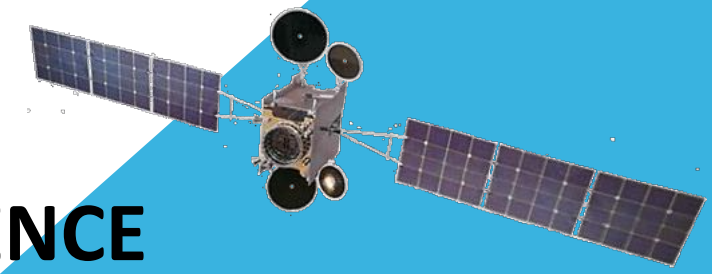


C-BAND DOWNLINK INTERFERENCE IN GEO SATELLITE NETWORKS ORIGIN, MITIGATION AND TROUBLESHOOTING

C BAND (GEO) SATELLITE SERVICES

DOWNLINK INTERFERENCE SOURCES AND THEIR INFLUENCE

TROUBLESHOOTING

INTERFERENCE MITIGATION

Prepared by Konstantin Busyrev

C-BAND IN THE SATELLITE COMMUNICATION

C-band was the first frequency band to be allocated for use by the satellite communications industry for Fixed and Broadcasting Satellite Services.

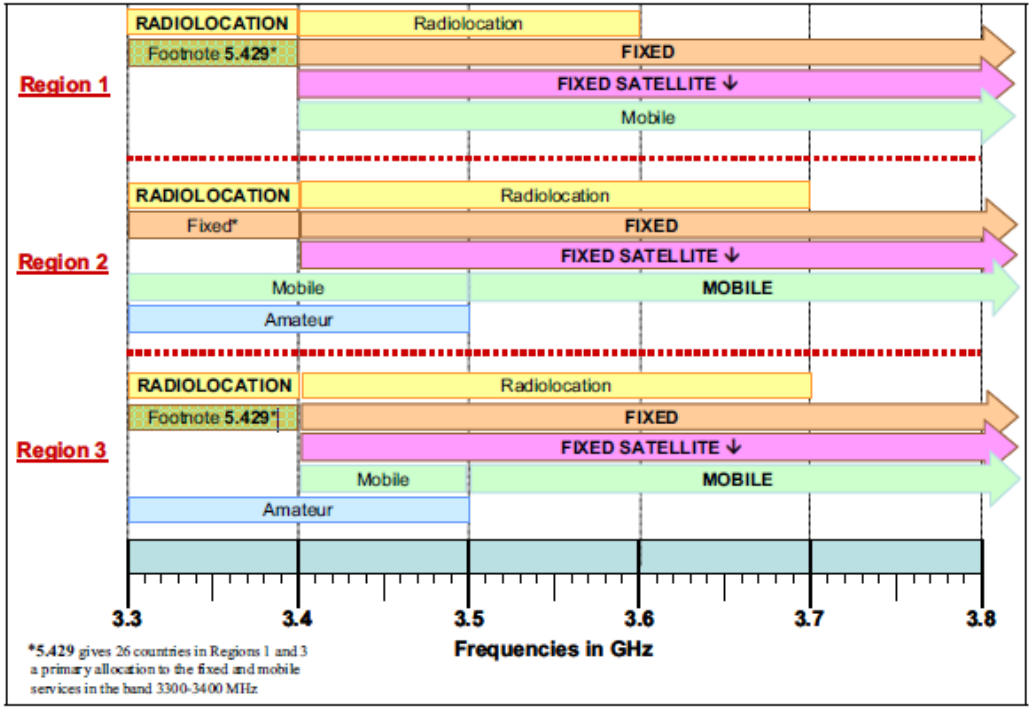
The large geographic coverage of C-band satellite beams represents a cost-effective communication solution, while its robustness to weather impairments makes C-band the most suitable band to guarantee high service availability.

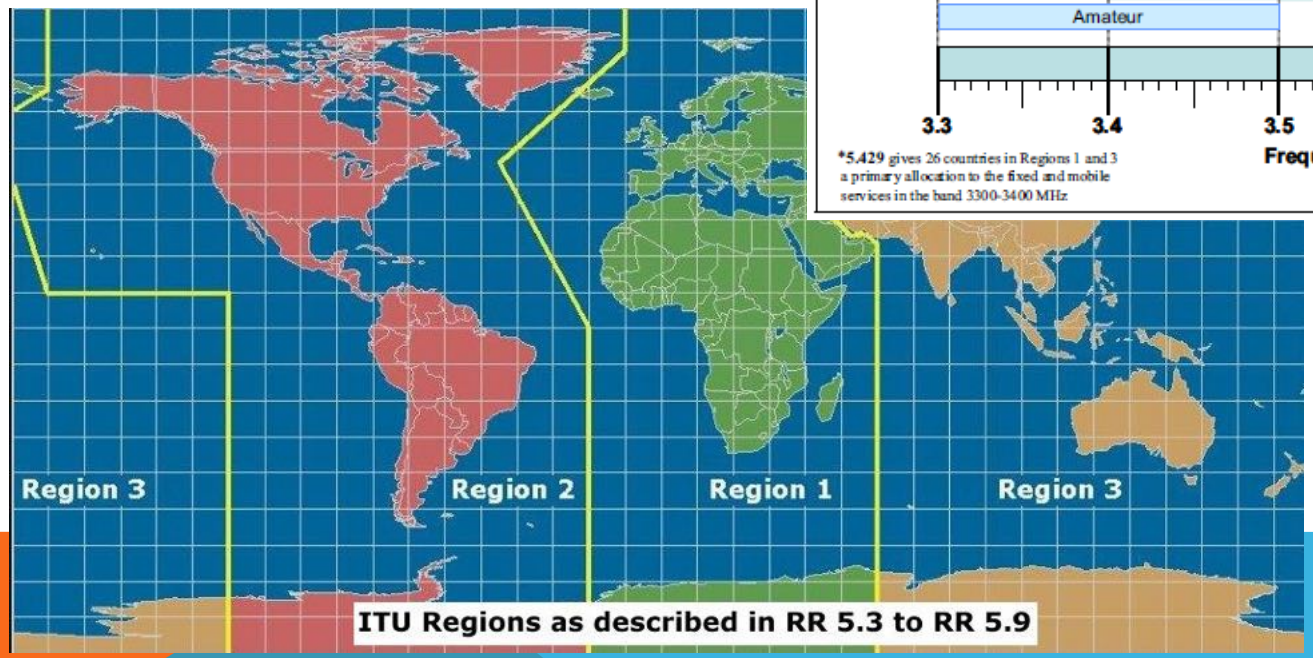
C-band frequencies have long been recognized to perform better under adverse weather conditions such as rain and snow fade in comparison with other satellite frequency ranges, such as Ku- and Ka-band. Although new frequencies have emerged over the years and are being used by the satellite industry, C-band still represents a highly significant portion of the total capacity currently supplied by satellites.

C-BAND FREQUENCY PLAN

Lower part of C-Band uses for:

