Global Navigation Satellite System (GNSS) Spectrum Protection

October 31, 2015

PNT Advisory Board Meeting
Boulder, CO

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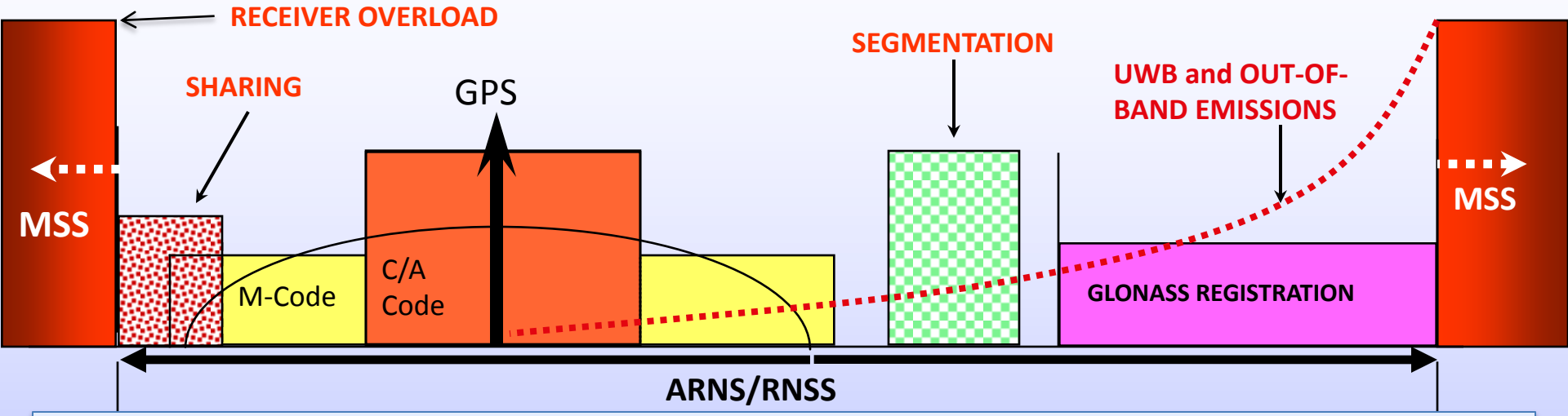
GPS can be Harmed Several Ways



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**

Spread spectrum GPS signals are unlike communication signals

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

Noise Floor Based Interference Protection

- International recommendations on protecting GNSS use 1-dB limit on signal-to-noise ratio (SNR) degradation
  - SNR is ratio of received GNSS signal power to noise + interference power
  - SNR decreases when either: (a) GNSS signal power decreases, or (b) interference increases

- There have recently been proposals to reduce GNSS interference protection from adjacent-band systems

- GPS satellite transmit power for the L1 C/A code is ~20 watts
  - 1 dB SNR degradation is equivalent to reducing to ~16 watts
  - 2 dB SNR degradation is equivalent to reducing to ~13 watts
  - 3 dB SNR degradation is equivalent to reducing to ~10 watts

