Spectrum Management Brief

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Topics

1. 1675 – 1680 MHz and SPRES Report
2. DCPR Uplink RF Interference 402 MHz band
3. Analysis of likely source from a Small Satellite Constellation uplink
4. International Frequency Usage of 401-403 MHz

1675 – 1680 MHz and SPRES Report

- Spectrum Pipeline Reallocation Engineering Study Report

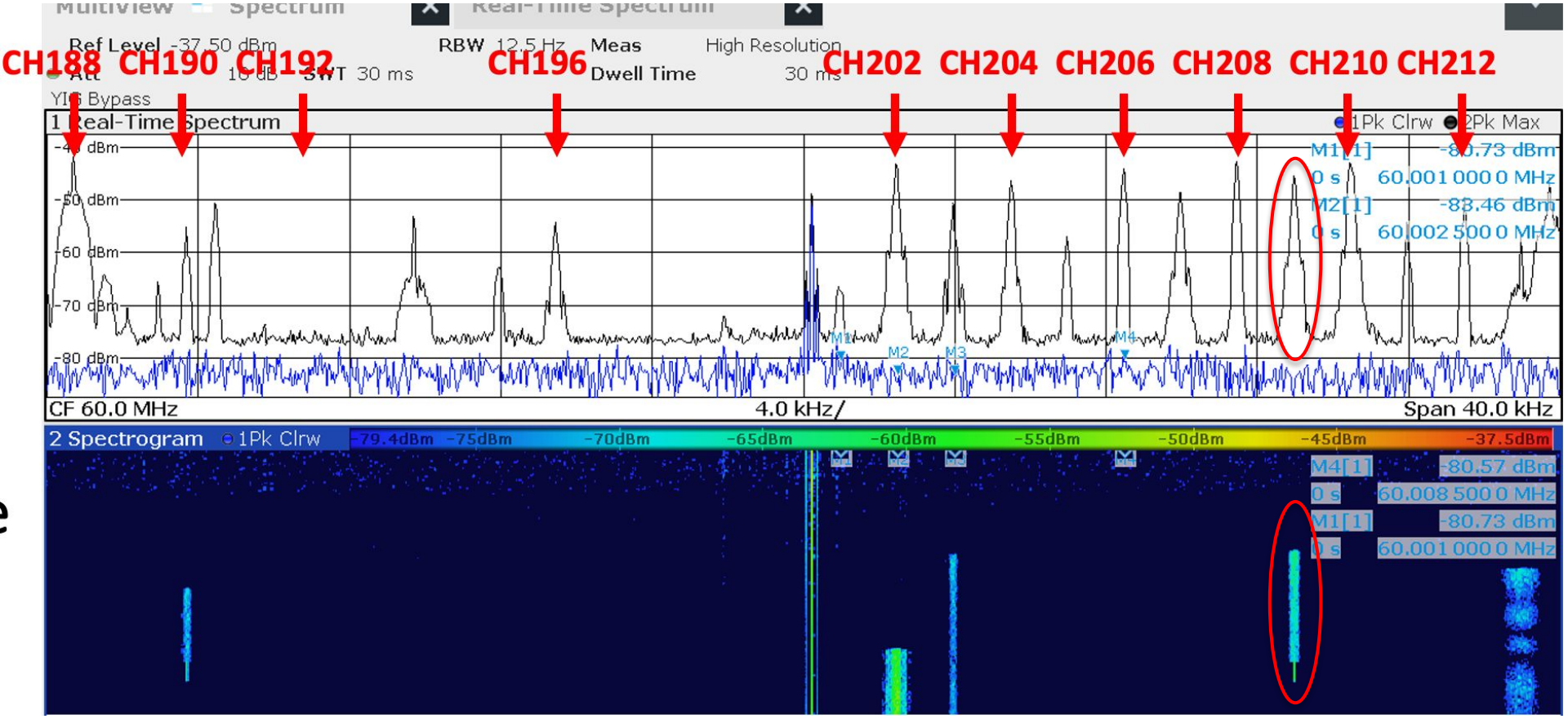
- 1675 – 1680 MHz regulatory status within US (FCC)
  - No change