- ✓ Fixed satellite services
- ✓ Radiolocation
- ✓ Broadband wireless access



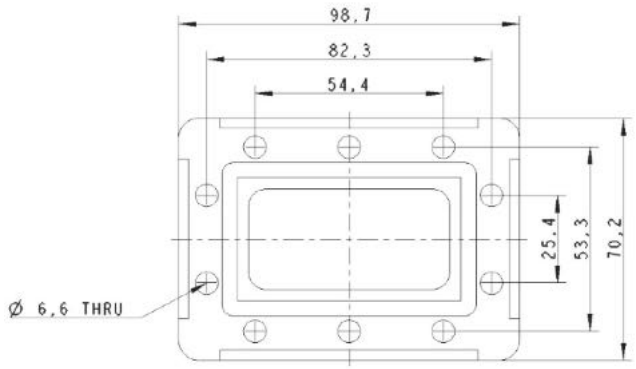


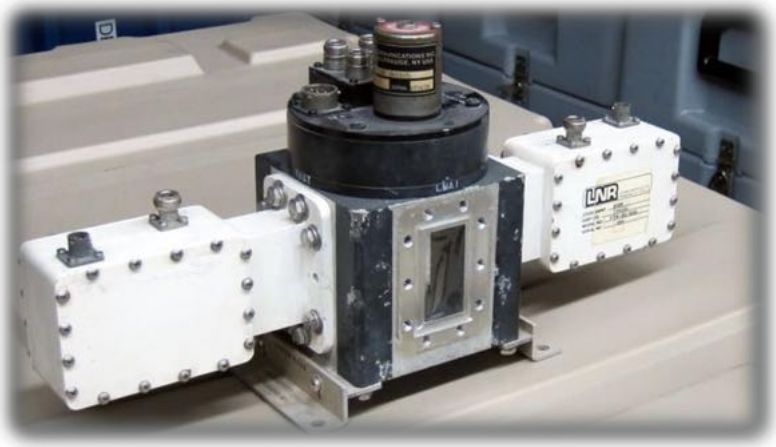
WR-229 CRITICAL FREQUENCY IS 2.58 GHZ

WR-229 waveguide size is 58.17x29.08mm

Critical Frequency for this waveguide 2.58 GHz

All frequencies upper 2.58 GHz affect to LNA

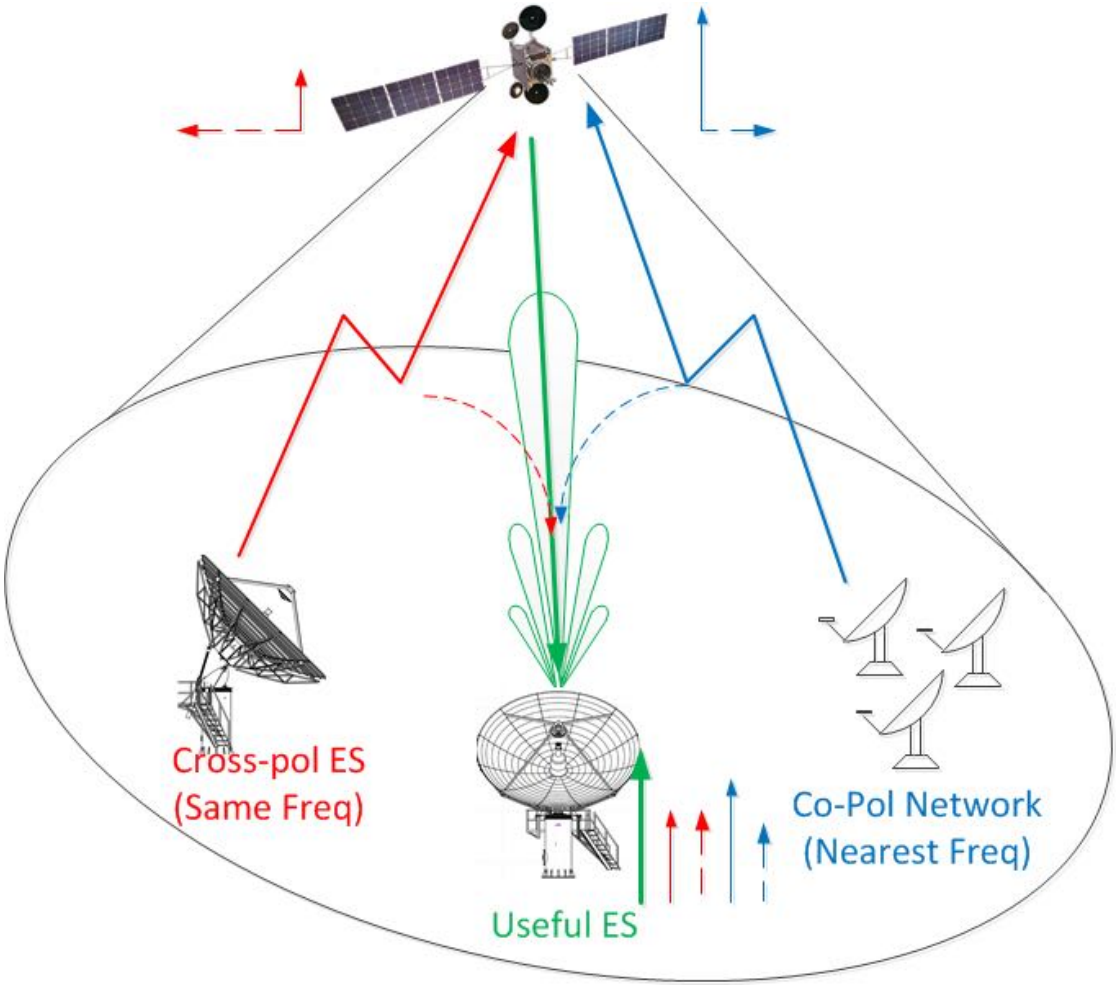




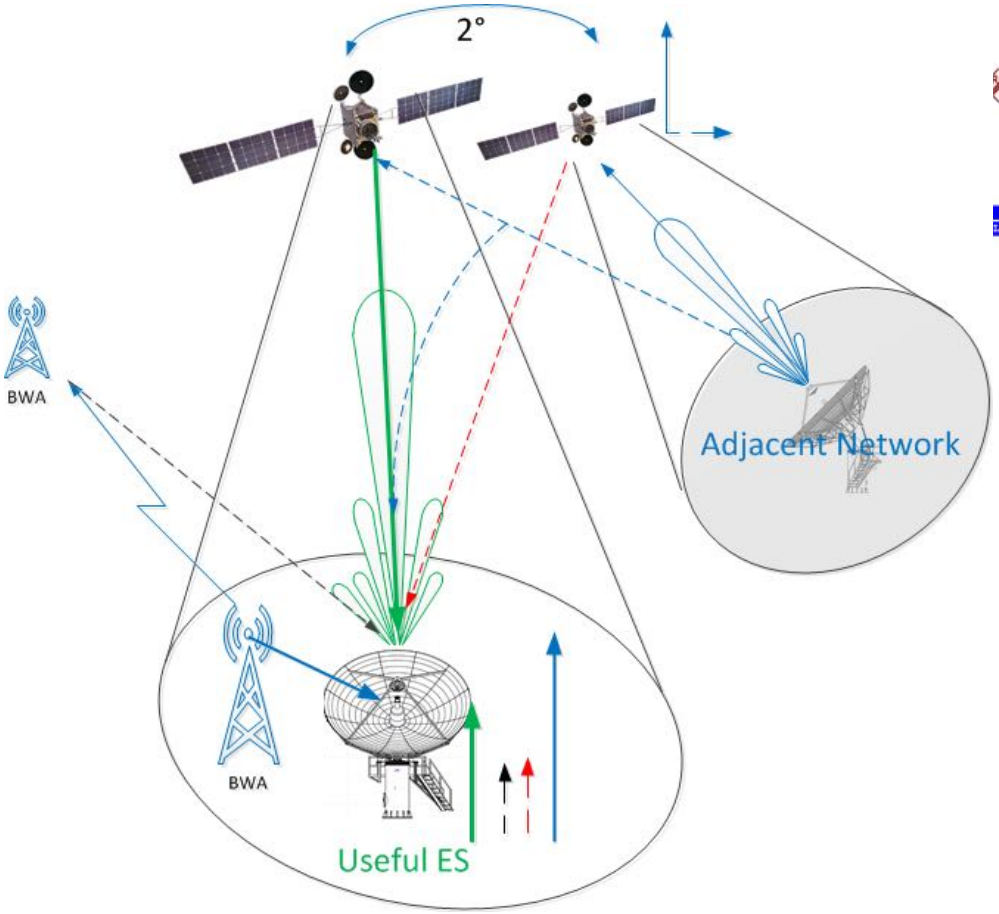
C-BAND DOWNLINK INTERFERENCE TYPES

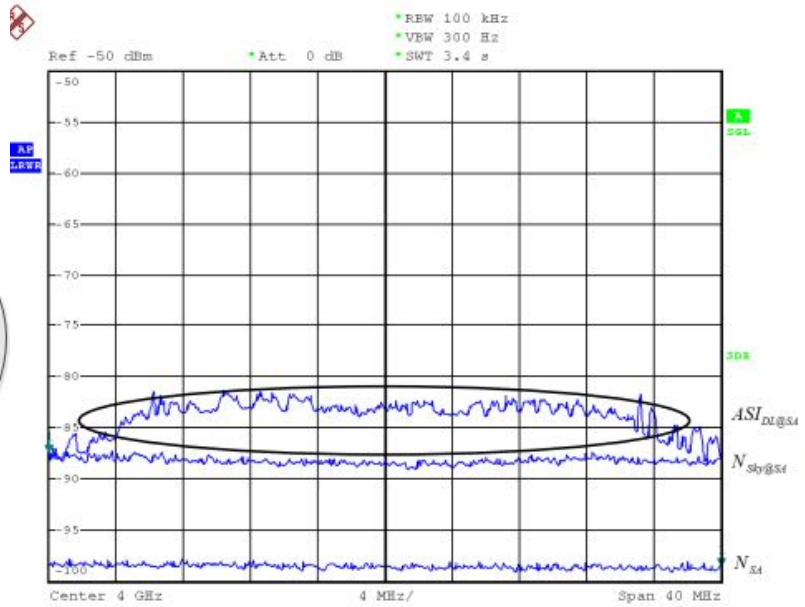
1. Adjacent satellite interference
2. Adjacent network interference (Cross Pol included)
3. Sun Interference
4. Tx to Rx out of band emission
5. Adjacent Fixed Wireless Broadband Access (FWBA) such as WiFi/WiMax etc.
6. Radars
