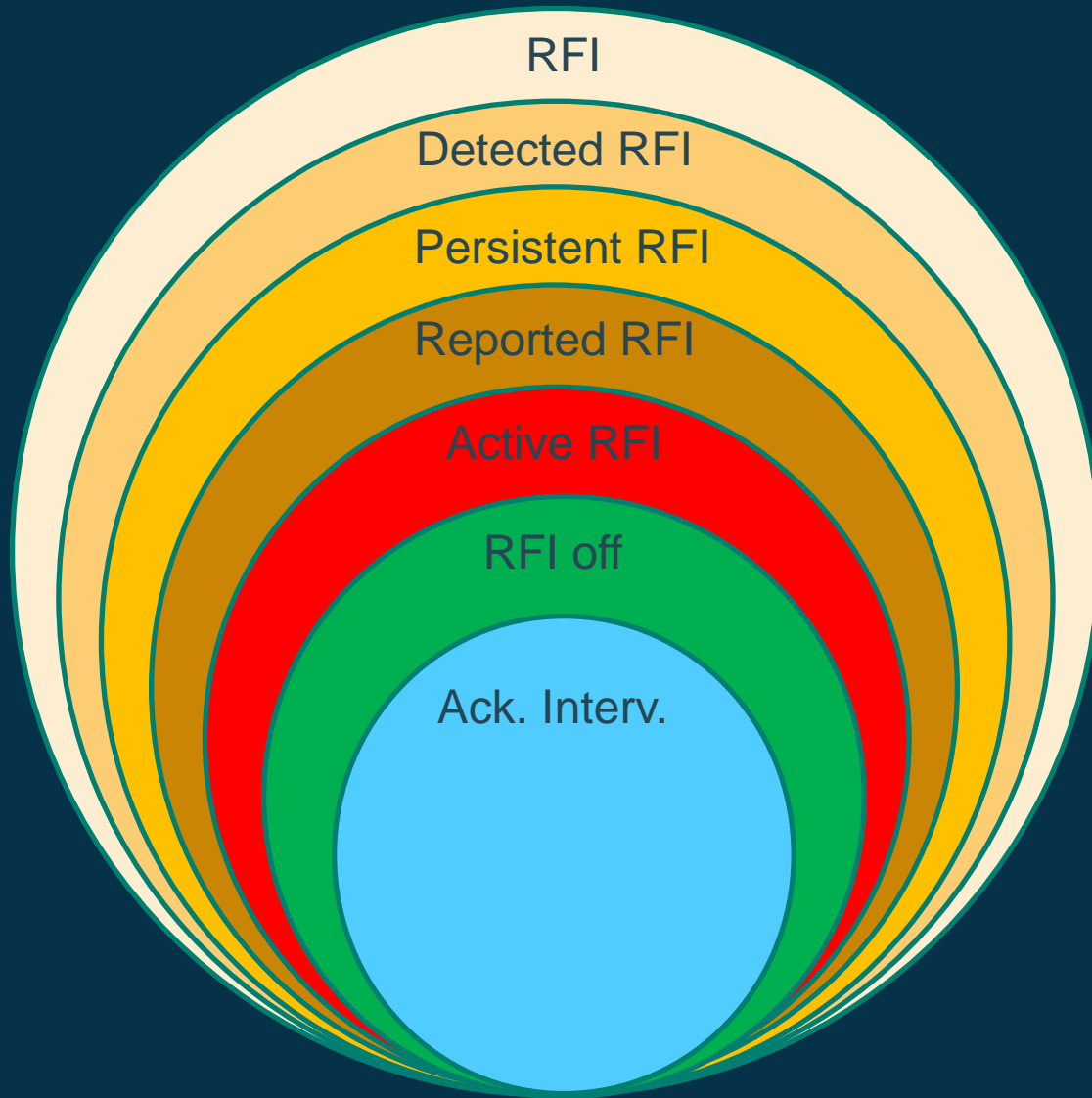
- **Reported RFI** according to mission impact & defined priorities **with SMAP**
- **RFI pending to report:**
  - Political instability, war zone
  - Low visibility frequency
  - **Low** Mission impact
  - RFI Team limited resources
  - **Not** Expected feedback from Administration
  - ...



