Satcoms Innovation Group

Colem Engineering

ISRMM Spectrum Monitoring

2nd September 2025:

EETT, Athens, Greece

The Spectrum We Take For Granted…

…is Spectrum Monitoring more S3A than RFI?

Notes:

S3A = **S**pace & **S**pectrum **S**ituational **A**wareness

RF = **R**adio **F**requency

RFI = **RF** **I**nterference

Link to UN Web Page:
https://sdgs.un.org/goals

SPACE…

…is a big part of making these 17 UN Goals possible!

…we know more about Objects & Debris than Spectrum Use!

…and if we don't look after Spectrum with the same priority as Objects & Debris then all is lost!

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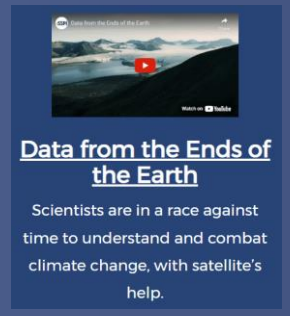
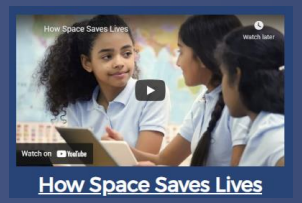
Spectrum…

…with

… & without





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SUSTAINING SPECTRUM:

Spectrum use in space is becoming increasingly complex due to the rapid growth of satellite networks and space-based services. The main issues involve technical, regulatory and geopolitical challenges:

1. Spectrum Congestion & Interference

2. Coordination & Regulation Challenges

3. Orbital & Spectrum Slot Allocation

4. Technology Limitations

5. Space Debris & Spectrum Use Linkage

6. Security & Spectrum Abuse

7. Equity & Access

In Summary: The need for **Spectrum Management** is now! To sustain **Spectrum Use** in space, the industry needs better…

- International cooperation and enforcement of spectrum rules
- Technological Innovation & Tools to improve & advance **Spectrum Management** & **Use Efficiency**
- Mechanisms to prevent monopolization and promote equitable access
- Solutions linking orbital and spectrum sustainability (e.g., active debris removal, spectrum reallocation, etc.)

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MANAGING SPECTRUM:

Spectrum Management has been talked about but, real action is needed and soon!

So, where are we right now?

1) *Satellite Operators need to enhance their **Spectrum Monitoring Capabilities** &…*
   *…move towards **ML/AI**.*
2) *Coordination & Regulation Challenges:*
   *Regulators do not have **Spectrum Data - Used & Not Used** or Monitor **Compliance**.*
3) *LEO operators do not **Share** operational **RF Data** & **Co-manage** their systems.*
4) *The SES / INTELSAT Now Part of SES Merger - will help to **manage GEO/Spectrum/RFI**?*
5) *A "**Digital Divide in Space**".*
6) *Adoption of **S3A** (**S**pace & **S**pectrum **S**ituational **A**wareness) - **ITU**…*
7) *New Tools are starting to emerge e.g., **THRIMOS**…*

Space Sustainability Forum
International Conference Centre, Geneva
7th to 8th October 2025

"to achieving effective **S3A** as a critical element for mission success, security & sustainability of space radiocommunications systems."

The Questions…

a) *Can Satellite Operators **Share** their **RF Data**?*
b) *How can Satellite Operators improve their use of internal **RF** Datasets?*
c) *Do we know what **Spectrum** is **Used** and, more importantly, **Not Used**?*
d) *How do we get to Global **Spectrum Management**?*

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E.G., USING ML/AI TO RESOLVE SPECTRUM MANAGEMENT?

Using machine learning (ML) and artificial intelligence (AI) for **Spectrum Management** in space offers powerful tools to tackle challenges like congestion, interference and dynamic allocation. Below are key areas where AI/ML can help, along with examples of specific techniques:

1. Dynamic Spectrum Allocation

2. Interference Detection & Mitigation

3. Spectrum Prediction & Forecasting

4. Spectrum Sharing & Coordination

5. Cognitive Radio in Space

6. Satellite Health & Spectrum Utilization Monitoring

7. Decision Support for Regulators

Key Benefits of ML/AI for Spectrum Management…

Benefit	Impact
Faster Decision-Making	Real-time or near real-time Adaptation
Improved Efficiency	Better use of limited Spectrum, especially in LEO
Resilience	Adaptive to unexpected Interference or Failure
Autonomy	Essential for Large Constellations & Deep Space Ops