DCPR Uplink RF Interference 402 MHz band

- As reported in the last STIWG / DCS-TWG, NOAA had seen some RF interference in 401.7-402.4 MHz range at the space-based DCPR receiver on GOES
- We have continued to evaluate data seen at DRGS at NOAA and other signals noted at Microcom
  - We believe some of the interfering signals contribute to data loss in affected DCS channels
  - Not all signals have yet been evaluated in detail, and as work continues, the technical team may reach out to in-country DCS users for assistance in contacting regulators or sources.
  - None of the sources initially identified originate in the USA

DCS Interference: Satellite Uplink Example

- Spectrum analyzer plot showing some DCS channels and corresponding spectrogram with each row showing about 30 milliseconds of time. DCP looks like an upside-down candle.



DCS Interference: Satellite Uplink Example

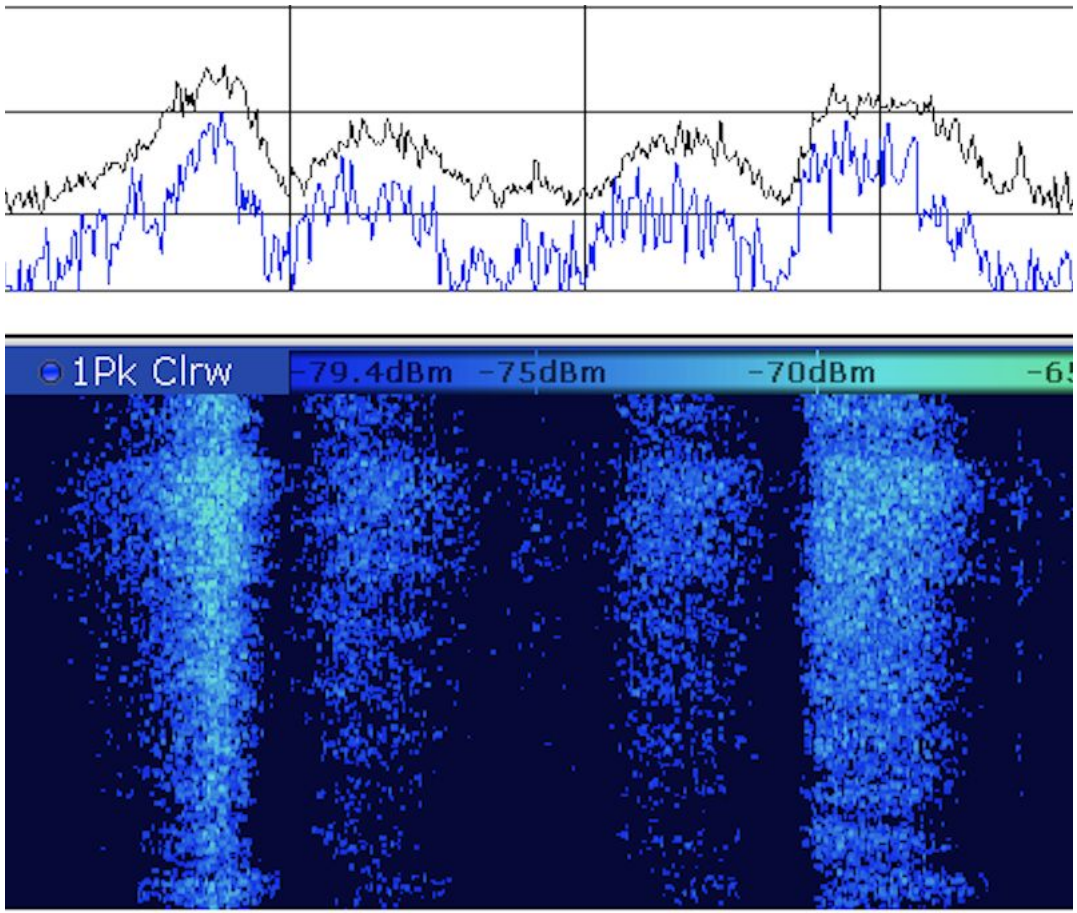
- A private, commercial satellite system, used to detect methane emissions that contribute to greenhouse gas levels in the atmosphere, is an apparent source of one predominant interfering signal type
  - This signal, uplinking command data from an earth station to a non-geostationary (e.g., orbiting NGSO) satellite, could be received by the DCPR uplink receiver(s) in space.
  - DCPR uplink channels are located between 401.7 and 402.4 MHz in frequency
  - The satellite system under examination would transmit from Earth-to-space with signals from 16 kHz to 20 kHz bandwidth, centered very near 402 MHz