7. Aircraft radar altimeter
8. Obstructions (Trees, Aircrafts, Vehicles etc.)

DOWNLINK INTRA SYSTEM INTERFERENCE

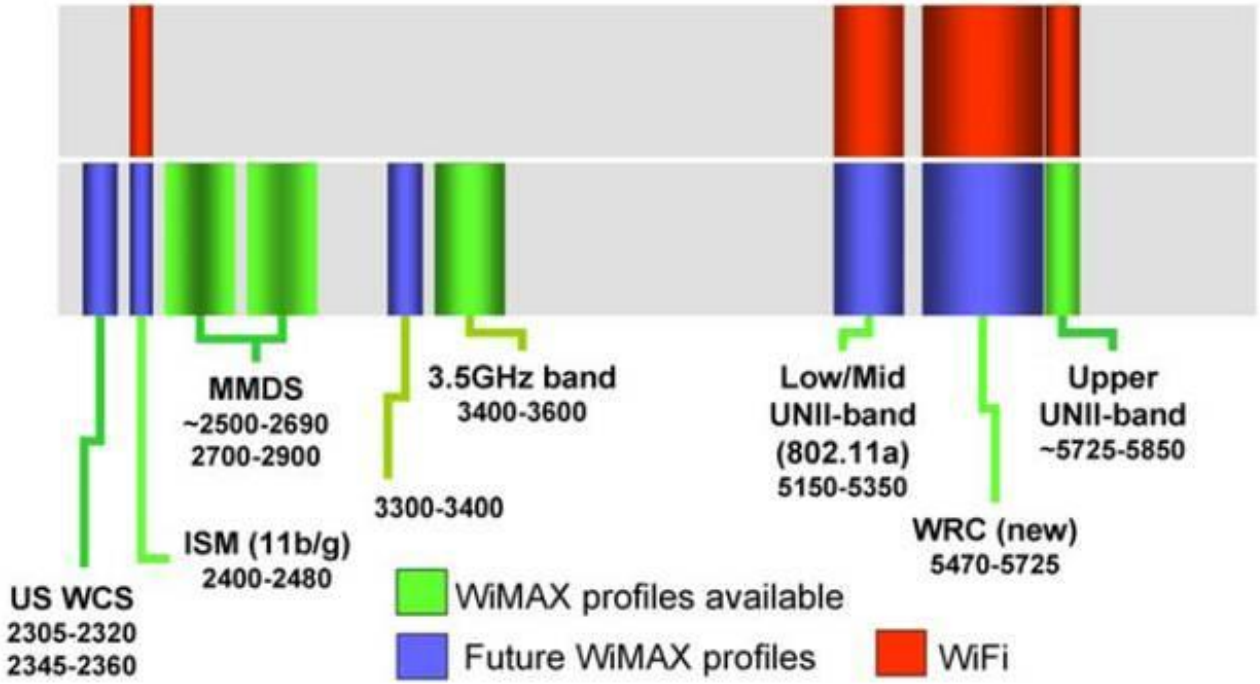


ADJACENT SYSTEMS DOWNLINK INTERFERENCE





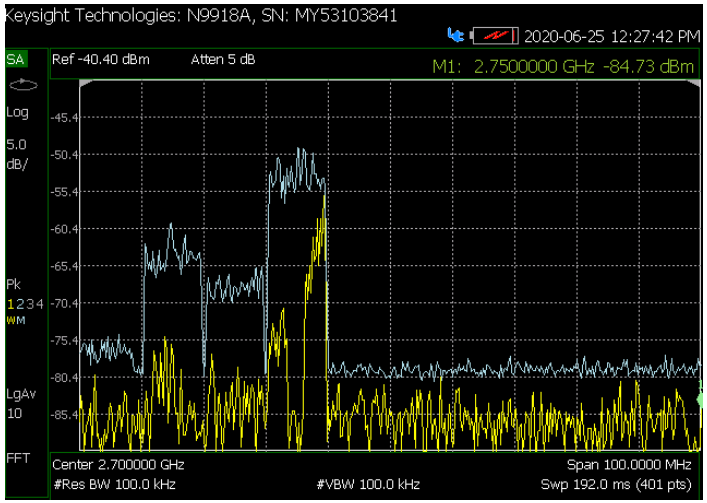
BROADBAND WIRELESS ACCESS INTERFERENCE

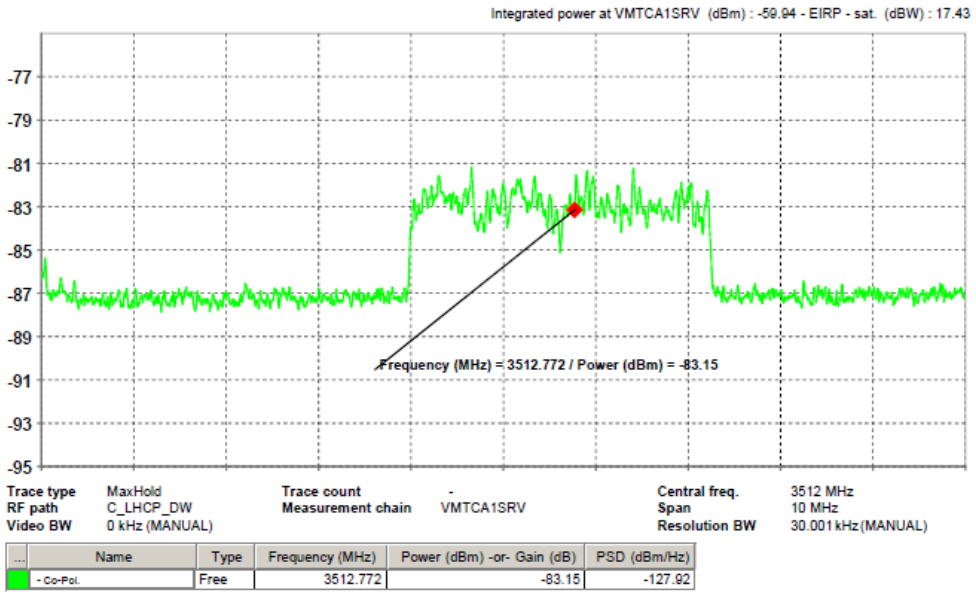


WiMAX certified system for the 3.5 GHz frequency band has:

- ✓ 3.40 - 3.60 GHz Frequency Range
- ✓ Output Power (at antenna input) Up to 21 dBm
- ✓ 18 dBi Antenna

BWA SPECTRUM PLOT IN 2,7GHZ AND 3,5 GHZ BAND





WiFi 2,7 GHz Plot

WiMax 3,5 GHz Plot

BWA Power level have shown on plots are non critical for Earth Station downlink.
It would affect if frequency is be the same for ES and BWA

