Spectrum Protection: An Examination of the Policy and Practical Implications

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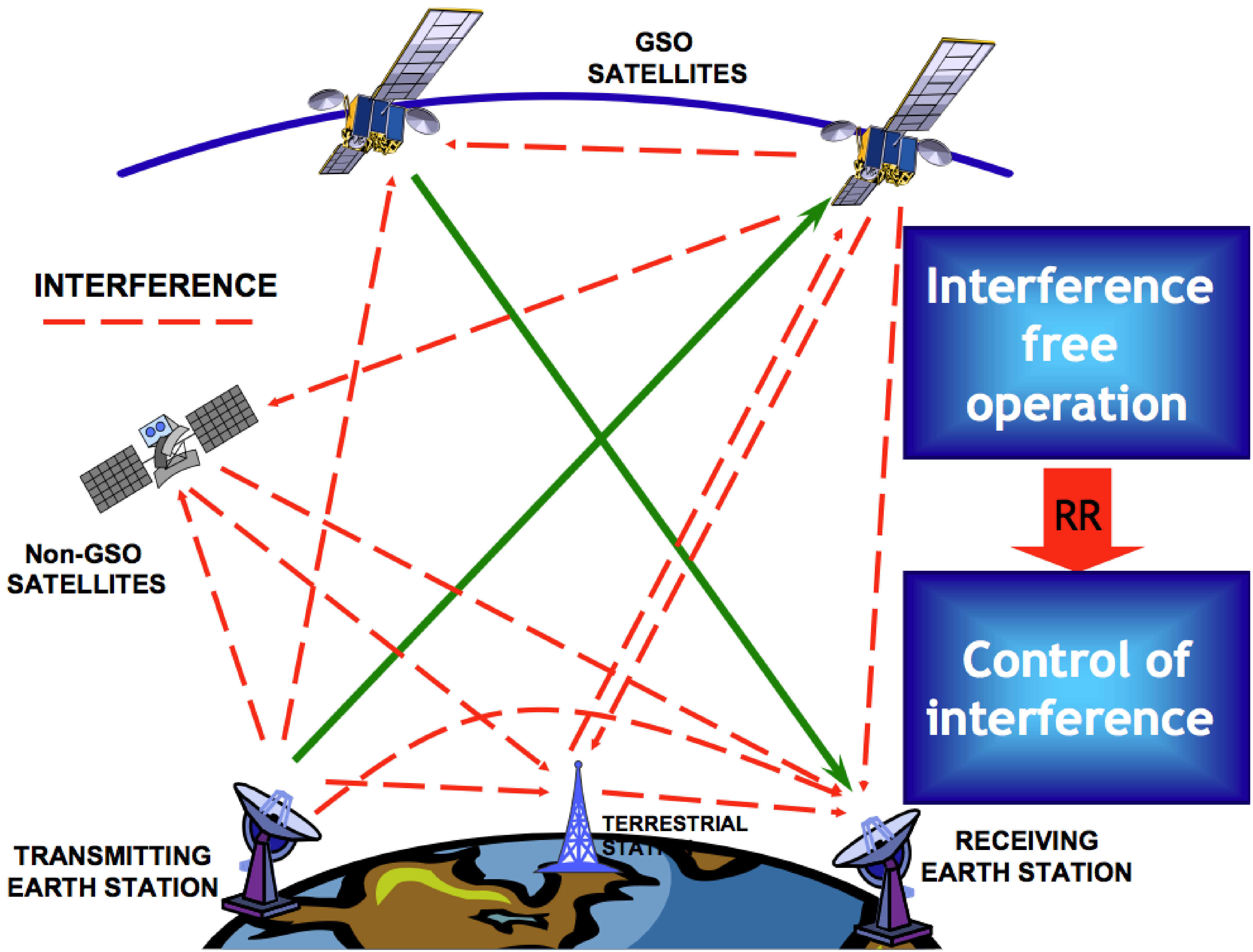
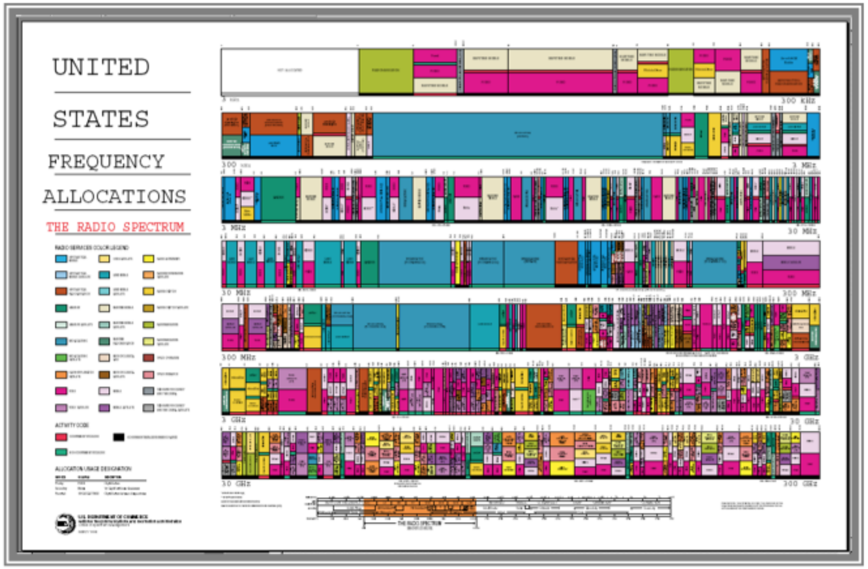


