ALION

Demystifying Spectrum

Interference Propagation Variances

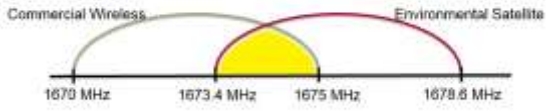
Radio Frequency Interference (RFI) Definitions

- Radio Regulations (RR1.166 to RR1.169) define interference as follows:
  - **Interference**: the effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.
  - **Permissible interference**: Observed or predicted interference which complies with quantitative interference and sharing criteria contained regulations or in ITU-R Recommendations or in special agreements as provided for in regulations.
  - **Accepted interference**: Interference at a higher level than that defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations.
  - **Harmful interference**: interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations.

Sound Wave Interference Example

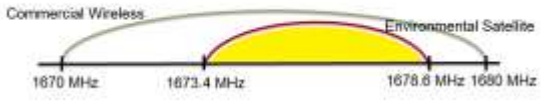
- Two people are having a conversation without issue when a telephone rings; the person listening now has trouble understanding due to added noise

Spectrum Sharing – Partial Frequency Overlap



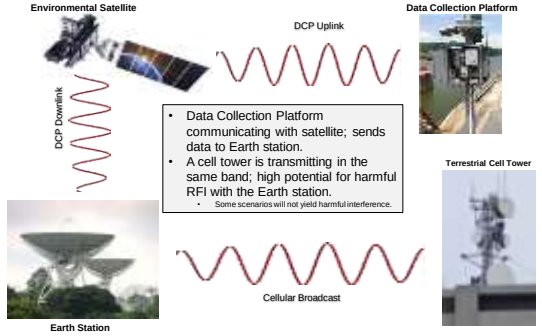
- Commercial Wireless transmits terrestrial broadcasts in the 1670 – 1675 MHz Band
- An Environmental Satellite transmits Sensor Data in the 1673.4 – 1678.6 MHz Band
- Partial Radio Frequency overlap occurs between 1673.4 -1675 MHz: Possibly Permissible Interference, with occasional harmful RFI.

Spectrum Sharing – 100% Frequency Overlap



- Commercial Wireless transmits terrestrial broadcasts in the 1670 – 1680 MHz Band
- An Environmental Satellite transmits Sensor Data in the 1673.4 – 1678.6 MHz Band
- 100% Radio Frequency overlap occurs to the satellites Sensor Data link: High probability for Harmful Interference

Radio Frequency Interference Example



- Data Collection Platform communicating with satellite; sends data to Earth station.
- A cell tower is transmitting in the same band; high potential for harmful RFI with the Earth station.
  - Some scenarios will not yield harmful interference.

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Propagation Mechanisms

- Interference may arise through a range of propagation mechanisms whose individual dominance depends on climate, radio frequency, time percentage of interest, distance and path topography. At any one time, a single mechanism or more may be present. The principal interference propagation mechanisms and models are as follows (excerpt from ITU R-REC-P.452):
  - Line-of-sight
  - Diffraction
  - Tropospheric scatter
  - Surface Ducting
  - Elevated layer reflection or refraction
  - Hydrometeor scatter
  - Terrain Loss
  - Freespace path loss
  - Clutter Loss
  - Gaseous attenuation
  - Mulitpath enhancement

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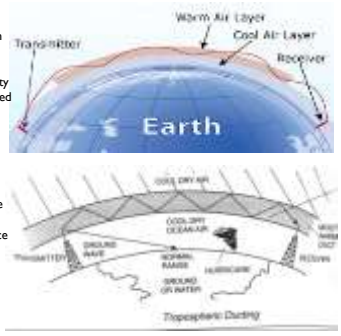
Tropospheric Ducting

- Electromagnetic (EM) wave propagation that are not encountered in a standard atmosphere due to a non-standard distribution of temperature and humidity with height in the atmosphere (as defined in Wikipedia by the World Meteorological Organization (WMO) 2012-09-10).
- Yields Anomalous Propagation through Atmospheric Ducting
- An atmospheric duct occurs when the inversion is very strong and shallow; the Electromagnetic wave is trapped within the inversion layer. The beam will bounce many times inside the layer as within a waveguide.



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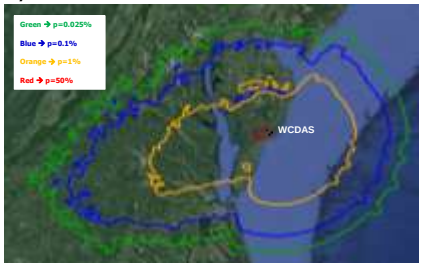
Different p% Results

- Different p% values used during interference assessment analyses have different results.



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Variances in Protection Criteria

- An important and complicated factor in any interference study is identifying the Interference Protection Criteria (IPC).
  - Determine necessary distance or frequency sharing constraints.
  - The NTIA, FCC, and International Telecommunication Union (ITU) have multiple definitions for interference.
    - Interference, Permissible Interference, Accepted Interference, and Harmful Interference.
  - To accurately assess the various models behind these interference classifications, numerous combinations of radio frequency interference situations must be considered.
    - E.G. terrestrial-terrestrial, terrestrial-space, aggregate, single source, power variations, modulations, etc. as appropriate.
- One important consideration for accurate interference assessments is the propagation percentages (p%) that are used during an analysis.
  - Propagation percentage is the percentage of time that the path loss is less than predicted, thus the received signal (interference) level is greater than predicted p% of the time.