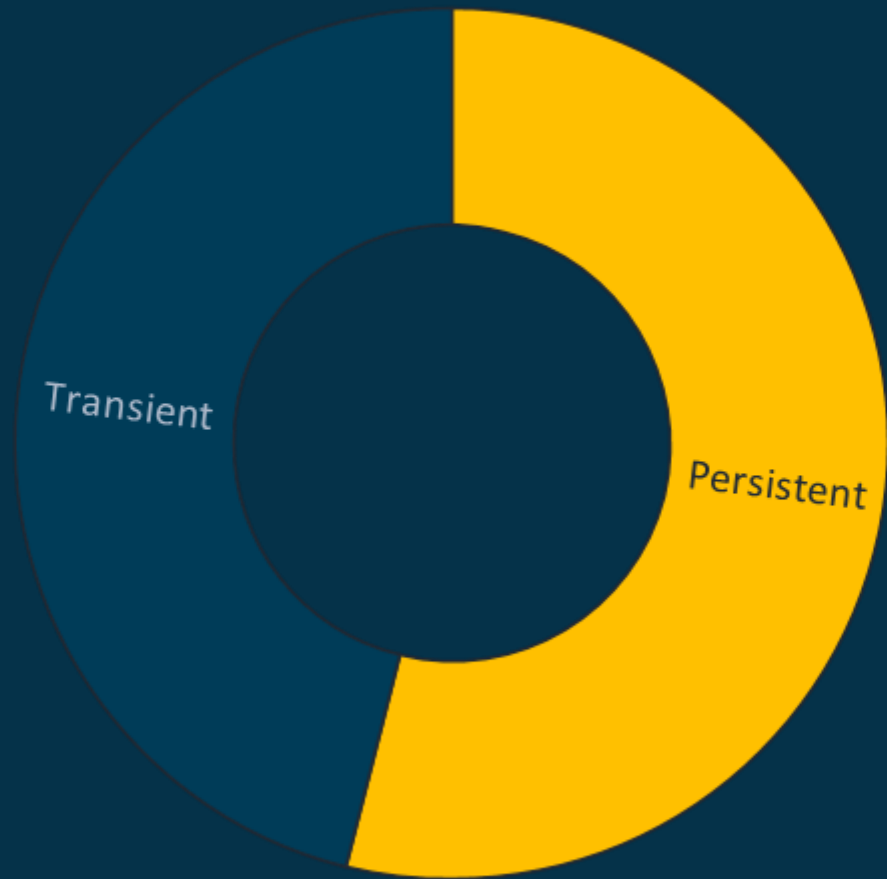
- **Reporting inactive RFI**
  - **Feedback to National Administrations after intervention**
  - **No feedback from National Administrations before new reporting**



- **Goal RFI team: every active RFI, OFF after reporting**
- **Sometimes our mission is not accomplished...**
- **...sometimes it is...**



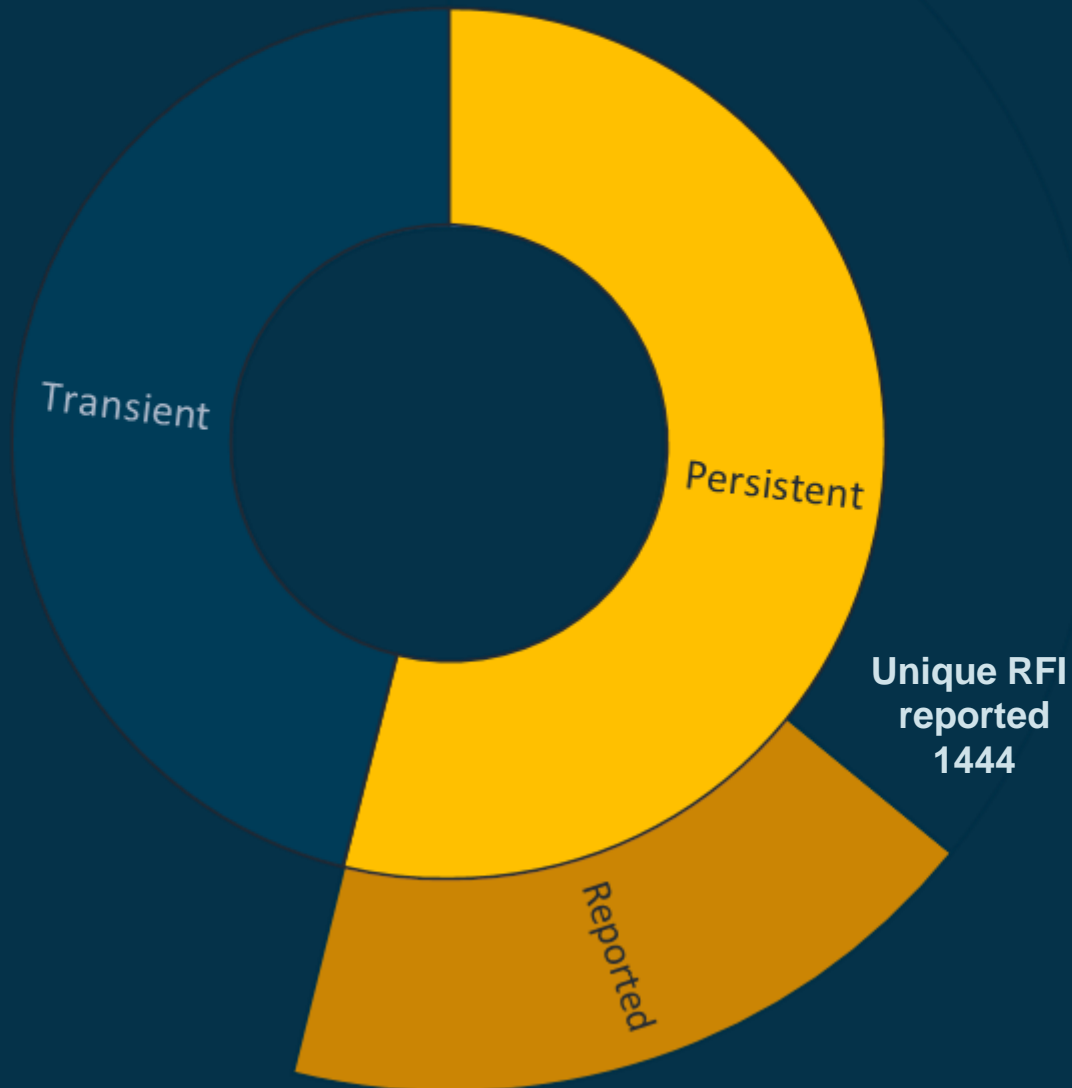
- ...and **sometimes jackpot!**
- **Intervention Acknowledged by Administration**
  - **Best case:**
    - RFI off
    - RFI info from Admin
  - **SMOS RFI Team full success!**
  - ...but let's see...