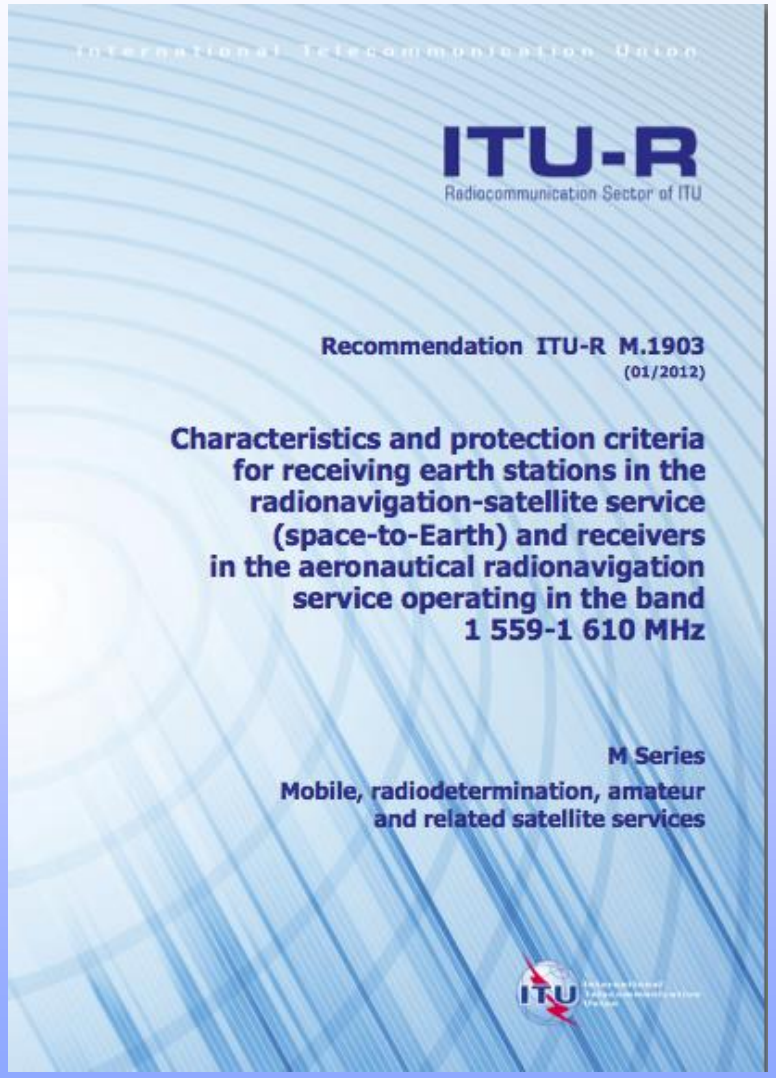
Would your GNSS applications still work with half-power satellites?

- If not, you'd better pay attention to regulatory developments in this area!

Current U.S. Policy Promotes Global Use of GPS Technology

- No direct user fees for civil GPS services
  - Provided on a continuous, worldwide basis
  - Including both current and future civil GPS signals
- Open, public signal structures for all civil services
  - Promotes equal access for user equipment manufacturing, applications development, and value-added services
  - Encourages open, market-driven competition
- Global compatibility and interoperability with GPS
- Service improvements for civil, commercial, and scientific users worldwide
- Protection of radionavigation spectrum from disruption and interference
  - "sustain the radiofrequency environment in which critical U .S . space systems operate" – National Space Policy (2010)

Approved ITU Recommendations on Protection Criteria Exist



International Aviation

The United Nations Convention for the Suppression of Unlawful Acts against the Safety of Civil Aviation is a multilateral treaty that was adopted by the International Conference on Air Law at Montreal on 23 September 1971.

The Convention signatories agree to prohibit and punish acts that threaten the safety of civil aviation. It entered into force on 26 January 1973 after ratification by 10 nations. As of today, the Convention has 188 signatories.

Several of the U.S. laws relevant to intentional interference and spoofing of civil aviation GNSS applications mentioned above were enacted to satisfy obligations made per this Convention.

ENFORCEMENT BUREAU
SIGNAL JAMMER ENFORCEMENT INITIATIVE

Legal Framework

Jammers disrupt critical public safety communications, placing first responders like law enforcement and fire fighting personnel at great risk. In addition, jammers can prevent 9-1-1 and other emergency phone calls from getting through when help is needed the most.

Broad Statutory Prohibition: The Communications Act prohibits the operation, manufacture, importation, marketing, and sale of **signal jamming devices** and other equipment designed to block, jam, or otherwise interfere with authorized radio communications (e.g., GPS, cell phone, Wi-Fi, and radar communications).

- 47 U.S.C. § 301: requires a valid FCC authorization or license for the operation of radio transmitting equipment. Signal jamming equipment cannot be authorized or licensed, however, because its purpose is to interfere with radio communications in contravention of Section 333.
- 47 U.S.C. § 302a(b): prohibits the manufacture, importation, marketing, sale, or operation of jamming devices within the United States.
- 47 U.S.C. § 333: prohibits willful or malicious interference with the radio communications of any station licensed or authorized under the Act or operated by the U.S. Government.