GSO
SATELLITES
INTERFERENCE
Non-GSO
SATELLITES
Interference free operation
RR
Control of interference
TRANSMITTING
EARTH STATION
TERRESTRIAL
RECEIVING
EARTH STATION

Spectrum Management

Four Major Spectrum Management Functions

- **Allocate Spectrum** to various radio services
- **Develop Service Rules** to provide administrative procedures, technical standards, and other operational requirements for shared intra- and inter-service use of the spectrum
- **Assign Frequencies** to individual systems or authorizes specific equipment use, assignments coordinated domestically and internationally
- **Enforce Rules** to ensure radio equipment and system compliance

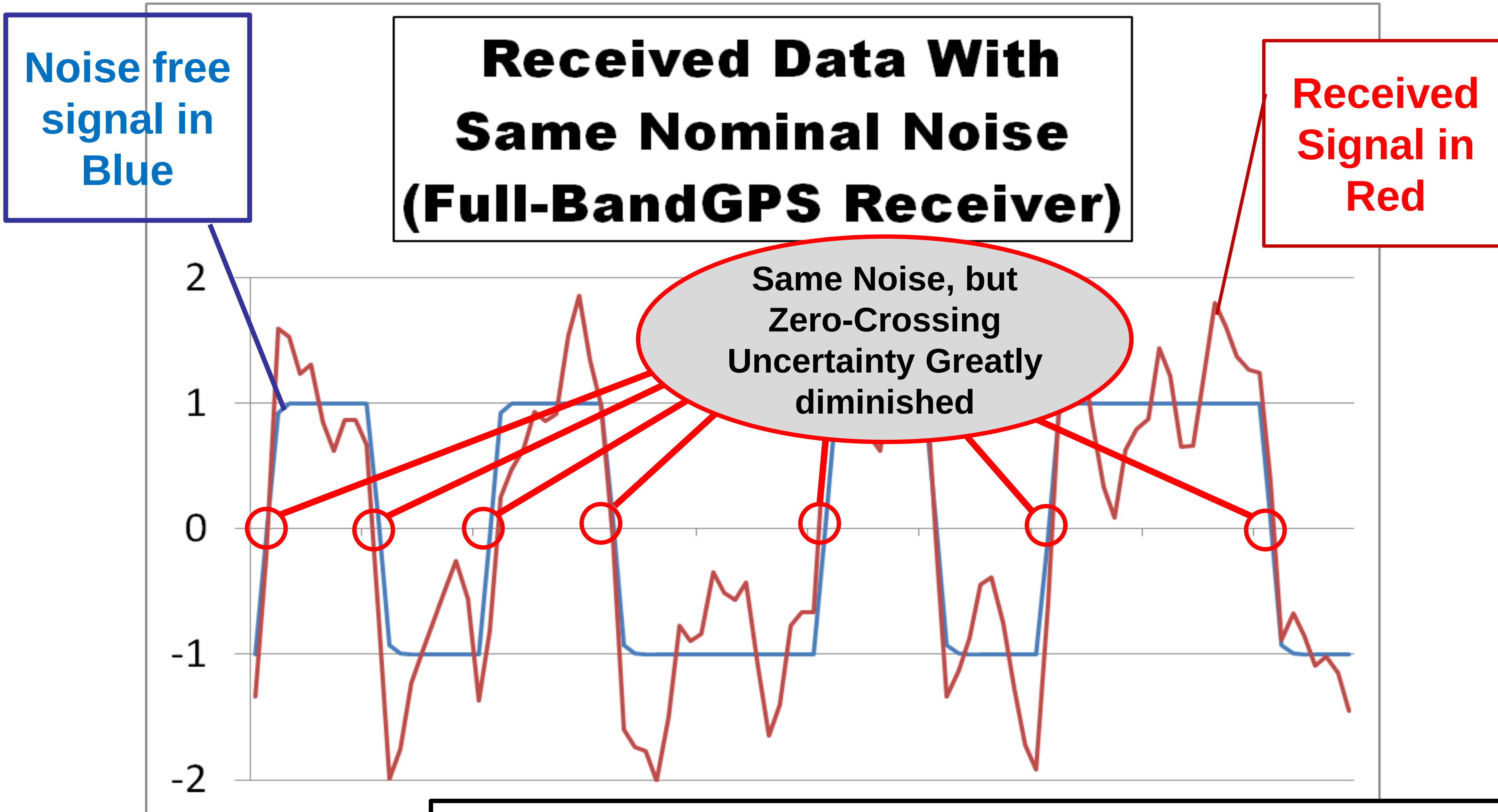


There are fundamental differences between Radio Communications and Radio Navigation

- **Digital Radio Communications:**
  - **Incoming *message is not known* – finding it is the whole point**
  - **Must determine whether each signal "bit" is a one or a zero**
  - **Use sophisticated methods to correct errors**
- **Digital Radio Navigation**
  - **Incoming signal sequence (ones and zeros) is totally known by user**
  - **The goal of the user is to *precisely time* the *transition* from one to zero (and zero to one)**