Interference Detection Process

- Collecting data and examining DADDS for losses, is a manual, very lengthy process.
  - A spectrum analyzer is configured to make measurements from one GOES satellite, with settings that are optimum to capture a portion of the DCPR uplink spectrum
  - An analyzer takes a snapshot in time and frequency, and depending on settings selected, may or may not capture the entire interference event
  - Data is taken over a 24-hour period, generating thousands of spectrum analyzer plots similar that shown on slide 5
- The interference has been seen on both GOES-W and GOES-E

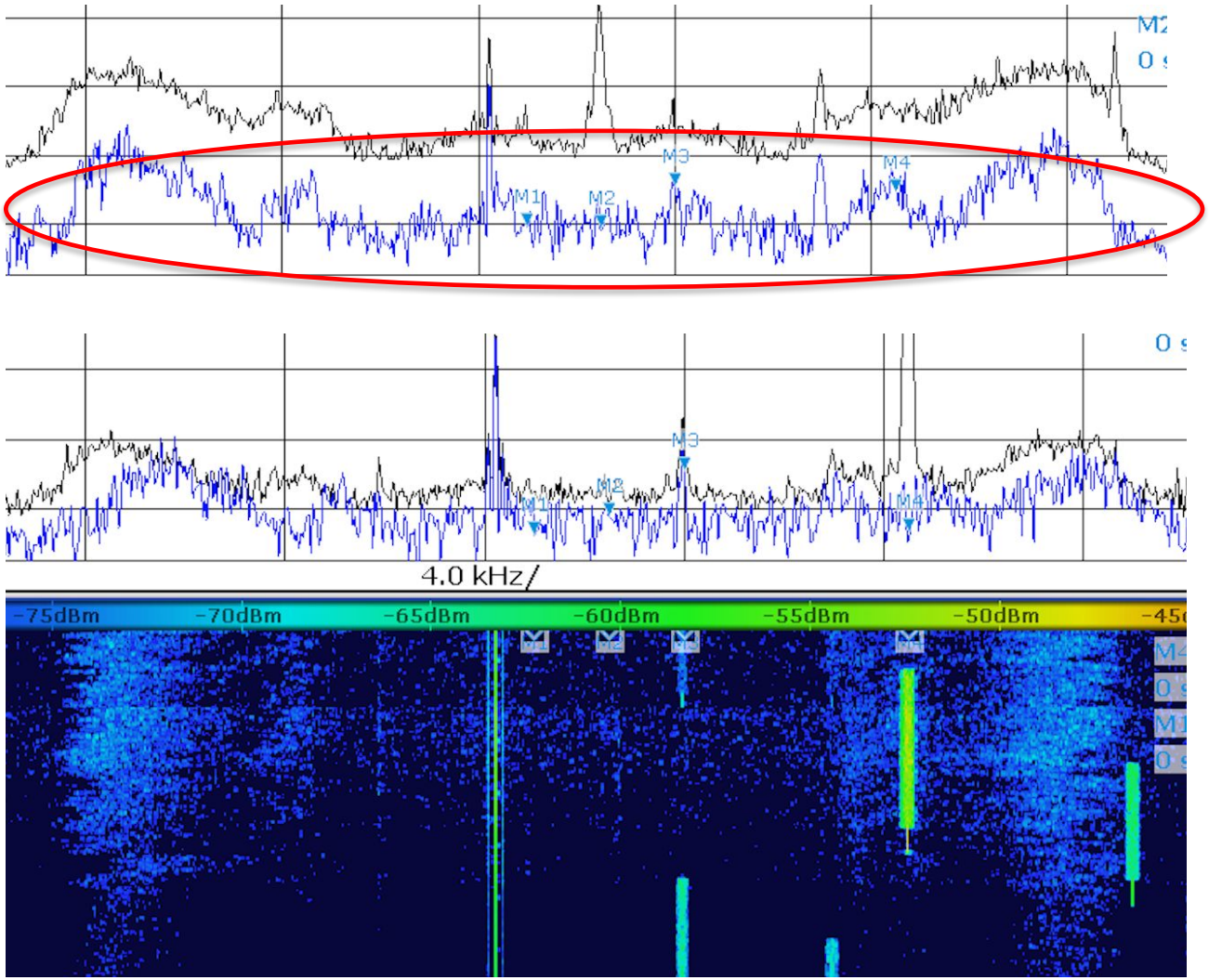
Interfering Satellite Uplink Example, cont.