- **Total number of RFI detected: ~ 8 000**
- **Transient vs. Persistent RFI**  
**15 days,  $\geq 3$  passes**
- **Statistics Persistent RFI**  
**4323 throughout SMOS mission (>12 years)**

**Transient RFI**  
3704  
46%

**Persistent RFI**  
4323  
54%

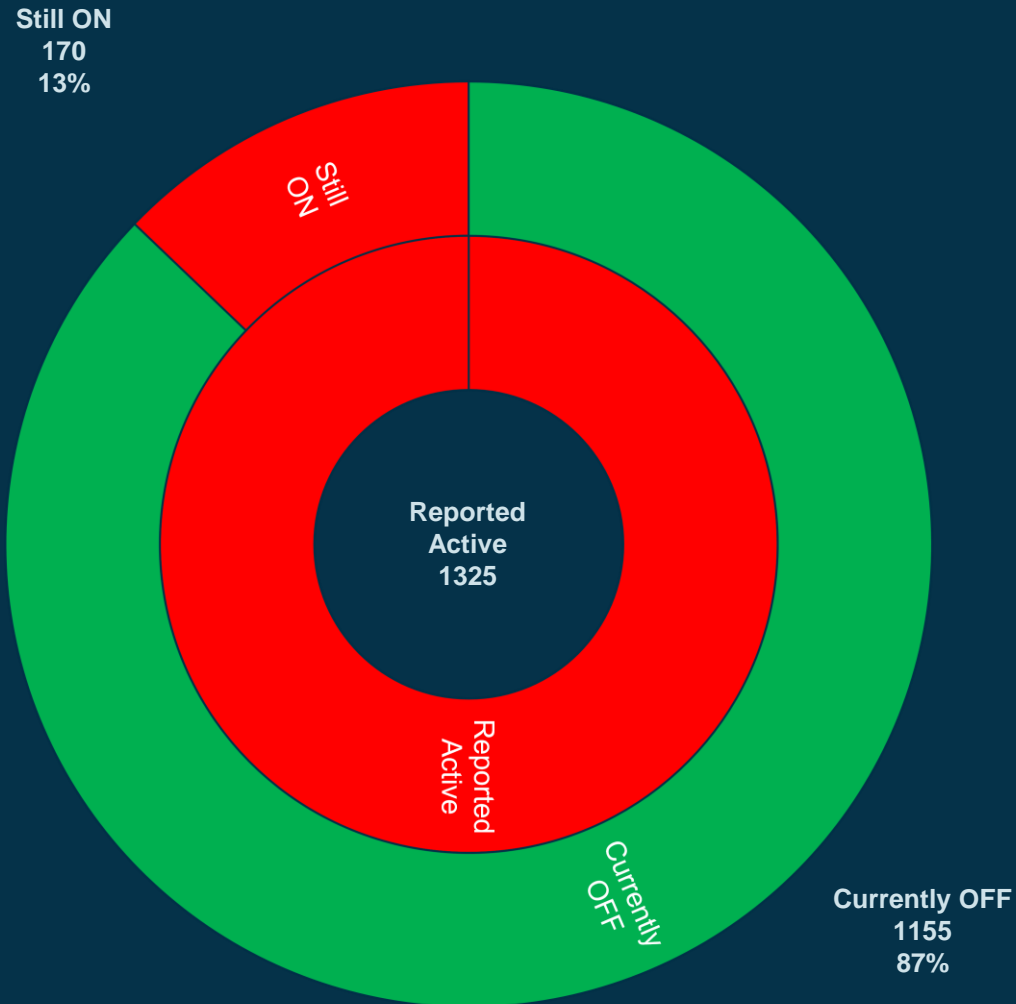


- **Reported RFI**

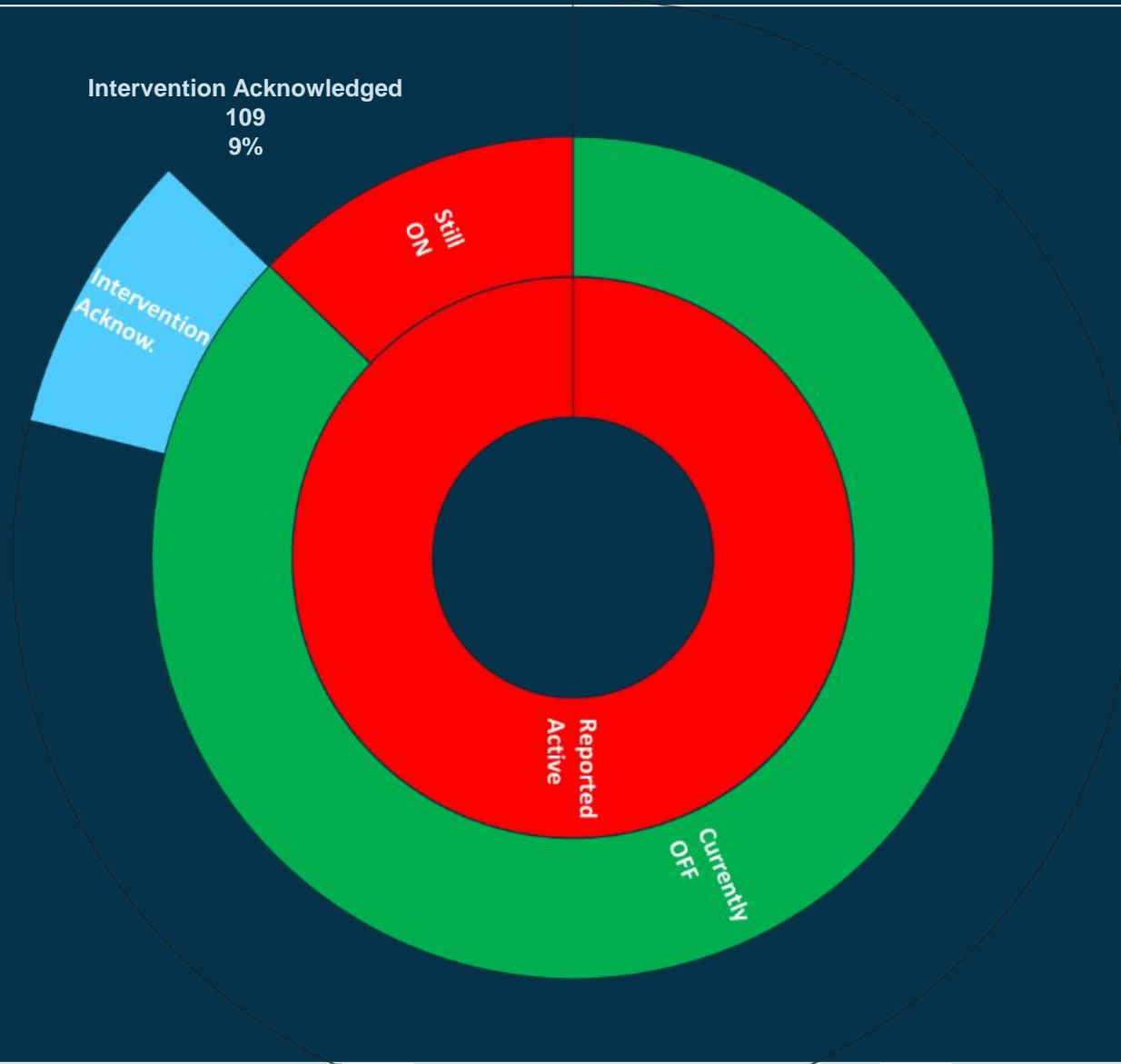
- **3414 non unique RFIs reported**
- **1444 unique RFIs reported**
- **An RFI is reported ~2.4 times**

