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| **Subject** | **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.)** |
| **In response to CGMS action/recommendation** | WGI/A51.04, WGI/A51.05 |
| **HLPP reference** | Radio Frequency (RF) protection 2.2, 2.2.3 |
| **Executive Summary** | Working Group I tasked the TGRFI (Task Group on RFI detection, monitoring and mapping) to continue pursuing the establishment of a proposed set of best practices, focusing on DCS RFI, for CGMS-54 based on the common aspects of the approaches already adopted by members.<br>This paper outlines the Task Group status, describes its activities in the past year and the plans for the coming period. |
| **Action/Recommendation proposed** | Recommendation: DCS RFI Best Practices be reviewed by WGI and, if deemed sufficient, to be endorsed by CGMS-54 Plenary.<br>Recommendation: Working Group I to instruct TGRFI for CGMS 55:<br>a. Evaluate the interference challenges posed by the proliferation of mega constellations to develop strategies for protecting vital meteorological frequency bands.<br>b. Analyze RFI considerations and data integrity standards within commercial data buys to ensure a consistent approach to quality assurance and spectral protection across member organizations. |

# 1 INTRODUCTION

The Task Group on RFI Detection, Monitoring and Mapping (TGRFI) was established in response to CGMS-49 request to establish the initial ideas about mechanisms regarding the detection, monitoring, and mapping of RFI, including the passive bands. The group began meeting in May 2022 and has continued meeting periodically since that original kick off.

This paper briefly summarizes the status of TGRFI, its activities to date, and its planned upcoming activities.

# 2 CURRENT STATUS

## 2.1 Membership

The current membership of the TGRFI, including guests, is listed:

| 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 |

## 2.2 Terms of Reference

The tasks undertaken by the TGRFI team for this year include:

- Analysing the inputs provided by CMA, ESA, EUMETSAT, JMA, and NOAA on spectrum concerns and activities on RFI detection, monitoring, and mapping and…
- Continuing to pursue the establishment of a proposed set of best practices by CGMS-54 focussing on DCS RFI best practices.
- Continuing to explore the potential / existing uses of AI/ML and pattern recognition in RFI detection.

Beau Backus from NOAA continued to lead TGRFI and Karolina Nikolova continued supporting as rapporteur.

## 2.3 Current and Upcoming Activities

### 2.3.1 TGRFI Intersessional #1 (15 August 2025)

The TGRFI 54.1 meeting convened to address critical action items for CGMS-54, beginning with a review of task group membership and the identification of additional participants needed to support the group's objectives. A primary focus was the development of a draft set of best practices for data communications (DCS) RFI, aimed at harmonizing member approaches for endorsement at the upcoming cycle. The group also noted the positive reception of the "CGMS Agency Guidance for RFI Detection, Monitoring, and Mapping for Remote Passive Sensors." Furthermore, members prioritized the identification of AI/ML and pattern recognition projects to ensure inter-organizational cognizance and reduce overlap in RFI detection and mitigation efforts. The next session, CGMS-54 WGI TGRFI Intersessional Meeting #2, is scheduled for September 16, 2025.

### 2.3.2 TGRFI Intersessional #2 (16 September 2025)

The CGMS-54 WGI TGRFI Intersessional Meeting #2 focused on refining the group's approach to addressing RFI issues. Key points included the need for practical goals and clear communication of risks to maintain interest and participation. The group proposed focusing on improving DCS capabilities, leveraging NOAA's efforts and AI/ML (Artificial Intelligence/Machine Learning) for pattern recognition. They also discussed aligning with SFCG and WMO positions for the WRC 2027 and ensuring national authorities are informed. The next meeting is scheduled for October 17, with a draft of best practices for DCS to be circulated in advance.