- In spring 2020, measurements detected a 16 kHz wide signal
- It occurred over several frequencies that covered slightly different DCS channels
- The shaded areas of the spectrogram show the unwanted signal power seen by GOES



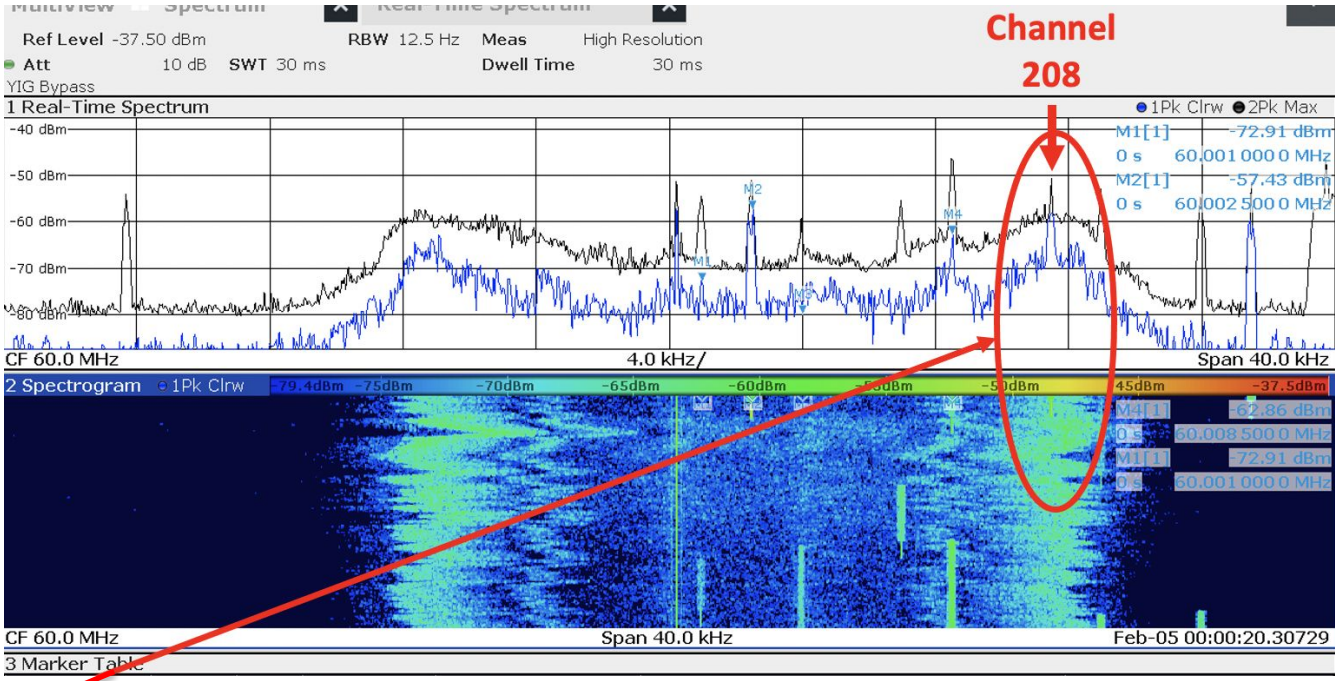
Interfering Satellite Uplink Example, cont.