- **RFI pending to report**

- **Selection RFI to report by affected polluting area, visibility frequency, BT (easier to geo-locate) , admin commitment.**
- **Located in countries at war, conflict zones, politically unstable regions, etc.**
- **Hidden by very strong RFIs only detectable after reporting and intervention by Admin.**
- **Persistent RFIs can vanish: OFF before reporting**
- **Limitations SMOS RFI Team**



- **OFF after reporting 87%**
- **Still ON 13%**
  - Administration did not geo-locate RFI on field
  - RFI geo-located by Admin but RFI not switched off
  - Admin did not take any known action to geo-locate RFI



- **Information of most vanishing RFI (91%) not retrieved from National Administrations**

**Administration policy, classified information, military official secrets, etc.**

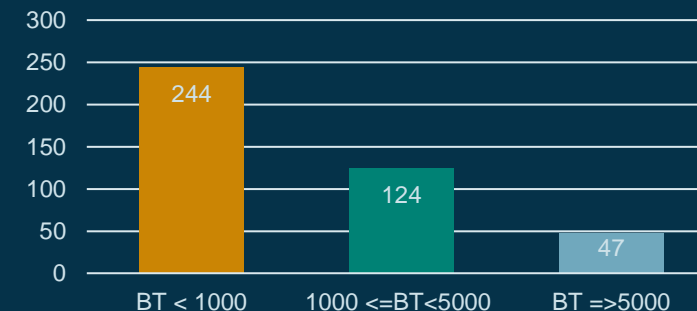
**Opaque National Administrations**

- **But for 109 sources we have got feedback from administration → **very interesting information!** (devices, geo-location accuracy, etc.)**