REAL-WORLD & EMERGING EXAMPLES:

- DARPA's Spectrum Collaboration Challenge (SC2): Demonstrated autonomous, **AI-driven spectrum coordination** among radios.
- NASA's Cognitive Communications Project: Researching intelligent SDRs & Predictive **Spectrum Management**.
- ESA ARTES Program: Exploring AI for next-gen satellite networks, including **Spectrum Efficiency**.
- Commercial Sector (e.g., Starlink): ***Probably*** using **predictive algorithms** for Traffic Balancing & Channel Assignment.

KEY FUNCTIONAL POSSIBLE OUTCOMES:

- Real-time Spectrum Optimization
- Minimized Crosslink Interference
- Automated Conflict Detection & Resolution
- Predictive Planning for High-Demand Windows
- Compliance with ITU/National Policies

BUT NOTHING YET FROM REAL OPERATIONS!

THE MAJOR CHALLENGE TO ANY PROPOSAL TO MANAGE SPECTRUM?

- **To use ML/AI you need DATA!** *…and plenty of it!*
- **Satellite Operators have their own RF Data but cannot Share!**
- **Satellite Operators can "train" ML/AI systems from their RF Data…**

  …a good start but a limiting factor to using ML/AI!
- **ML/AI needs more Data to improve the "learning" process.**
- **…but there is a Scarcity of Sharable, Independent RF Data!**

  Space related RF Data is limited and mostly Proprietary!

…THIS WILL BE HARD TO RESOLVE!

…OR WILL IT?

REVISED THINKING & NEW TOOLS REQUIRED:

…from "gut instinct" to Evidence!

- Possible LEO constellation interference incidents were discussed within **SIG** as early as 2017.
- No claims of interference, including GEO! Relying on Conjecture. And why? **No Evidence**! No Supporting Data! Talk & No Action, just Rumour!

…Just that "gut-instinct" told SIG Members that new RFI problems were brewing!

- On the 'initiative' of a few curious **SIG** Members, actively looking at RF LEO operations, **recorded** the initial **Evidence** that LEO-to-LEO **RFI** existed!

…What is still missing? A scarcity of Sharable RF Data!

…What is needed? A systematic approach to collect **Spectrum RF Data**, received simultaneously from two or more Satellites within a receiving antenna's beam.

- **THRIMOS** - Development started early 2024. Fully Operational since August 2024. Gathering **Spectrum RF Data** & **Real Evidence** of LEO-to-LEO **RFI**!
- A new era of collecting raw, meaningful & quality **Spectrum RF Data** now exists!

In Conclusion: THRIMOS Starts to solve the **scarcity of Sharable RF Data** to ensure **Spectrum Management** is doable.

Moving Forward:

Satellite Operators:	**Regulators / ITU…**	**More Importantly…**

• Monitor their Spectrum & its Use more intensively.
• Constellation with Co-managed Service Planning to avoid RFI at **ALL** times!
• Plan & bring in New Tools to move towards ML/AI **Spectrum Management**.
	• A method to Verify / Falsify International Agreements?
	• Ensure Agreements made so Compliance can be Measured
	• Move Static Filing towards:
	  ○ Dynamic, Performance-based Spectrum Rights
	  ○ Realtime Coordination Mechanisms
	  ○ Stronger Enforcement of "use-it-or-lose-it" Rules
	  ○ Better Inclusion of Emerging Actors.
		Create both National & Global Repositories of Sharable RF Data!