- In late 2020 and early 2021, measurements began seeing a much wider interfering signal about 20 kHz wide
- In this image, the signal is shown with DCP that were likely unimpacted by the interference



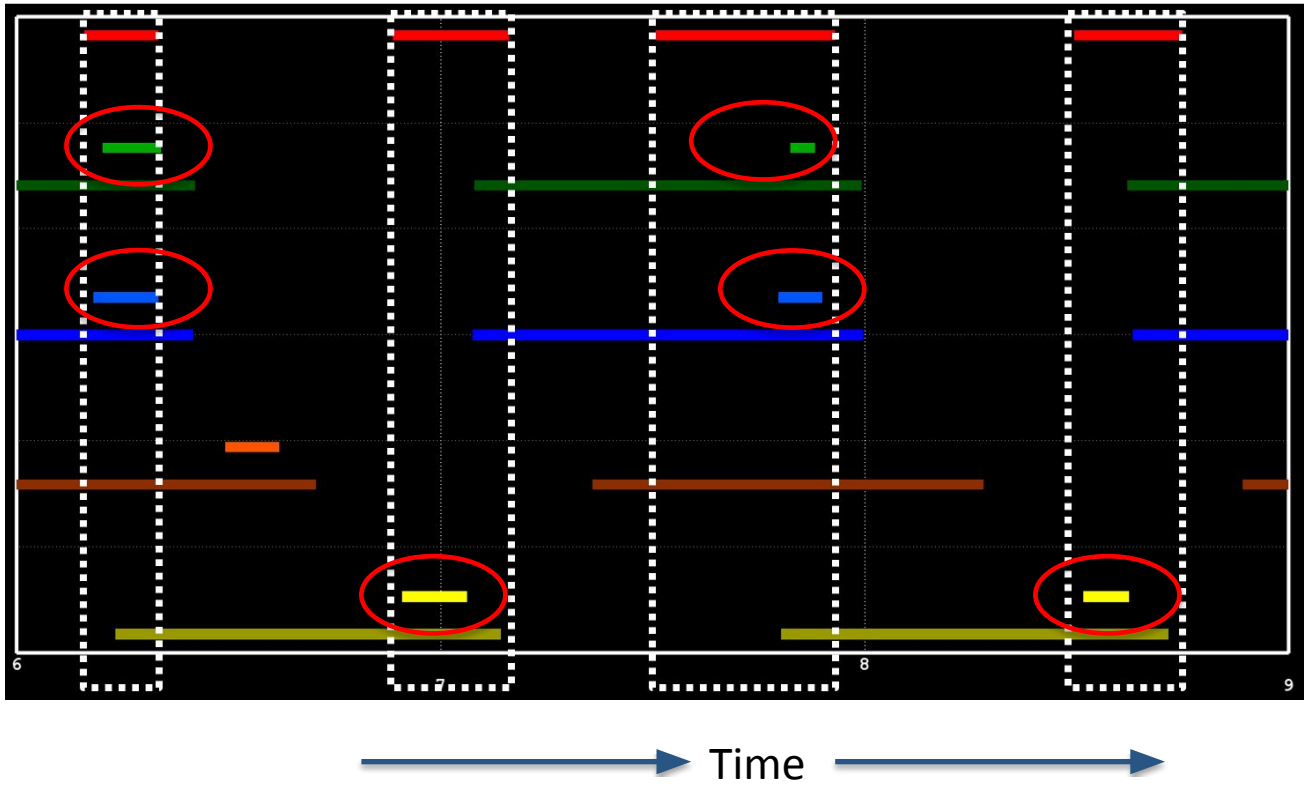
Interfering Satellite Uplink Example, cont.

- In some cases, the interference covers the desired DCP uplink, causing loss of that support
- This Ch 208 DCP was covered by the interference and not received



Correlation between RFI source and DCS

- Computer modeling of the interference source visibility to their moving satellite versus when interference was seen on GOES
- Green, Blue and Yellow signals correspond to RFI noted



Green, Blue and Yellow: Times when satellite could be seen by offending earth station, where uplinking would occur

White Box: Interference Time Durations

Interfering Satellite Uplink Example, cont.

- The prime candidate source for this particular system, is a three-satellite constellation of small satellites, about the size of a microwave oven, that orbit the earth multiple times per day
- They have three ground station locations, all in Canada, where this system is operated
- This company plans ten satellites in orbit by the end of 2022
- NOAA and ECCC are currently investigating the best next steps in resolving this issue.