Operating a jammer violates **Sections 301, 302(b), and 333 of the Act**.
Manufacturing, importing, marketing, or selling a jammer violates **Section 302(b) of the Act**.

Violations of the jamming prohibition can lead to substantial monetary penalties (up to $112,500 for any single act), seizure of the illegal jammer, and criminal sanctions including imprisonment.

Spectrum Protection

- Challenged by global growth of all types of wireless devices
  - Unwanted emissions from adjacent bands can raise the RNSS noise floor and blur the precise measurement of transitions
  - Excessive power in adjacent bands can overload RNSS receivers (or any other receiver)
  - In the past, incompatible mobile satellite services and low-powered devices have unsuccessfully sought to operate across restricted RNSS bands
  - industry-level agreements (e.g., low-power digital TV) can and have restrained unwanted emissions

- Protection of GNSS spectrum by just one country is inadequate if commercial devices that cause harmful emissions proliferate
  - Pressure for L-band spectrum to support mobile broadband and other innovations, e.g., unlicensed devices, cloud computing, software radios, etc.
  - International use of unlicensed repeaters and licensed in-band pseudolites, intentional and unintentional spoofers
  - Intergovernmental coordination of space-based L-band radars for EESS applications
  - Industry-level negotiations, interagency agreements, and international regulatory cooperation will be needed to sustain the RNSS bands

United Nations A/AC.105/C.1/L.340

General Assembly

Distr.: Limited
22 October 2014

Original: English

Draft Guidelines on the Long-term Sustainability of Outer Space Activities

Spectrum protection (guideline 4)

States and international intergovernmental organizations should ensure that all space activities under their jurisdiction and/or control are carried out in accordance with the Convention of the International Telecommunication Union and the Constitution and the Radio Regulations of the International Telecommunication Union (ITU), in order to enhance the long-term sustainability of space activities and in support of sustainable development on Earth. In accordance with the ITU Radio Regulations and Recommendations, States should facilitate prompt resolution of identified harmful radio frequency interference….In their use of the electromagnetic spectrum, States and international intergovernmental organizations should consider the requirements for space-based Earth observation systems and other space-based systems and services in support of sustainable development on Earth, …

States and international intergovernmental organizations should facilitate the implementation of the radio regulation procedures established by ITU for space radio links. Moreover, States and international intergovernmental organizations should encourage and support regional and international cooperation aimed at improving efficiency in decision-making and implementation of practical measures to eliminate identified harmful radio frequency interference in space radio links.

Potential PNT Advisory Board International Member Contribution

- Draft language to the ICG Plenary on protecting RNSS spectrum
  - Inclusive of all GNSS systems using existing RNSS bands
  - Encouragement of regulations that prevent all types of unintentional harmful interference
    - Protection of the RNSS noise floor; prevention of receiver overload, band segmentation, and sharing with incompatible services
    - Strict controls on GNSS repeaters; no intentional in-band emissions inconsistent with the RNSS allocation (e.g., communication services)
  - International cooperation in preventing the proliferation and use of devices designed to jam or spoof GNSS signals
- First step toward a consensus within UN COPUOS, followed by inclusion in a UN General Assembly Resolution

Potential PNTAB Recommendations

- Member States of the United Nations that are users of GNSS, should evaluate existing and emerging capabilities for detection, localization, characterization, and prevention of RNSS interference. and consider developing, testing and implementing these or similar capabilities at the national level.
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Potential PNTAB Recommendations

- The ICG Office of Outer Space Affairs should continue to organize workshops for Member States of the United Nations to provide education on the importance of RNSS spectrum protection and of building capacity in Interference Detection and Mitigation (IDM) in order to protect the worldwide access to the benefits of GNSS.

Potential PNTAB Recommendations

- Member States of the United Nations, in particular ICG members, are encouraged to actively participate in the ITU-R Regional and World Radiocommunication Conferences on new International Mobile Telecommunications (IMT) spectrum allocations to ensure IMT-GNSS compatibility for existing and future GNSS operations.