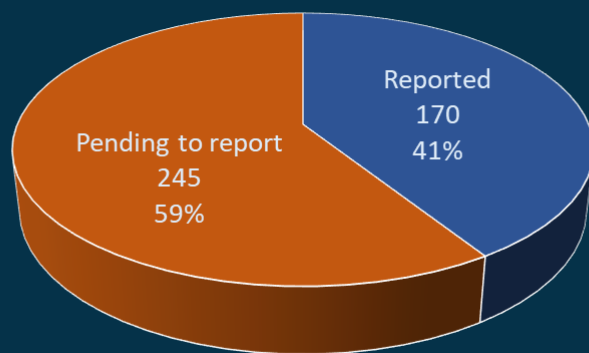
## Statistics Persistent RFI

- 4323 throughout SMOS mission (>12 years)
- Status 2021-12-31: 415 active RFI

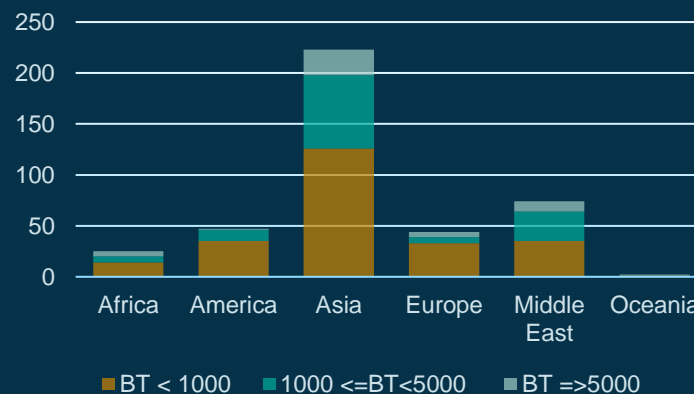
### N. RFI / Strength



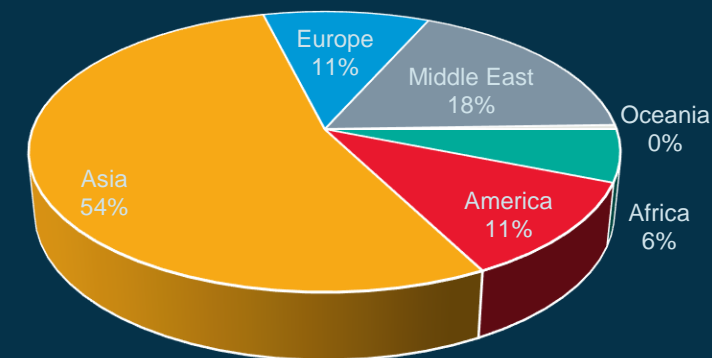
### Active on 2021-12-31



### N. RFI / Strength/ Continent



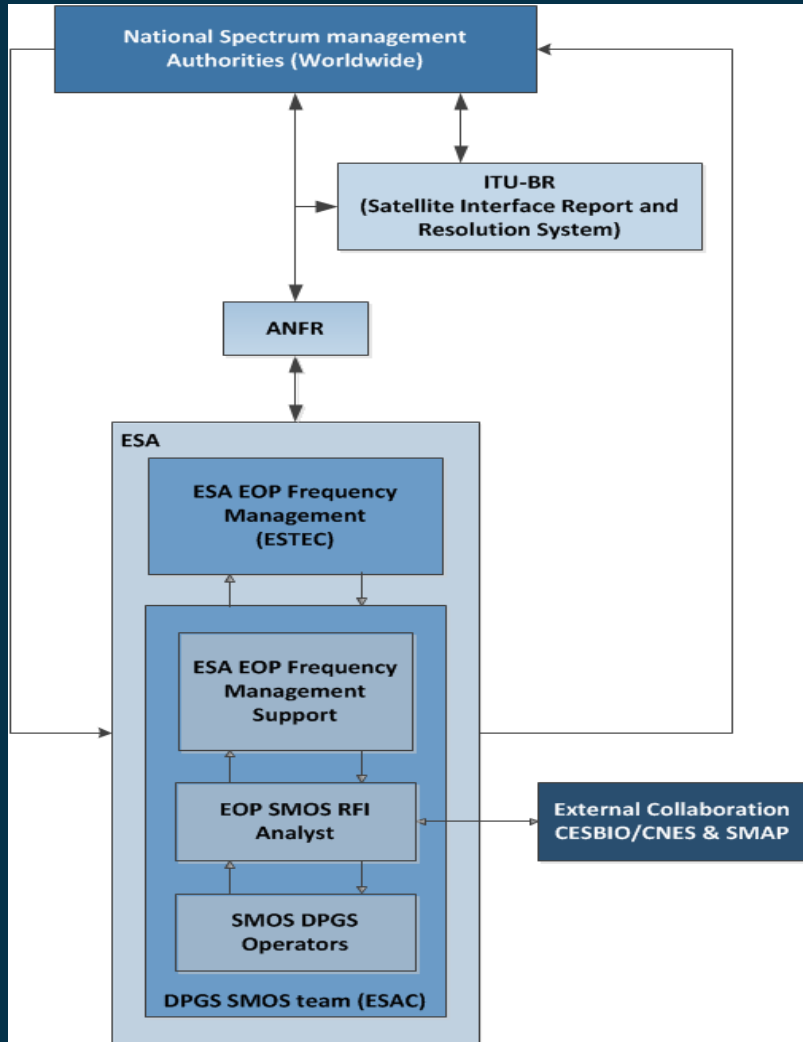
### Continent / N. RFI



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# SMOS RFI Reporting: Reporting process

## SIRRS



Case ID	Affected Adm	Operator	Affected Station	GSO Long.	Implicated Adms	Status	Date of receipt	BR Request	Last modification
F2019-20946	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		COD, F	Published	16/09/2019 9:53 (GVA)	📄	16/09/2019 9:53 (GVA)
F2019-19381	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		BGD, F	Published	20/08/2019 11:41 (GVA)	📄	20/08/2019 11:41 (GVA)
F2019-19380	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		F, KWT	Published	20/08/2019 11:18 (GVA)	📄	20/08/2019 11:18 (GVA)
F2019-18923	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		F, PAK	Published	20/08/2019 10:39 (GVA)	📄	20/08/2019 10:39 (GVA)
F2019-18630	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		F	Published	17/07/2019 9:44 (GVA)	📄	17/07/2019 9:44 (GVA)
F2019-18629	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		F	Published	16/07/2019 15:59 (GVA)	📄	16/07/2019 15:59 (GVA)
F2019-14734	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		CAF, F	Published	11/06/2019 18:03 (GVA)	📄	11/06/2019 18:03 (GVA)
F2019-14352	F	AGENCE SPATIALE EUROPEENNE (ESA)	SMOS		CHN, F	Published	22/05/2019 18:25 (GVA)	📄	22/05/2019 18:25 (GVA)