Courtesy: Brad Parkinson

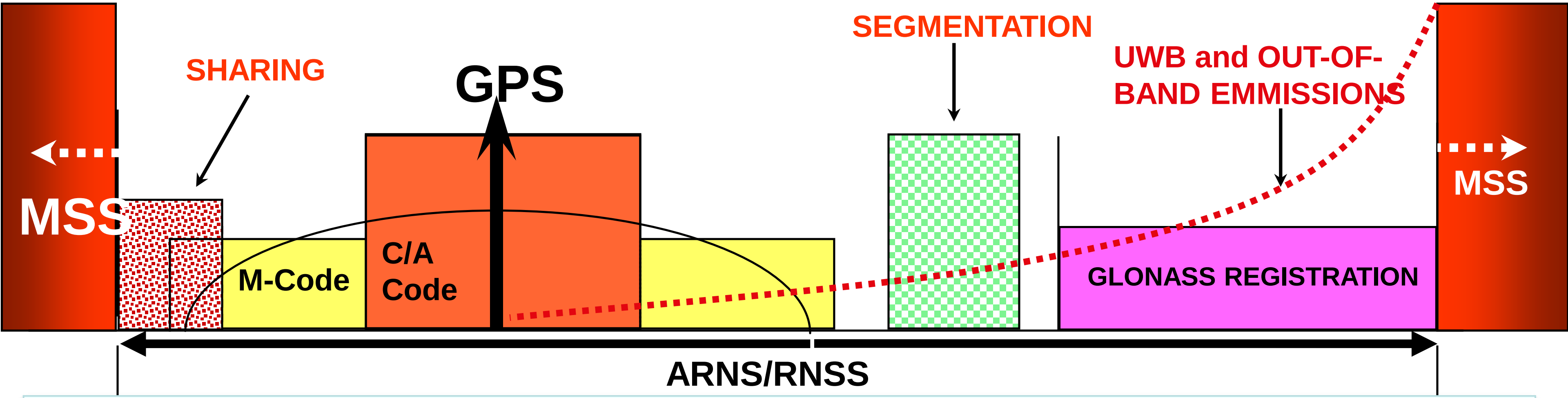
To Achieve the Maximum Accuracy, the Full Band GPS receiver has "sharper transitions," reducing the effect of noise and allowing a more precise timing measurement



Thus, the Full-Band GPS receiver enables sub-meter accuracy

Courtesy: Brad Parkinson

GPS Spectrum can be Harmed Several Ways



The ARNS/RNSS spectrum is a unique resource

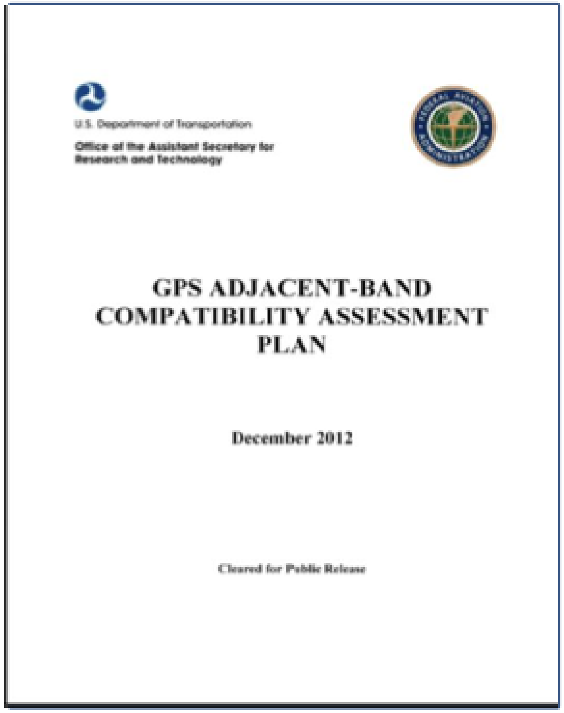
- Sharing with higher power services jams weaker signals
- Out-of-band and ultra wide-band emissions raise the noise floor
- Segmentation prevents future evolution
- Very high power in adjacent bands causes receiver overload

Spread spectrum GPS signals are unlike communication signals

- 10^{-16} W received power, one-way
- Any filter can be overwhelmed if exposed to enough power

GPS Adjacent Band Compatibility Assessment

- DOT Study to Evaluate:
  - Adjacent-band power levels, as a function of offset frequency, necessary to ensure continued operation of all applications of GPS services
  - Adjacent-band power levels to ensure continued operation of all applications of GPS services by future GPS receivers utilizing modernized GPS and interoperable Global Navigation Satellite System (GNSS) signals