### 2.3.3 TGRFI Intersessional #3 (17 October 2025)

The CGMS-54 WGI TGRFI Intersessional Meeting #3 focused on reviewing and refining a document on best practices for mitigating RFI from NOAA's perspective. Key points included the need to align with WMO's position on spectrum management, particularly regarding the impact of Starlink's high-frequency operations on passive services. The group discussed the potential shift of space weather activities from NOAA to the Department of Defense and emphasized the importance of international cooperation and regulatory alignment. They also planned to incorporate additional inputs from China and Japan to broaden the best practices document.

### 2.3.4 TGRFI Intersessional #4 (21 November 2025)

The CGMS-54 WGI TGRFI Intersessional Meeting #4 focused on spectrum management issues, particularly the use of AI and machine learning (ML) in RFI mitigation. Beau Backus discussed an AI-generated paper highlighting dynamic spectrum management and cognitive satellite networks. Markus emphasized the need for practical best practices, suggesting a structure that differentiates between general and DCS-specific applications. The group also debated the importance of user-

operator communication channels for RFI reporting and the challenges of scaling RFI mitigation strategies to large user bases. The next meeting will review and refine the best practices document.

### 2.3.5 TGRFI Intersessional #5 (16 January 2026)

The CGMS-54 WGI TGRFI Intersessional Meeting #5 focused on the status of various actions, including the closure of the AI/ML action and the ongoing work on the DCS best practices. Key points included the need for a robust process to geolocate and resolve RFI sources, the importance of user advocacy in interference resolution, and the potential for a WMO initiative to report anomalies. The group discussed the feasibility of creating a checklist or flowchart to guide users and service providers through the RFI resolution process. The next meeting is scheduled for February 13th, with a possible time adjustment due to other commitments.

### 2.3.6 TGRFI Intersessional #6 (13 February 2026)

The CGMS-54 WGI TGRFI Intersessional Meeting #6 focused on finalizing the best practices for Data Collection Systems (DCS) and addressing RFI. Key points included the need for a proactive design phase to mitigate RFI costs efficiently, the importance of direct and informal engagement strategies for RFI resolution, and the potential benefits of AI/ML in RFI detection and mitigation. The group also discussed the inclusion of real-world examples from NOAA, JAXA, and EUMETSAT in future appendices. The meeting concluded with a plan to present these findings to the working group and consider future tasks related to mega constellations and commercial data buys.

## 2.4 Upcoming Activities

The Task Group's next recommended tasks are to evaluate the interference challenges posed by the proliferation of mega constellations to develop strategies for protecting vital meteorological frequency bands. Additionally, the Task Group will analyze RFI considerations and data integrity standards within commercial data buys to ensure a consistent approach to quality assurance and spectral protection across member organizations.

The best practices for data communications systems RFI has been completed. Recommend it be reviewed by WGI and, if deemed sufficient, to be endorsed by CGMS-54 and used to assist members in implementing a standard approach for assessing RFI and developing more robust systems and processes for minimizing data communications loss due to RFI.

Six intersessional meetings have been tentatively planned. The first is scheduled on 31 July 2026. The remaining are planned for 11 September, 23 October, 20 November, 22 January, and 5 February 2026. Additional dates may be scheduled depending on the progress made by the team.

# 3 CGMS Interests Regarding AI/ML Use in RFI Detection and Mitigation

The CGMS must concern itself with the rapid integration and coordination of AI and ML techniques because the operational integrity of the global meteorological satellite infrastructure is critically threatened by modern RFI that traditional detection methods cannot effectively handle. The transition to AI/ML is an operational necessity to protect high-value Earth observation data used for Numerical Weather Prediction (NWP) and climate monitoring.

## 3.1 The Escalating Threat of RFI and Failure of Legacy Methods

CGMS's primary concern stems from the pervasive and evolving nature of RFI, primarily from anthropogenic sources, which fundamentally risks the accuracy of Earth observation data.