12 years of SMOS RFI Reporting 2010-2021

Afghanistan	Croatia	Iraq	Pakistan	South Korea
Albania	Czechia	Ireland	Paraguay	Spain
Algeria	D.R.Congo	Israel	Peru	Sudan
Argentina	Denmark	Italy	Philippines	Sweden
Armenia	Egypt	Japan	Poland	Taiwan
Australia	Fiji	Kuwait	Portugal	Tanzania
Bahrain	Finland	Latvia	Qatar	Thailand
Bangladesh	France	Liberia	Romania	Tunisia
Belarus	Germany	Libya	Russia	Turkey
Bolivia	Ghana	Lithuania	Rwanda	UAE
Brazil	Greece	Malaysia	Samoa	UK
Bulgaria	Guatemala	Mexico	Saudi Arabia	Ukraine
Burundi	Guinea-Bissau	Morocco	Serbia	USA
Canada	Iceland	Myanmar	Solomon Islands	Uzbekistan
Central African Rep.	India	Namibia	Somalia	Zambia
China	Iran	Netherlands	South Africa	

## 79 countries



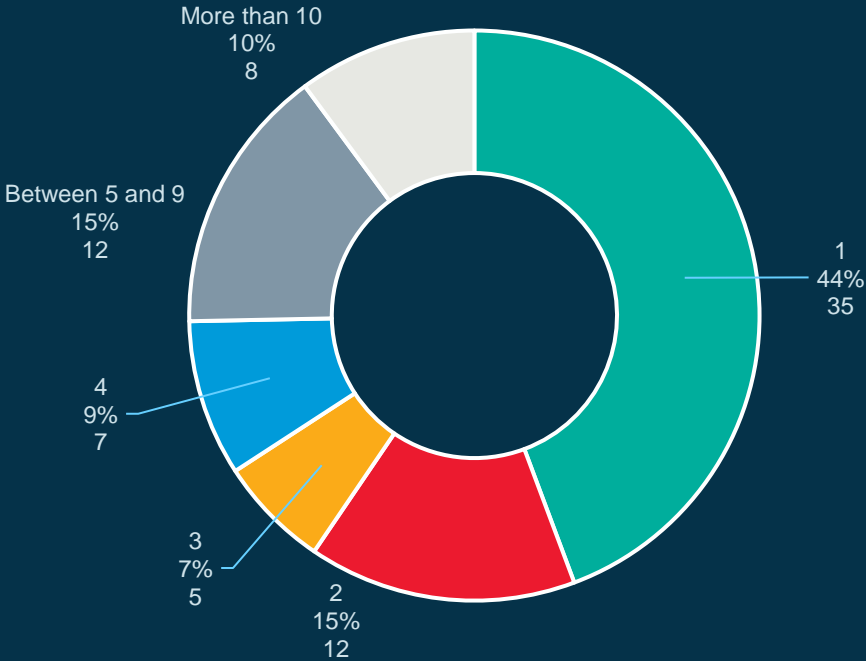
# SMOS RFI Reporting: Administrations contacted



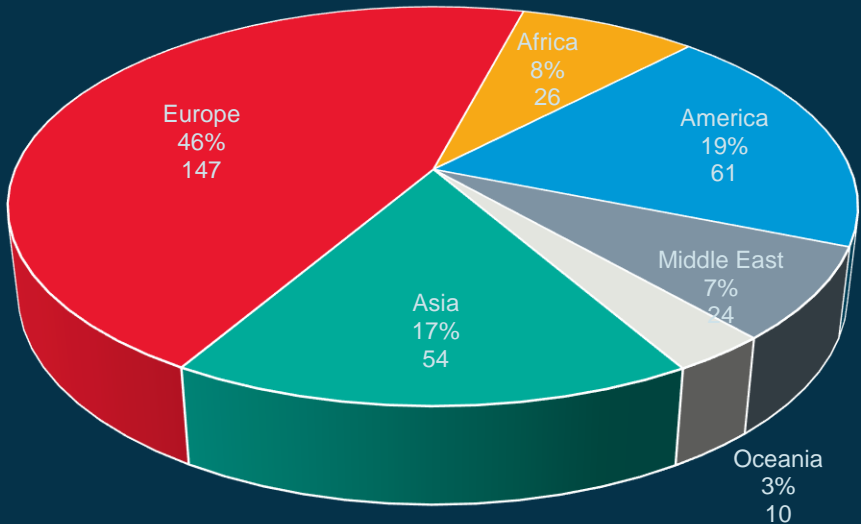
12 years of SMOS RFI Reporting 2010-2021