WIMAX SPURIOUS AND OUT OF BAND EMISSIONS

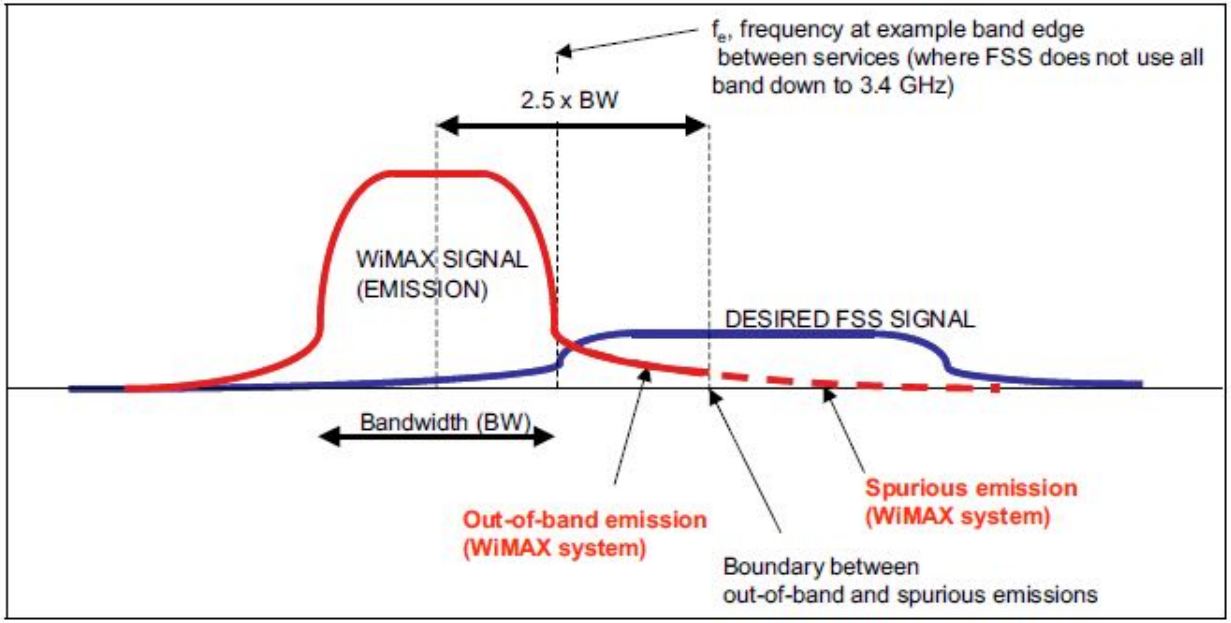
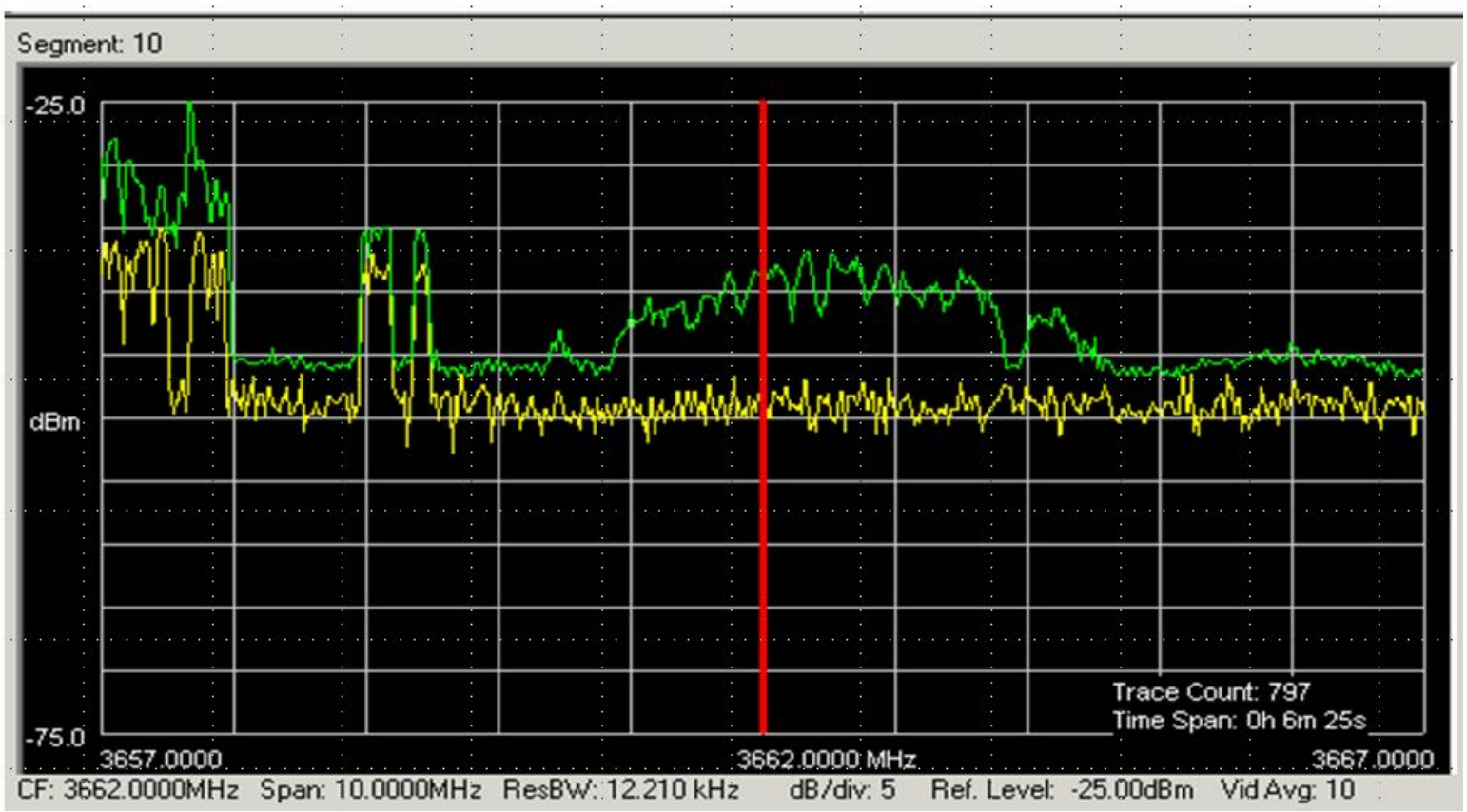


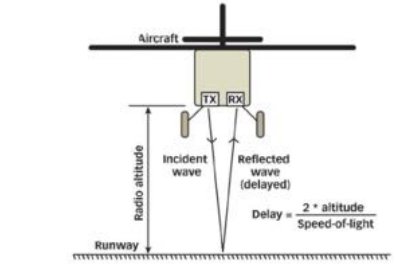
Illustration of the way in which interference due to out-of-band and spurious emissions may be caused from WiMAX systems into FSS earth station receivers in an adjacent band.