- **Insidious Spectral Contamination:** RFI originates from diverse sources, including fifth generation (5G) telecommunications, terrestrial radar, and massive Low Earth Orbit (LEO) satellite constellations. The proliferation of 5G is a major concern because its interference is often diffuse, unpolarized, and aggregated from multiple low-power sources, leading to an "insidious" increase in the noise floor.
- **Vulnerability of Passive Sensing:** Passive microwave radiometry is uniquely susceptible because its sensors are designed to measure extremely low levels of natural thermal emission (brightness temperature). These sensors are "blind" to the origin of collected photons, making it difficult to distinguish natural signals (like atmospheric water vapor) from man-made interference (like a terrestrial 5G base station's sidelobe leakage).
- **Insufficiency of Statistical Detectors:** Traditional RFI detection techniques, such as the Kurtosis algorithm, rely on the assumption that natural noise follows a Gaussian distribution. However, modern 5G RFI often possesses statistical characteristics that mimic Gaussian noise, allowing it to evade traditional, threshold-based flags.

## 3.2 The AI/ML Imperative: Next-Generation Detection and Mitigation

The complexity and dynamism of new RFI sources necessitate the adoption of AI/ML, which allows CGMS members to automate detection, analyze massive data volumes, and improve real-time mitigation.

### 3.2.1 Advanced Detection Techniques

AI and ML architectures can recognize complex interference "signatures" that statistical methods miss by treating detection as a pattern recognition task:

- **Supervised Learning (Convolutional Neural Networks - CNNs):** CNNs are trained on thousands of labeled examples (spectrograms—visual representations of signal power over time and frequency) to identify the unique

patterns of different interference types, such as military radar crosshatch or 5G spectral leakage.

- **Unsupervised Learning (Autoencoders):** When labeled RFI data is scarce, autoencoders are trained only on "clean" (RFI-free) data. The model flags data as an anomaly when it encounters RFI, as indicated by a significant increase in the reconstruction error. This is effective for identifying "residual" RFI in sensitive bands like the L-band (1.4 GHz) that passes through traditional filters.
- **Density-Based Spatial Clustering (DBSCAN):** Used for archival data analysis, DBSCAN identifies clusters of low-power, persistent interference in the time-frequency domain that do not trigger threshold alarms.

### 3.2.2 Advanced Mitigation and Predictive Modeling

Beyond detection, AI/ML is essential for developing proactive and autonomous mitigation strategies:

- **Adaptive Filtering and Reinforcement Learning (RL):** RL-powered filters can dynamically adjust their parameters to "notch out" time-varying RFI while preserving the geophysical signal, which is crucial in complex environments with dense, rapidly changing RFI sources like 5G base stations.
- **Predictive RFI Modeling:** ML models are being trained to predict *when* and *where* RFI is likely to occur by combining orbital mechanics with terrestrial spectrum use databases. This enables proactive mitigation, such as temporarily switching to more robust sensing modes.
- **Cognitive Satellite Receivers:** The long-term goal is to deploy on-board AI systems (cognitive receivers) to autonomously detect, classify, and mitigate RFI before data is downlinked. This is critical for managing the increasing data volume from high-resolution sensors, making ground-based manual analysis impractical.

## 3.3 Inter-Agency Cognizance: The CGMS Coordination Imperative

CGMS's primary function is coordination, and the reliance on AI/ML requires a concerted, international effort to maximize effectiveness and ensure the data from member agencies (NOAA, EUMETSAT, CMA, JMA) remains cohesive and interoperable.

- **Standardization of Techniques:** CGMS, through Working Group I (WG-I) and the Task Group on RFI Detection, Monitoring, and Mapping (TGRFI), must establish common "Best Practices" for AI/ML-based RFI flagging and mitigation.
- **Harmonizing Data and Instruments:** Standardization of RFI flagging protocols and harmonization of Spectral Response Functions (SRFs) is essential for the crosscalibration of microwave instruments (e.g., ATMS and MWS). Without precise SRFs, agencies cannot determine if RFI is due to illegal in-band or legal out-of-band emissions from adjacent services.