Other Sources

- A few other sources were noted in our investigations. They were not quite as obvious to source type, when compared to the satellite uplink shown.
  - Further due diligence has not been performed on these signals, which appear to originate from Central and South America
- Our technical team may reach out to DCP operators in those countries for assistance in contacting frequency regulators or in coordinating discussions with a source of interference, once that potential source is identified.

Why Are We Seeing Other Services As Interference?

- The use of the radio spectrum follows a roadmap.
- This allocation is determined by the International Telecommunications Union (ITU)
- Our region of the world is Region 2; note the Earth-to-space use

Allocation to services		
Region 1	**Region 2**	**Region 3**
401-402	METEOROLOGICAL AIDS SPACE OPERATION (space-to-Earth) EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile 5.264A 5.264B	
402-403	METEOROLOGICAL AIDS EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile 5.264A 5.264B	

USA Frequency Use "Roadmap"

Table of Frequency Allocations			400.15-456 MHz (UHF)	
International Table			United States Table	
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table
401-402 METEOROLOGICAL AIDS SPACE OPERATION (space-to-Earth) EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile			401-402 METEOROLOGICAL AIDS (radiosonde) US70 SPACE OPERATION (space-to-Earth) EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) US64 US384	401-402 METEOROLOGICAL AIDS (radiosonde) US70 SPACE OPERATION (space-to-Earth) Earth exploration-satellite (Earth-to-space) Meteorological-satellite (Earth-to-space) US64 US384
402-403 METEOROLOGICAL AIDS EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile			402-403 METEOROLOGICAL AIDS (radiosonde) US70 EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) US64 US384	402-403 METEOROLOGICAL AIDS (radiosonde) US70 Earth exploration-satellite (Earth-to-space) Meteorological-satellite (Earth-to-space) US64 US384

United States use modified by a footnote to rules (US384) that effectively limits use to DCPs

US384 In the band 401-403 MHz, the non-Federal Earth exploration-satellite (Earth-to-space) and meteorological-satellite (Earth-to-space) services are limited to earth stations transmitting to Federal space stations.

Other Domestic Frequency Regulations in the Hemisphere Do Not Have A Restrictive Footnote on Use of This band

Brazilian Table of Frequency Allocation: ANATEL

MHz

REGIÃO 2	BRASIL
401-402 AUXÍLIO À METEOROLOGIA OPERAÇÃO ESPACIAL (espaço para Terra) EXPLORAÇÃO DA TERRA POR SATÉLITE (Terra para espaço) METEOROLOGIA POR SATÉLITE (Terra para espaço) Fixo Móvel exceto móvel aeronáutico	401-402 AUXÍLIO À METEOROLOGIA OPERAÇÃO ESPACIAL (espaço para Terra) EXPLORAÇÃO DA TERRA POR SATÉLITE (Terra para espaço) METEOROLOGIA POR SATÉLITE (Terra para espaço)
402-403 AUXÍLIO À METEOROLOGIA EXPLORAÇÃO DA TERRA POR SATÉLITE (Terra para espaço) METEOROLOGIA POR SATÉLITE (Terra para espaço) Fixo Móvel exceto móvel aeronáutico	402-403 AUXÍLIO À METEOROLOGIA EXPLORAÇÃO DA TERRA POR SATÉLITE (Terra para espaço) METEOROLOGIA POR SATÉLITE (Terra para espaço)

CANADIAN TABLE OF FREQUENCY ALLOCATIONS

MHz

401 - 402	METEOROLOGICAL AIDS SPACE OPERATION (space-to-Earth) EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile
402 - 403	METEOROLOGICAL AIDS EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile

Why Are We Seeing Other Services As Interference?

- Because under the roadmap adopted by each country, other uses of this band are permitted.
- With the growth in spectrum usage, small satellite uplinks for earth exploration or meteorological satellite applications are allowed.
- Private sector, non-government satellites may apply for use in accordance with the table of allocations
- GOES has seniority as they were licensed prior to these uses, but identifying the source is the first step in preventing such interference.