U.S. Department of Transportation

Office of the Assistant Secretary for Research and Technology

GPS ADJACENT-BAND COMPATIBILITY ASSESSMENT PLAN

December 2012

Cleared for Public Release

International Disconnects between Regulatory Authorities and Industry Standards

- **The European Union Radio Equipment Directive (RED) will require compliance for all equipment, including GNSS receivers, to be sold in Europe after June 2016.**
- **Presentations from European standards bodies suggest the inclusion of "spectrum sharing and mitigation techniques" standards that would create interference risks to RNSS receivers.**
- **European industry standards may lead to *de facto* spectrum sharing not permitted by the ITU or authorized by responsible national spectrum administrations.**
- **CEPT ECC Recommendation 11(08), "Authorisation Regime of Indoor Global Navigation Satellite Navigation (GNSS) Pseudolites in the Band at 1599-1610 MHz", was approved 21 October 2011 for European member state adoption. Of the 48 CEPT Administrations, 17 have voted to adopt it as of February 2016.**
- **This creates a path for licensed, unintentional jammers to operate across Europe, leading to no-fly zones and other restrictions to GNSS use.**

Non-GNSS Critical Infrastructure Reliance on Space

- **Very few people understand the use of nearly 30,000 terrestrial sensors relayed via GOES / GOES-R or how important they are to the nation's infrastructure.**
  - **About 422 sub channels are included between 1679.7 and 1680.4 MHz, with defined time slots. Devices from the Arctic to the tip of South America and from the Atlantic areas just short of Africa to the Eastern Coast of Australia report through this transponder relay.**
  - **Data is used for flood forecasting, drought monitoring, setting water levels for inland navigational waterways and for flows at dams and locks, tsunami warning, wildfire weather data in support of wildfire firefighters, data necessary for hydroelectric dam operation in 17 western states, USGS water monitoring programs, indication of volcanic eruption or earthquake by measuring changes and channel depth at all US ports.**
  - **The release of water from reservoirs into the Potomac and then into the DC metro water supply is managed by data passing through 1679-1680 Mhz.**

Aviation Severe Weather Warnings from GOES Direct Broadcast

Severe weather warnings to aviation indicating en route weather phenomena which may affect the safety of aircraft operations are issued by NWS.

These Significant Meteorological Information (SIGMET) warnings are developed from GOES/GOES-R satellite imagery as received via direct broadcast in 1675-1695 MHz.

Pink overlay shows actual flight routes for the time this image was applicable for forecast purposes.

Note that severe areas highlighted in Red are weather and convective SIGMET areas issued on that date, especially in western U.S. and over the Great Lakes region of U.S. Flights are actually routed around those areas of warning.