- **Shared Training Datasets:** A significant bottleneck for robust AI development is the scarcity of accurately labeled training data for rare or emerging interference types. CGMS members must collaborate on releasing large, open datasets of RF spectrograms to train generalized "foundation models" that can work across different sensors.
- **Cognizance and Reporting:** The shared nature of the electromagnetic spectrum means interference identified by one satellite (e.g., a CMA Fengyun satellite) can pre-emptively inform others (EUMETSAT or NOAA) as their assets transit the same latitudes. This requires a centralized **RFI Register** for documenting known sources and standardized reporting of RFI cases through the ITU's Satellite Interference Reporting and Resolution System (SIRRS).
- **Firmware Integration:** Coordination is needed to ensure RFI mitigation is incorporated directly into the firmware of ground-based systems, such as the transition to the Enhanced Data Collection Platform (EDCP) standard, to ensure increased bandwidth does not create new interference challenges.

### 3.4 Summary on AI/ML for RFI Detection and Mitigation

The evolution of RFI detection and mitigation within the CGMS framework represents a shift toward a more intelligent, automated, and collaborative paradigm. The integration of AI, ML, and pattern recognition is no longer a research luxury but an operational necessity for protecting the multi-billion-dollar investment in meteorological satellite technology. Through the activities of Working Group I and its Task Group on RFI, CGMS member organizations are ensuring that the global weather prediction system remains resilient in an increasingly crowded electromagnetic environment. By standardizing detection techniques, sharing training datasets, and maintaining cognizance of regional RFI trends, the international meteorological community can ensure the continued availability of high-quality data for critical applications in disaster early warning, climate monitoring, and global sustainability.

## 4 ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY CGMS WORKING GROUP I

Recommendation: Working Group I to instruct TGRFI to:

a. Evaluate the interference challenges posed by the proliferation of mega constellations to develop strategies for protecting vital meteorological frequency bands.
b. Analyze RFI considerations and data integrity standards within commercial data buys to ensure a consistent approach to quality assurance and spectral protection across member organizations.

### 4.1 Rationale for Proposed TGRFI Tasks:

- **Addressing Mega Constellations:** The rapid deployment of large-scale LEO satellite constellations presents an unprecedented risk of aggregate interference and out-of-band emissions. It is critical to evaluate these challenges now to develop proactive mitigation strategies and ensure the long-term protection of frequency bands essential for passive sensing and meteorological operations.
- **Standardizing Commercial Data Buys:** As meteorological agencies increasingly supplement traditional observations with commercially sourced data, there is a growing need for harmonized RFI detection and data integrity protocols. Establishing these standards ensures that commercial datasets are subject to the same rigorous spectral protection and quality assurance as member-owned assets, maintaining the overall reliability of the global observing system.

## 5 CONCLUSIONS

The Task Group on RFI Detection, Monitoring and Mapping has made significant progress since its inception in 2022, successfully harmonizing member inputs to establish standardized approaches for the evolving RFI landscape. Having completed the draft set of best practices for Data Collection Systems (DCS) RFI, the group now recommends these for CGMS-54 endorsement to provide a robust framework for minimizing data loss and implementing a standard approach to spectral protection. The integration of AI, machine learning, and pattern recognition has been identified as an operational necessity rather than a research luxury, offering a critical path for identifying insidious spectral contamination from 5G and other anthropogenic sources that evade legacy detection methods.

Moving forward, the TGRFI will focus on the emerging interference challenges posed by the rapid proliferation of mega constellations and the need for rigorous data integrity standards within commercial data buys. By evaluating these new threats and continuing a series of intersessional meetings through 2027, the Task Group ensures that CGMS members remain proactive in protecting vital meteorological frequency bands. Ultimately, by embracing advanced automated detection and strengthening international coordination, the TGRFI ensures the continued availability of high-quality Earth observation data for critical applications in weather prediction and climate monitoring.