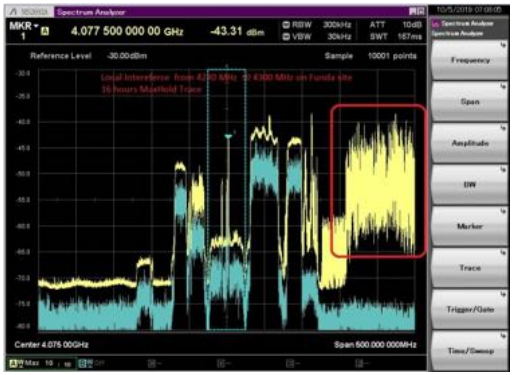
RADAR INTERFERENCE

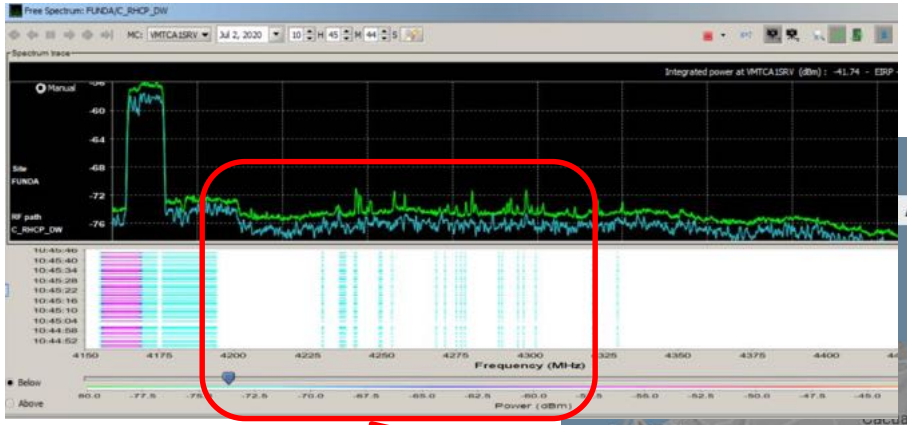


AIRCRAFT RADAR ALTIMETERS

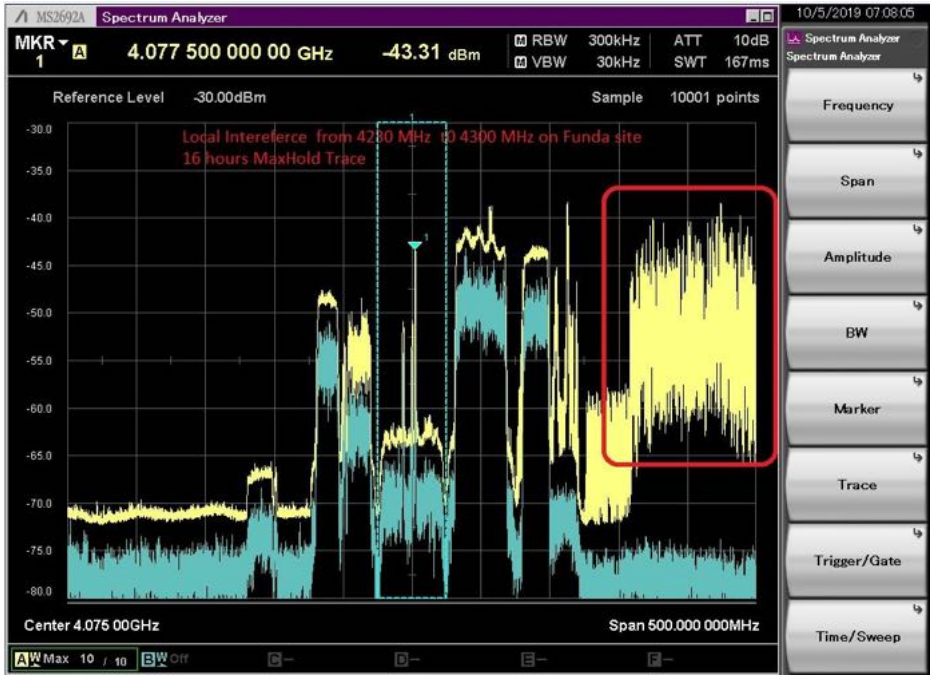
Aviation radio altimeters operate in the 4.2-to-4.4-GHz frequency band.
Transmitter power ranges are up to 500 mW (+27 dBm).
The directivity of transmit antenna is limited to about 10 dBi to allow the operation of the radio altimeter at moderate pitch and roll angles of the aircraft.

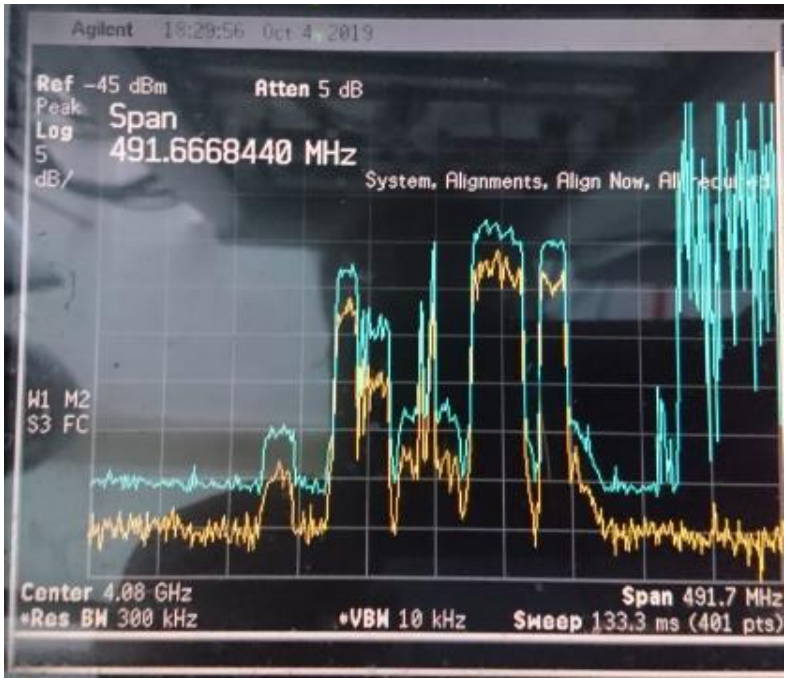




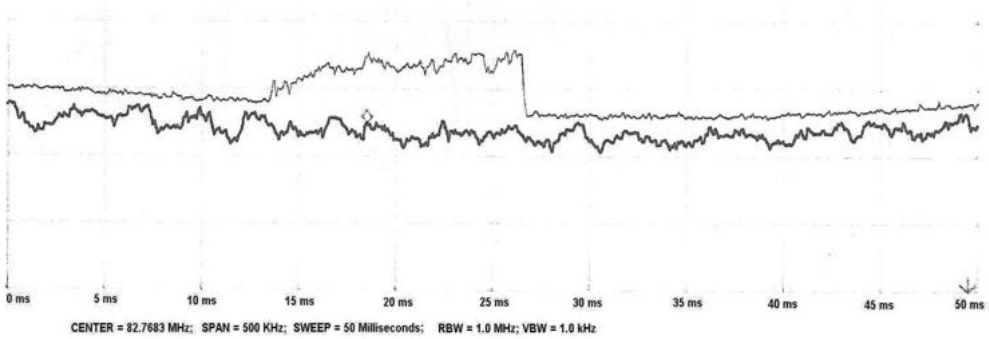


AIRCRAFT RADAR ALTIMETER EMISSION RESULT

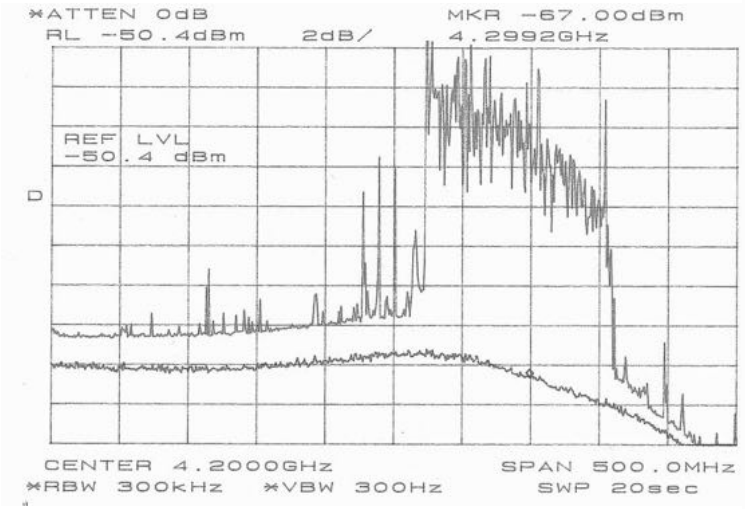


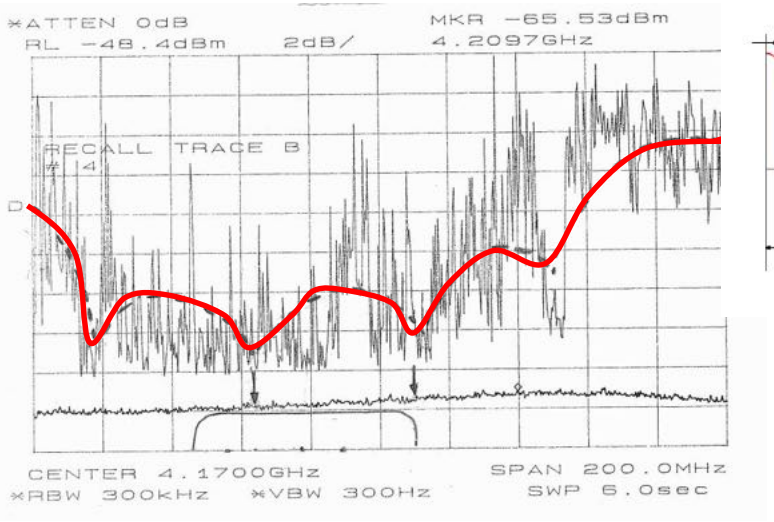


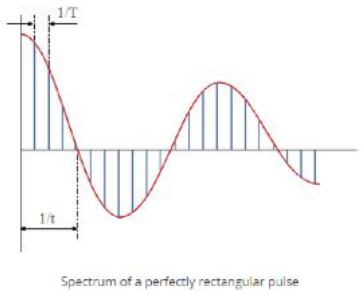
AIRCRAFT RADAR ALTIMETER EMISSION RESULT



