Overview: Radio Frequency Spectrum

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Working Group on Spectrum and Operational Challenges with the Emergence of Small Satellites

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Secure World Foundation

Secure World Foundation ***is a private operating foundation*** that promotes cooperative solutions for space sustainability

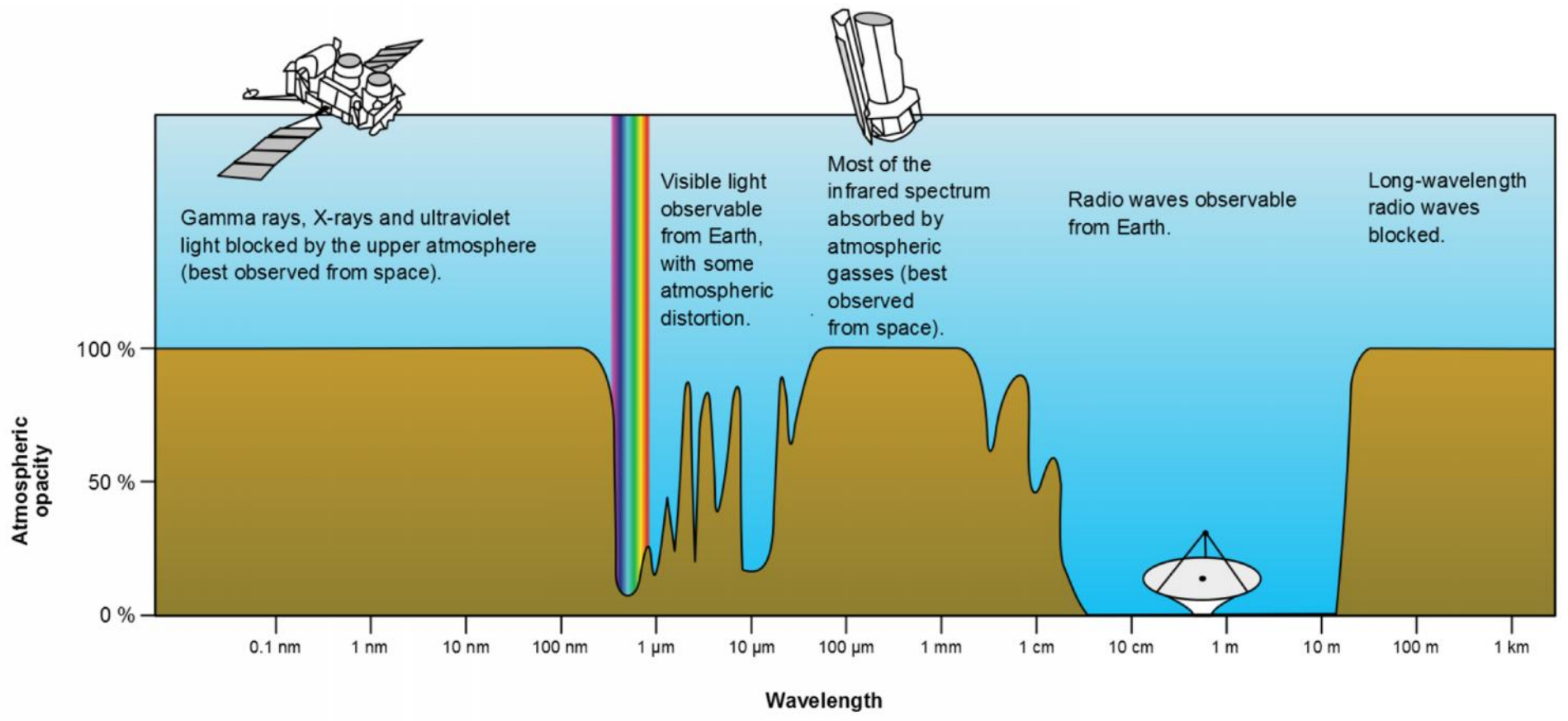
- **Our vision:** The secure, sustainable and peaceful uses of outer space contributing to global stability and benefits on Earth

- **Our mission**: To work with governments, industry, international organizations, and civil society to develop and promote ideas and actions to achieve the secure, sustainable, and peaceful uses of outer space benefiting Earth and all its peoples

Summary

- Critical component of space activities
- Satellites use spectrum to used to communicate with the ground or other satellites
- Limited natural resource
- Managed internationally and nationally
- Radio frequency interference
  - Unintentional congestion
  - Natural events
  - Intentional activities