…and something Practical :

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...from the Original Thinking behind S3A:

...an Educational/Science Project:

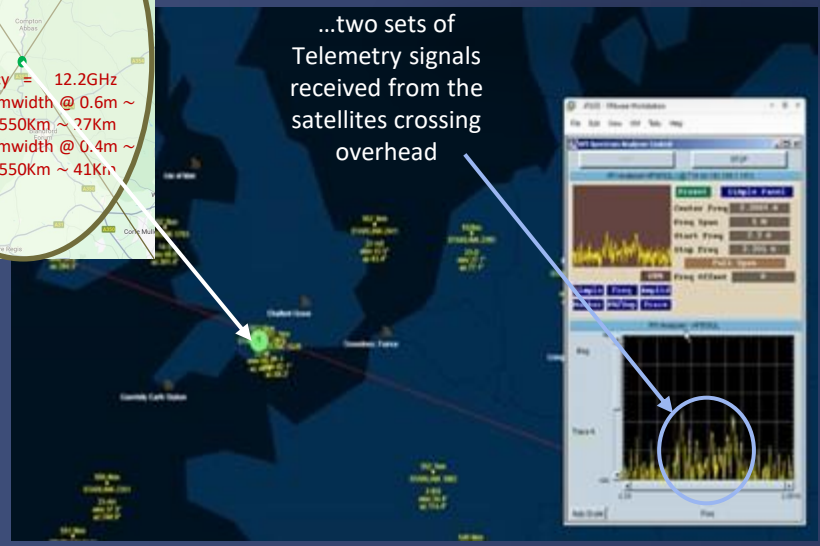
...a Colem/SIG Experiment started in 2020!

GEO Reference:

FreeSat on ASTRA Fleet @ 28.2°E

Zenith:

Starlink & OneWeb Tracking Reference Position



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…those Initial (*albeit basic*) Results!

…an Educational/Science Project:

…approx. coverage of 0.6m x 0.4m Rx Antenna at 550Km Altitude.

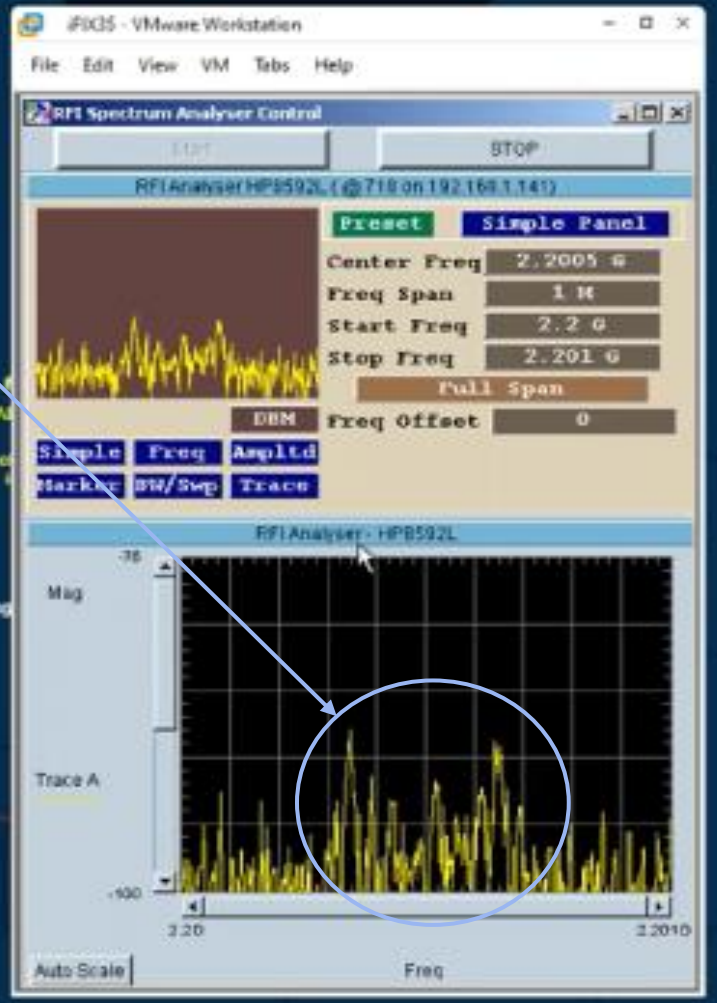
Notes:

Rx Frequency = 12.2GHz

3dB Beamwidth @ 0.6m~2.85° @ 550Km~27Km

3dB Beamwidth @ 0.4m~4.30° @ 550Km~41Km

…two sets of Telemetry signals received from the satellites crossing overhead



Support from…

Contact…

Martin Coleman:

SIG: Board Member

COLEM: Partner
Engineering

…THANK YOU

…THRIMOS next!

Websites:

SIG: https://www.satig.space/

COLEM RESOURCE LIBRARY:
https://rfi.colem.co.uk/

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