Interference Frequency 4300 MHz
Interference type: Impulses 10.. 20 ms







Spectrum of a perfectly rectangular pulse

$$\gamma = \frac{\sin(x)}{x}$$

AIRCRAFT RADAR ALTIMETER INTERFERENCE ATTRIBUTES

- ✓ The interference in most cases has a clear schedule several times per a day or a week
- ✓ Simultaneous impact at earth stations located nearby
- ✓ Short exposure time (10..20 ms) during several seconds
- ✓ The interference affects whole or almost of whole services
- ✓ It detects only with a quick sweep on a spectrum analyzer
- ✓ The spectrum looks like an array of randomly occurring harmonic carriers
- ✓ In a wide range, the spectrum envelope has the form same as Sin(X)/X
- ✓ The spectrum at 4300 MHz (in MaxHold mode) corresponds to the plots above

EARTH STATION`S LNA SATURATION

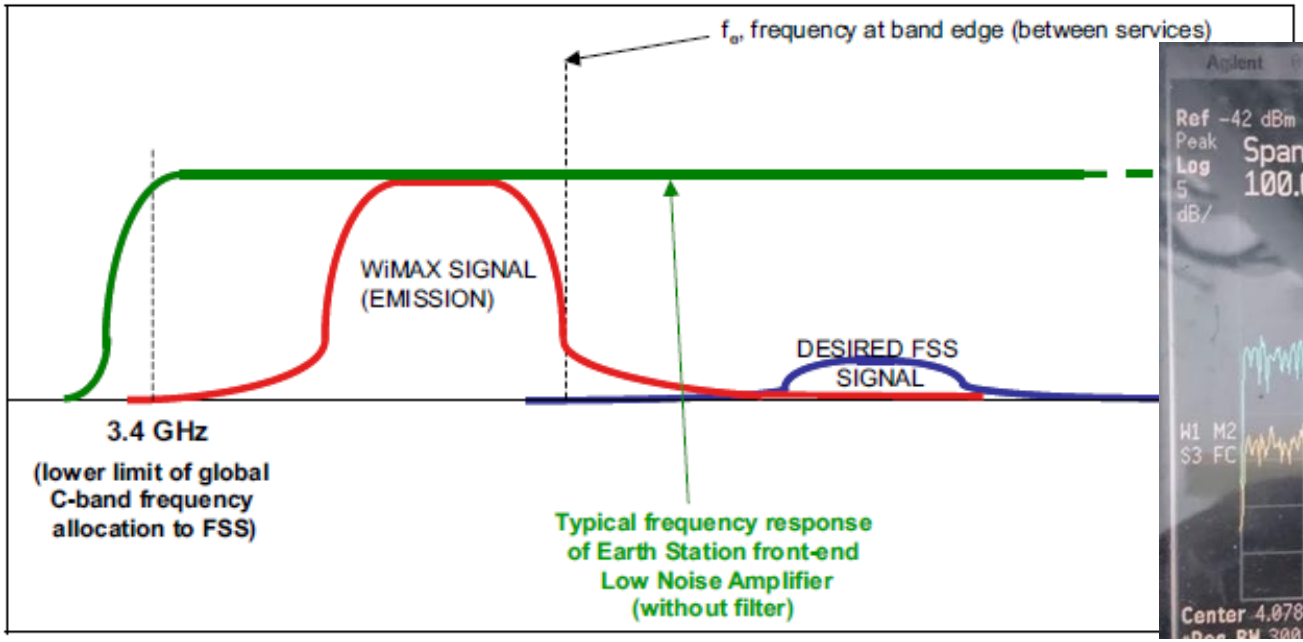


Illustration of the case where compression/saturation of an earth station front-end amplifier can occur from a nearby terrestrial interference emission within the passband of the amplifier.

EARTH STATION`S LNA SENSITIVITY

GEO satellite earth stations use extremely sensitive receivers.

The power density for long-term interference for earth station is typically of the order of -148dBW/MHz.

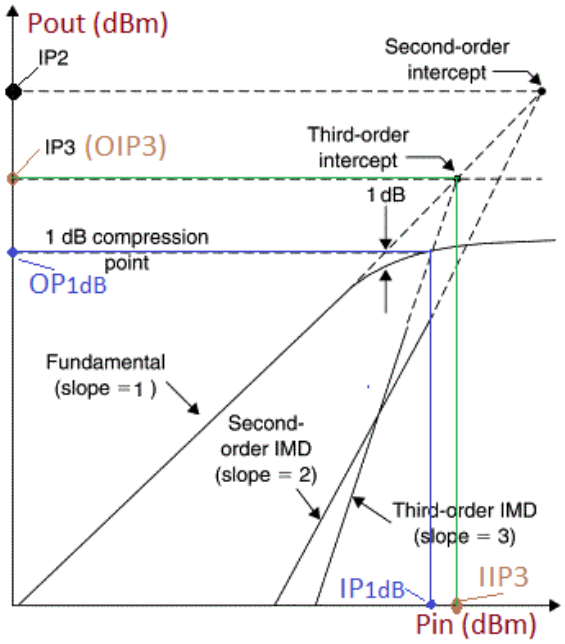
Rx equipment sensitivity is so high, that not only main beam has to be considered, but also side lobes should be taken into account.

So this requires significant isolation to protect the Earth station from nearby BWA or Radar systems transmissions.

Also third order interference, caused by LNA is important. Third orders may by estimated and adjusted by choosing appropriate equipment.

The level of third order interference may be estimated as $CI_3=2*(OIP_3-S_{out})$.