Electromagnetic Spectrum



Basic RF Concepts and Terminology

- RF energy, like other parts of the EM spectrum, is identified by either its ***frequency (Hertz or Hz)*** or ***wavelength (meters)***
- The ***power*** or strength of an RF signal is often measured in ***Watts***
- A specific portion of RF spectrum is known as a ***band***, and often will have a certain letter or name designated to it
  - Within a band, a slice of spectrum is referred to as ***bandwidth***
- RF transmission and reception requires an ***antenna***
- The ***gain*** of an antenna is a measure of how well it can amplify the signal either received or transmitted in a certain direction
  - Gain is usually measured in ***decibels (dB)***
- A ***parabolic dish*** is one type of antenna commonly used for receiving satellite signals because of its high gain
- Broadcast communications satellites frequently use ***transponders to*** receive signals over one or more uplink frequencies and rebroadcast them over one or more downlink frequencies

Common Radio Frequency Band and Applications

Band Name			Frequency (ITU)	Common Uses	
ITU	NATO	IEEE		Space	Ground
Very High Frequency (VHF)	A Band (0-250 MHz)	VHF	30MHz to 300MHz	satellite uplinks	analog TV
Ultra High Frequency (UHF)	B Band (250-500 MHz) C Band (500-1000 MHz)	UHF (300-1000 MHz) L Band (1-2 GHz) S Band (2-3 GHz)	300MHz to 3000MHz	Mobile Satellite Services satellite navigation signals	analog TV, 2-way radios, cordless phones, WiFi, Bluetooth, mobile phones
Super High Frequency (SHF)	F Band (3-4 GHz) G Band (4-6 GHz) H Band (6-8 GHz) I (8-10 GHz) J (10-20 GHz) K Band (20-30 GHz)	S Band (3-4 GHz) C Band (4-8 GHz) X Band (8-12 GHz) Ku Band (12-18 GHz) K Band (18-27 GHz) Ka Band (26.5-40GHz) V Band (40-75 GHz) W Band (75-110 GHz)	3GHz to 30GHz	Fixed Satellite Services Broadcast Satellite Services satellite uplinks and downlinks	weather radar amateur radio imaging radar air traffic control
Extremely High Frequency (EHF)	K Band (30-40 GHz) L Band (40-60 GHz) M Band (60-100 GHz)		30GHz to 300GHz	inter-satellite links military survivable satcom	microwave data links active denial system

Regulation of RF Spectrum

- A complex regulatory framework has been created to manage the RF spectrum because it needs to be shared by many different applications and users
- International Telecommunication Union (ITU)
  - The competent body for the management of the RF spectrum
  - Manages allocation of a frequency band which designates its use for specific space or terrestrial applications
  - ITU Radio Regulations incorporates the decisions of World Radiocommunication Conference (WRC)
- National administrations
  - Authorizes or licenses a specific terrestrial or space operator to use specific frequencies or channels for a specific use
  - Ex. Federal Communications Commission and National Telecommunications and Information Administration in the US

World Radiocommunication Conference

- ITU treaty conference held every 4 years in Geneva for 25 days
  - To revise the ITU Radio Regulations, which includes spectrum for geostationary and non-geostationary satellite orbits
- Pre-determined agenda against which regions and countries submit proposals and consider study group outcomes
- Lots of resources and lobbying
- Years of planning, very few exceptions

RF for Small Satellites

- International Telecommunication Union (ITU)
  - WRC-12 Resolution 757
    - Study Group outputs: Report ITU-R SA.2312, Report ITU-R SA.2348
  - WRC-15 Resolution 659
- National administrations
  - Some have provided guidance on spectrum use for small satellites
  - Financial resources issues
  - Classification - amateur, experimental, operational
- ITU Symposium and Workshop on small satellite regulation and communication systems, Santiago de Chile, Chile, 7-9 November 2016

Large Satellite Constellations

- National administrations
  - National administrations register the satellite networks at the ITU
  - Strategic registration
- International Telecommunication Union (ITU)
  - Expensive, though less for nongeostationary
  - Pre-emptive filling due to first come, first serve
    - Starts 7 year deadline for “bring into use”

Radio Frequency Interference (RFI)

- Unintentional accounts for most RFI
- Reasons for interference
  - More powerful signals
  - Two signals on the same frequency
  - Incorrect position of ground equipment
  - Weather, both terrestrial and space
  - Overlap between signals for satellites and mobile phone networks
  - Jamming, rising in recent years

Mobile Versus Satellite

- Ongoing conflict between satellite and terrestrial services
  - Back to WRC-07 and beyond
- Value of the C-band, bands above 6GHz
- WRC-15
  - Identified bands for study
  - US, FCC intentions
- Is sharing really possible?
  - Interference
  - Exclusion zones, shielding & filters
  - Satellite backhaul of mobile networks

Questions?

Thanks.

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