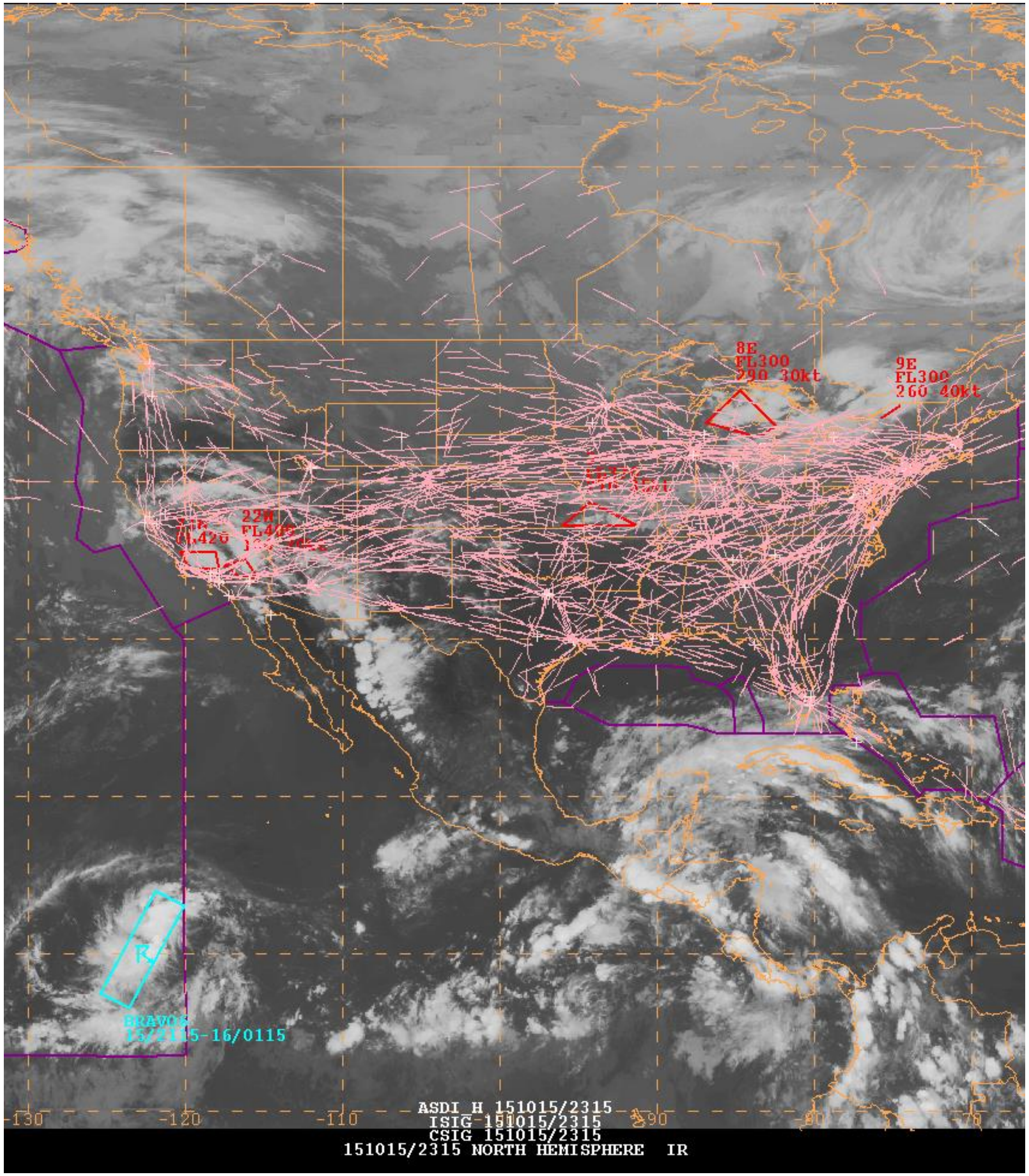


Illustration Source: NOAA / Aviation Weather Center
http://Aviationweather.gov

Conflicting Public-Private Sector Interests

- **Strong interest in weakening international protections for space services in and near bands coveted by terrestrial mobile broadband**
  - **FCC Chairman's speech to the Satellite Industry Association, March 7, 2016**
  - **Spectrum reforms that may work for communications may not work for non-communications functions like navigation and remote sensing.**

- **Concerns not limited to space users but include commercial license holders. A major AWS-3 licensee ex parte stated:**
  - **"...it will be difficult, if not impossible, to reconcile the interference experienced by Federal Users' systems between AWS-3 operations and proposed operations in the 1670 – 1680 MHz band. When there are two potential interfering operators from two different spectrum bands, specifically mobile operations from 1695 – 1710 MHz as one operator, and 1675 – 1680 MHz base station operations as a second operator, identifying the offending party will be difficult, if not impossible, because the interference will be due to the combined operations of two different wireless providers."**

Policy and Politics are Important, but Electrons and Radio Waves Don't Care

- In advocacy for receiver standards, harm claim thresholds, and opposition to noise floor protection criteria, the blurring of accountability is an intrinsic feature.
- As the noise floor rises, it will be hard to hold a particular emitter culpable. This shifts the burden for resolving interference impacts from transmitters to receivers. This is a particular problem for RNSS, EESS, and other space services.