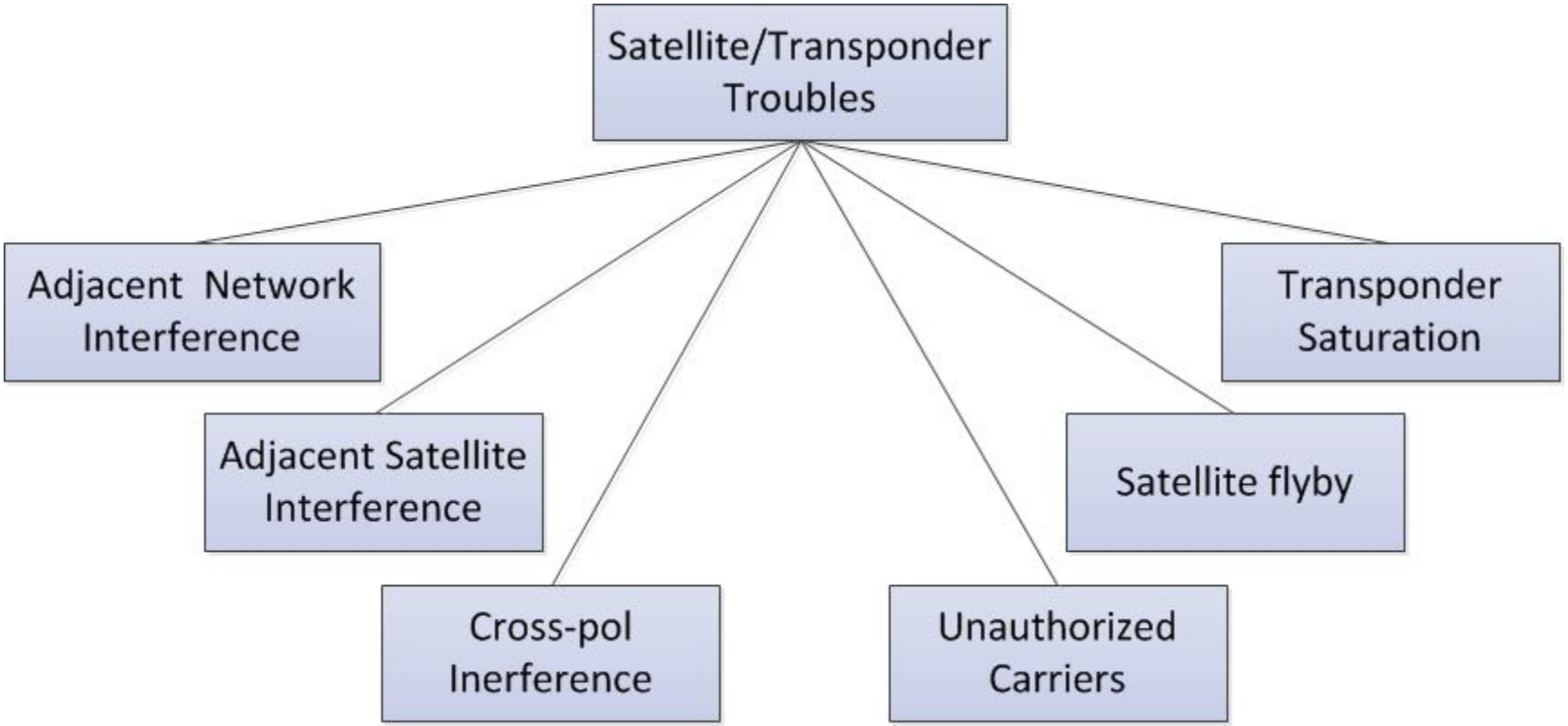
CI_3 level has to be 20-30 dB below the level of LNA output signal, depending on signal modulation.



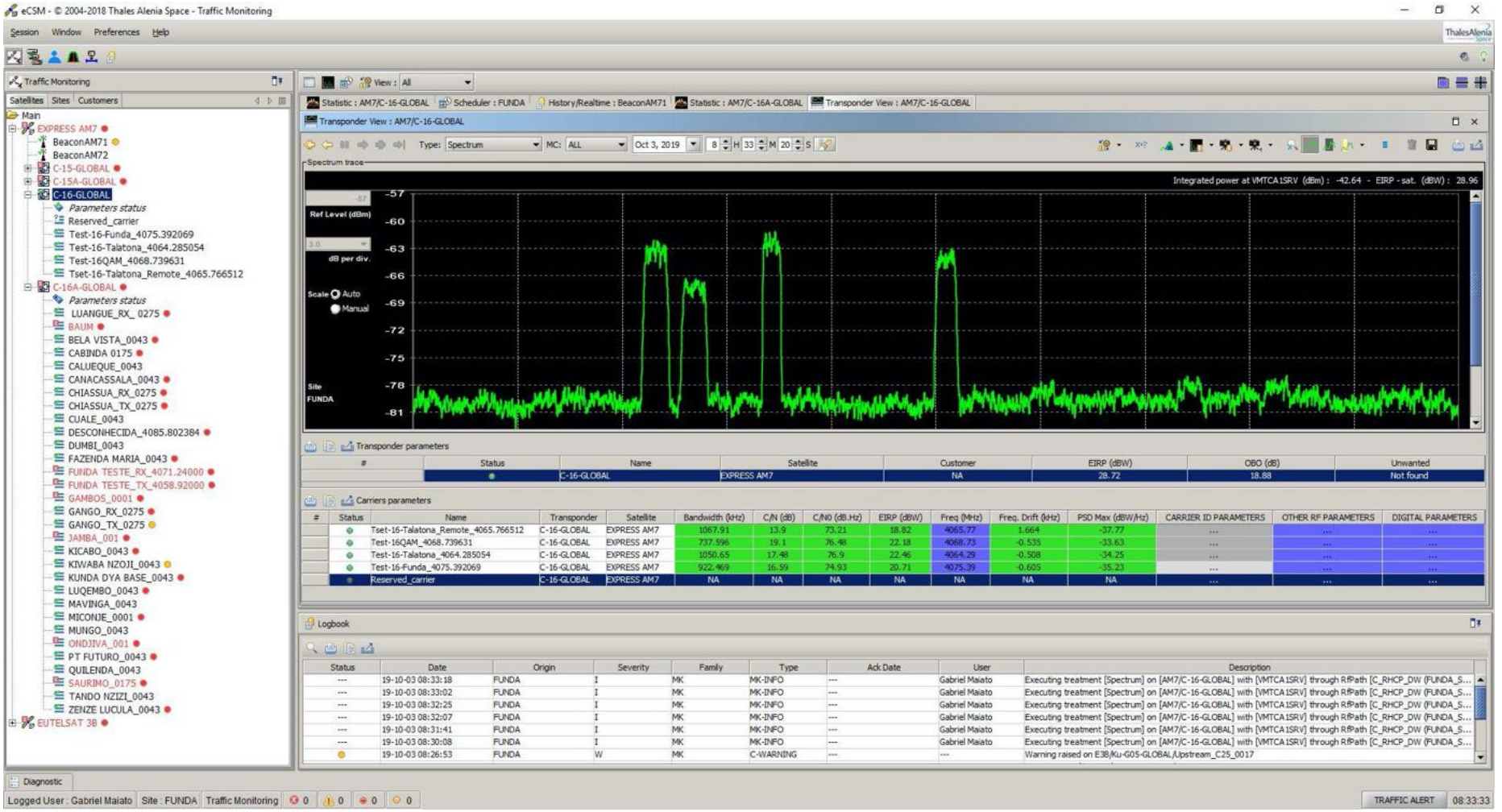
OTHER FACTORS

- ✓ Satellite Transponder Saturation/Compression
- ✓ Weather Conditions
- ✓ Satellite Flyby
- ✓ Sun Interference
- ✓ Obstructions (Trees, Aircrafts, Vehicles etc.)
- ✓ Earth station`s RF Equipment or cables faulty

TROUBLESHOOTING (SATELLITE PROBLEM)



COMMUNICATION SYSTEM MONITORING



CSM GENERAL FUNCTIONS

Carriers monitoring at RF level :

- Downlink EIRP
- Transponder aggregate power
- Central frequency
- Bandwidth
- C/N; C/N0

