

Report from the CGMS WGI Task Group on RFI detection, monitoring and mapping (*incl. latest ToR, status on current & proposed/planned activities, and use of AI.*)

Presented to CGMS-54 Working Group I session, agenda item 3.1

Executive summary of the WP

The Task Group on RFI Detection, Monitoring and Mapping (TGRFI) has made significant progress since its 2022 inception in harmonizing international efforts to detect and mitigate radio frequency interference (RFI). A primary milestone for this cycle is the completion of a draft set of "Best Practices for Data Collection Systems (DCS) RFI," which is recommended for endorsement by CGMS-54 to provide a standardized framework for minimizing data loss. These practices emphasize proactive design phases, informal engagement strategies for RFI resolution, and the establishment of robust communication channels between users and operators.

A critical strategic shift identified by the group is the operational necessity of integrating Artificial Intelligence (AI) and Machine Learning (ML) to counter "insidious" spectral contamination from sources like 5G, which often evades legacy statistical detectors by mimicking natural Gaussian noise. Looking ahead, the TGRFI proposes prioritizing the emerging interference challenges posed by the rapid proliferation of Low Earth Orbit (LEO) mega-constellations and the development of rigorous data integrity standards for commercial data buys. Through continued intersessional collaboration, the group aims to ensure the long-term resilience of global meteorological satellite infrastructure in an increasingly crowded electromagnetic environment.

TGRFI Background & Membership



Established: In response to CGMS-49 to address RFI detection and mapping, including passive bands.



Meeting Cadence: Periodic meetings held since May 2022; six intersessional meetings conducted for the CGMS-54 cycle.



Current Member Organizations: CMA, ECCC, ESA, EUMETSAT, JMA, and NOAA.



Key Objective: Harmonizing member approaches to protect vital meteorological frequency bands.

Organization	Name	
CMA	NIE	Jing
CMA	WU	Shengli
ECCC	Alec	Casey
ESA	Yan	Soldo
EUMETSAT	Markus	Dreis
EUMETSAT	Simon	Elliott
EUMETSAT	Karolina	Nikolova
JMA	Toshiyuki	Kurino
NOAA	Beau	Backus
NOAA	Skip	Dronen

Major Achievement: DCS RFI Best Practices



Status

Draft set of best practices for Data Collection Systems (DCS) RFI has been completed.



Goal

Provide a standard approach for assessing RFI and developing robust systems to minimize data loss.



Core Elements

- Proactive design phases to mitigate RFI costs.
- Direct and informal engagement strategies for resolution.
- Establishment of user-operator communication channels for reporting.



Recommendation

WGI to review and, if approved, submit these practices to CGMS-54 Plenary for endorsement.

The AI/ML Imperative: Operational Necessity



Beyond Research:

The integration of AI/ML is no longer luxury, but an operational necessity to protect multi-billion-dollar satellite infrastructures.



Protecting High-Value Data:

AI/ML is required to safeguard critical data used for Numerical Weather Prediction (NWP) and climate monitoring.



Automation at Scale:

The massive volume of data from high-sensors makes ground-based manual analysis impractical; automation is the only way to maintain operational integrity.



Real-Time Mitigation:


AI enables the transition from forensic (after-the-fact) analysis to real-time detection and mitigation.




AI/ML as a Pattern Recognition Task




Identifying “Signatures”: AI architectures treat RFI detection as a pattern recognition task, identifying complex interference signatures that statistical methods miss.



Supervised Learning (CNNs): Convolutional Neural Networks are trained on thousands of labeled spectrograms to recognize unique patterns, such as military radar crosshatch or 5G spectral leakage.



Unsupervised Learning (Autoencoders): By training only on “clean” data, these models flag RFI as anomalies based on reconstruction errors—highly effective for “residual” RFI in sensitive bands like the L-band (1.4 GHz).



Archival Discovery (DBSCAN): Clustering algorithms identify low-power, persistent interference in archival data that fails to trigger traditional alarms.

Proactive and Autonomous Mitigation



Adaptive Filtering (RL)

Reinforcement Learning-powered filters dynamically “notch out” time-varying RFI while preserving essential geophysical signals.



Predictive Modeling

ML models combine orbital mechanics with terrestrial spectrum databases to predict when and where RFI is likely to occur, allowing for proactive sensor adjustments.



Cognitive Satellite Receivers

The long-term goal is on-board AI that autonomously detects and mitigates RFI before the data is even downlinked.



Standardization & Cross-Calibration

Harmonizing Spectral Response Functions (SRFs) and AI flagging protocols is essential for the cross-calibration of microwave instruments across different agencies.

The CGMS Coordination Imperative



Shared Training Datasets: Robust AI requires labeled data; CGMS members must collaborate to release large, open datasets to train generalized 'foundation models'.



Regional Cognizance: Interference identified by one agency (e.g., CMA) can pre-emptively inform others (e.g., EUMETSAT or NOAA) as their assets transit the same latitudes.



Firmware Integration: Ensuring mitigation is built into ground-based systems like the Enhanced Data Collection Platform (EDCP).



Global Resilience: Standardizing these advanced techniques ensures that the global weather prediction system remains resilient in an increasingly crowded electromagnetic environment.

Future Work (1): Mega-Constellations



The Risk

Rapid deployment of LEO constellations (e.g., Starlink) creates an unprecedented risk of aggregate interference.



Proposed Task

Evaluate interference challenges and develop strategies to protect vital frequency bands.



Key Focus

Monitoring high-frequency operations and their impact on passive services.

Future Work (2): Commercial Data Buys



Standardization Needs: As agencies buy more commercial data, harmonized RFI protocols are essential.



Quality Assurance: Ensuring commercial datasets meet the same spectral protection standards as member-owned assets.



Data Integrity: Developing consistent approaches to spectral protection across all member organizations.

Roadmap & Schedule (2026-2027)



DCS Best Practices:
Review and endorsement by CGMS-54.

Upcoming Intersessionals (Tentative)



Coordination Group for Meteorological Satellites



Key issues of relevance to CGMS:

- **The Mega-Constellation Crunch:** The rapid deployment of large-scale LEO satellite constellations (like Starlink) presents an unprecedented risk of aggregate interference and out-of-band emissions. CGMS should develop proactive strategies to protect the vital passive sensing bands these constellations threaten.
- **Standardizing Commercial Data Buys:** As agencies move toward purchasing third-party observations, there is a critical need to ensure these commercial datasets meet the same rigorous spectral protection and RFI-flagging standards as member-owned assets. Harmonizing these protocols should maintain the integrity of the global observing system.
- **The "Invisible" AI/ML Shift:** Traditional RFI detection methods are effectively being "blinded" by modern 5G signals that mimic natural Gaussian noise. Transitioning to AI/ML is no longer a research experiment but an operational necessity to limit insidious spectral contamination from corrupting weather and other earth-centric data.
- **Reference to HLPP 2.2**

To be considered by CGMS:

- For endorsement by CMGS-54 Plenary: DCS RFI Best Practice.
- For action by Working Group I:
- **Evaluate Mega-Constellations:** Develop strategies to mitigate risks from large-scale LEO deployments.
- **Standardize Commercial Data:** Analyze RFI considerations in commercial data buys to ensure data integrity.