

# Report on status of RFI best practices in the area of DCS

Presented to CGMS-54 Working Group I session, agenda item 3.2

## Executive summary of the WP

This document outlines a comprehensive, lifecycle-based framework for managing Radio Frequency Interference (RFI) within satellite-based Data Collection Systems (DCS). It establishes that ensuring operational resilience is a strategic imperative that must be integrated from initial system design through ongoing operations, as a proactive design posture is the most effective and cost-efficient strategy for managing interference. The scope encompasses the end-to-end movement of data , organized into five key stages: planning, monitoring, characterization, mitigation, and removal. Central to these best practices are requirements for flexible hardware, such as reprogrammable transmitters and transparent transponders , alongside the utilization of AI/ML for advanced performance monitoring. Ultimately, the successful removal of RFI depends on both technical signal characterization and the cultivation of strong organizational relationships to influence change in RFI source operations.

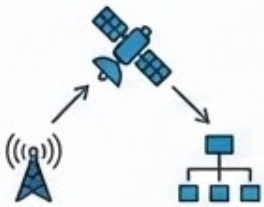
# Introduction & Scope



**Objective:** Define the framework for managing RFI throughout the DCS lifecycle.



**Definition of RFI:** Any human-caused (anthropogenic) or natural electromagnetic energy that negatively affects system performance.



**Scope:** End-to-end data movement—from terrestrial Data Collection Platforms (DCP) to terrestrial distribution systems via satellite relay.



**Exclusions:** Direct sensor interference, downstream distribution systems, and intentional/malicious disruption.

# Planning for RFI in System Design



**Communication Modeling:**  
Utilizing modified Shannon-Weaver models to identify RFI-vulnerable components.



**The Design Window:**  
Satellite hardware and spectrum architecture must be finalized early; modifications post-launch are nearly impossible.



**Proactive Acquisition:**  
DCS operators must be active in satellite acquisition to ensure RFI is factored into spectrum filing.



**Recursive Effort:**  
Once a variable is addressed in one part of the chain, the impact on others must be assessed.

# Technical Design Considerations



## Transmitter Requirements:



Must adhere to industry standards (spurious emissions, filtering).



**Flexibility:** Designed for remote commanding (backhaul) and firmware updates to adapt to new RFI avoidance techniques without hardware changes.



## Satellite & Receiver Resilience:



**Selectivity:** Satellite receivers should maximize desired signals and exclude undesired ones.



**Transparency:** Use transparent transponders so uplink signals can be analyzed via the downlink.



**Metadata:** Ground stations should process signal strength, timing, and variability metadata for each message.



**CGMS**

# Monitoring System Operations

## Categories of Monitoring:



**1. Supporting Infrastructure** performance.



**2. Data flow integrity** (identifying loss or corruption).



**3. Spectrum monitoring** (uplink/downlink) to confirm non-DCS RF energy.

## Key Capabilities:



- **Automated dashboards** for real-time status.



- **Extended storage** for historical trend analysis.



- **Advanced Analytics:** Leveraging AI/ML to merge performance metrics with In-Phase Quadrature (IQ) spectrum data.

# Characterizing RFI and Communicating Impact



**Characterization Data:** Aligning with ITU Satellite Interference Reporting and Resolution System (SIRRS) requirements.



**Required Documentation:**

- Source details (location and measured signal characteristics).
- Frequency assignments and scan/geolocation plots.



**The Regulatory Reality:** Unreported RFI is viewed as “no RFI” by regulatory bodies; documenting the specific impact on user operations is critical for support.

# Mitigation Strategies

- **Mitigation vs. Removal:** Focused on limiting data loss while the RFI source is still active.



## Operational Adjustments:

- Employing alternative broadcast times, redundant transmissions, or different channels.
- Repointing antennas or updating to modern, more robust DCP models.



## Technological Improvements:

Improving digital signal processing and using error correction or robust modulation.

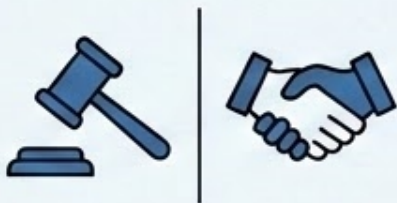


## Data Path Redundancy:

Using multiple satellites or commercial services to avoid single points of failure.

# Removing RFI & Organizational Relationships

## Formal vs. Informal Approaches



RFI removal via regulatory enforcement or collaborative engagement.

## The “Collaborative Approach”



International sources often unaware of interference.

## Effective Strategies



Radio-operator engagement is fastest. Emphasize “Safety of Life & Property” impact.

## Prerequisites for Removal



Clearly characterized signal & high certainty of operator identity.

# Conclusion – A Strategic Imperative



## Shift in Posture:

Move from reactive response to proactive, lifecycle-based management.



## Cost-Efficiency:

Embedding monitoring and flexibility during the design phase is the most cost-effective RFI strategy.



## Core Takeaway:

Reliable data integrity in a congested spectrum depends on robust technical design coupled with strong organizational relationships.

## Key issues of relevance to CGMS:

- **Proactive Lifecycle Design and Spectrum Management:** Satellite hardware and spectrum architectures must be finalized early in the acquisition process because modifications post-launch are generally impossible.
- **Advanced Monitoring and AI Integration:** Fundamental system resilience requires the ability to distinguish between nominal and degraded performance through dedicated spectrum monitoring and the analysis of signal metadata.
- **Regulatory Engagement and Collaborative Relationships:** Technical characterization is only one part of the solution; successful RFI removal relies heavily on formal reporting to regulators and maintaining organizational relationships.
- **Reference to HLPP 2.2**

## To be considered by CGMS:

- For endorsement by CMGS-54 Plenary as a DCS RFI Best Practice.