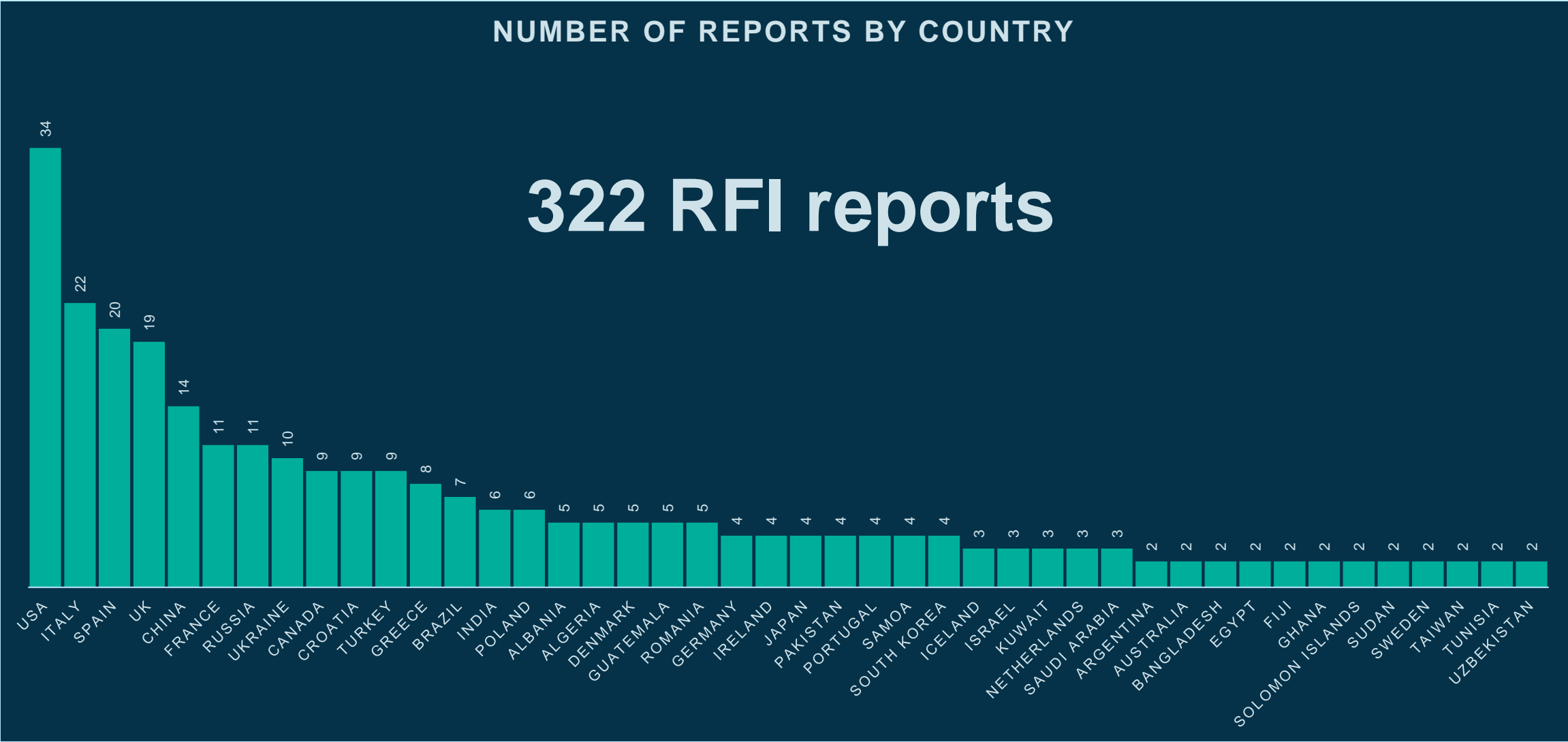
Number of countries reported n times



Number of reports by continent



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- It is **essential** to protect the **passive band 1400-1427 MHz** from both **illegal** and **excessive unwanted emissions**.
- Efforts have to be continued and intensified by **raising concern** among the different countries and organisations about the negative impact of RFI in scientific return of scientific space missions. The **solution** of the RFI due to illegal emissions **can be achieved** in **cooperation** with **national authorities** and **ITU**.
- There are other satellite missions, terrestrial radio astronomy organizations and local administrations, also reporting. It is important to try to **coordinate all these efforts**, as SMOS is currently doing with the **SMAP mission**.
- We are ensuring that the number of **interferences decreases** or does **not grow** despite the number of wireless equipment that can be a potential source of interference has been growing exponentially over the last 10 years.
- **SMOS activities**: 8027 RFI detected, 4323 of which Persistent, **1325 RFI ON** reported, **1155 RFI currently OFF**, **322 RFI reports** sent, **79 National Administrations** contacted.

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THANK YOU