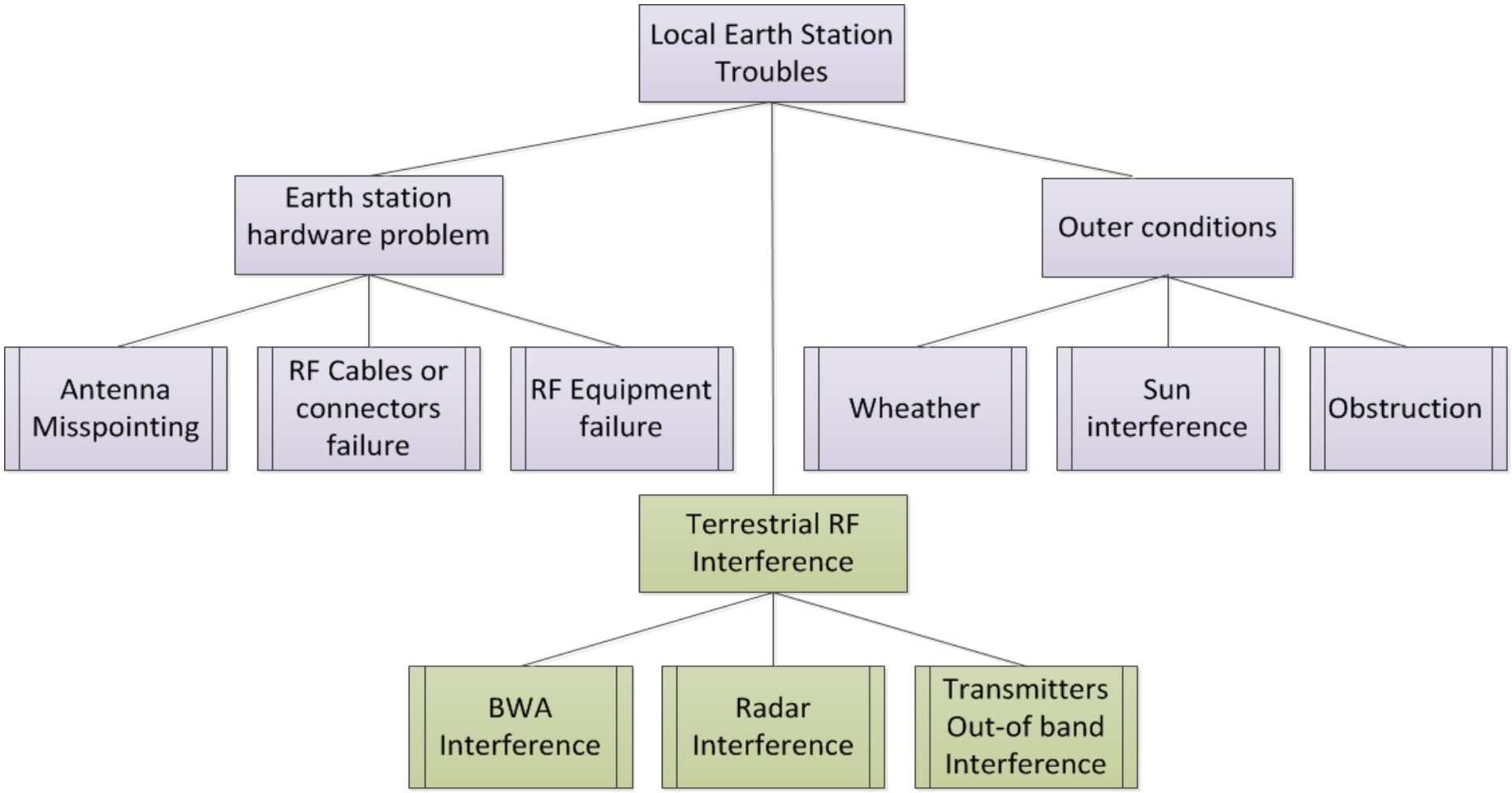
Digital parameters monitoring

allows to determine the main digital characteristics of a signal:

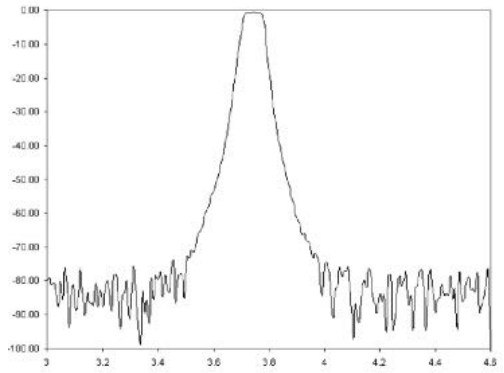
- Standards: IESS 308 309 310 314, DVB-S,DVB-SNG,DVB-S2(x)
- Modulation type and FEC
- Inner / Outer code
- BER & Eb/No

- ✓ Check the quality of satellite services in an automatic background mode
- ✓ Telecom Carrier Analyzer 10 times faster than a spectrum analyzer
- ✓ Unexpected carriers detection and characterization (also MF TDMA, CnC)
- ✓ Historical and statistic monitoring data, customer management

TROUBLESHOOTING (LOCAL PROBLEM)



BANDPASS FILTERS



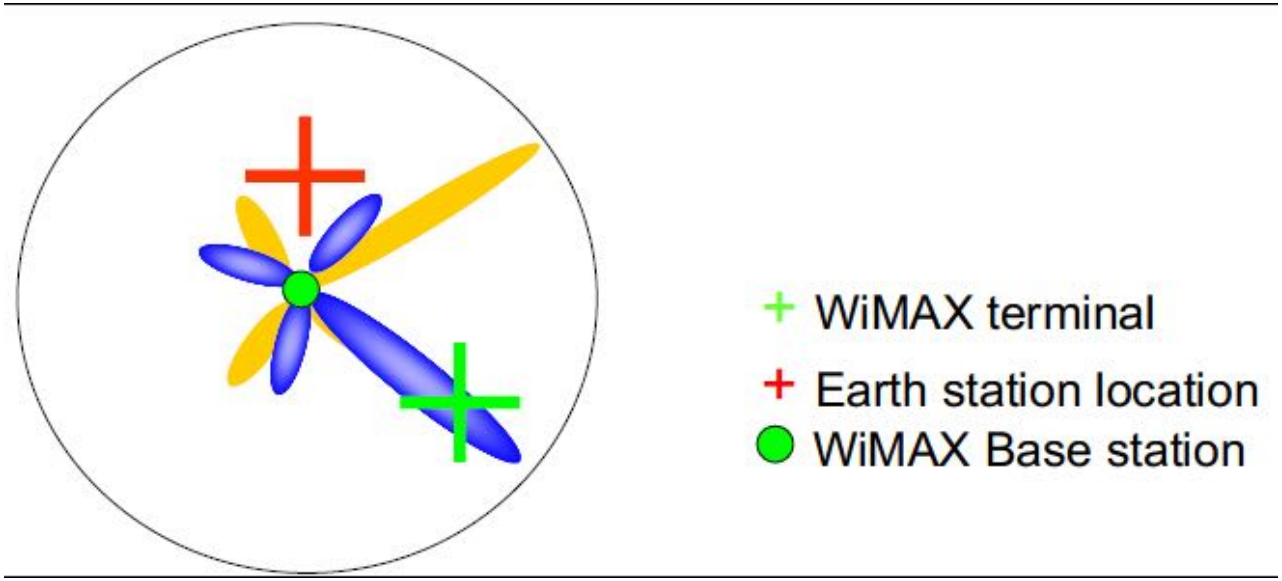
Rejects terrestrial interference in C-Band:

- ✓ WiFi/WiMax
- ✓ 5G
- ✓ Radar
- ✓ C-Band transmitter

Is used for interference reducing inside the standard receiver bands as a single transponder bandpass or Multi-purpose filter (with specific frequencies rejection).
These solutions offer the highest rates of success, by providing up to 75dB of protection against interference.
It should be noted that Waveguide Filters create insertion loss which may be unacceptable, depending on the link budget information specific to the downlink site. The insertion loss of a typical standalone Waveguide Filter will result in a carrier to noise (C/N) reduction by ~0.5-1.0dB

http://microwavefilter.com.s3-website-us-east-1.amazonaws.com/pdffiles/19759.pdf

BEAM STEERING COORDINATION



Use of beam steering with adaptive antennas on WiMAX base stations can help to ensure that known directions of interference victims such as earth stations can be avoided.
Of course this will only work if the WiMax base station and earth station are officially registered.

SHIELDING

EARTH STATION LOCATION IS IMPORTANT

The location of your Earth station can be a significant factor impacting reception of C Band satellite signals.

Ideally, satellite dishes should be mounted on the ground level away from elevated sources of interference, using buildings or natural barriers to shield the dish from known sources of interfering signals.

It should be noted that interference is likely to be more severe when receiving satellites that have a low look angle, although this does not preclude interference on dishes set to high elevation values.

Relocation of a satellite dish to a more protected area is a practical last resort option.

AT THE END

- ✓ C-Band for satellite networks nowadays and in the nearest future will continue to be in demand at least until the beginning of the reduction of the orbital group.
- ✓ Frequency Band 3.8-4.2 GHz will not alienated from FSS to FBWA in the nearest Future at least if we are not talking about the USA and China.
- ✓ The influence of local terrestrial interference could be reduce the performance of your C-band satellite network but you can mitigate it.
- ✓ The searching for interference and its source will be more effective if you coordinate with the Satellite owner or capacity provider who have spectrum and quality control tools.

THANK YOU
FOR YOUR ATTENTION!

Konstanin Busyrev

STECCOM Company

Moscow, Russia

K.Busyrev@steccom.ru

July, 22 2020