International Symposium on Advanced Radio Technologies

NASA Activities to Improve

Spectrum Efficiency

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NASA Requires Radio Spectrum

Communications & Data Transport

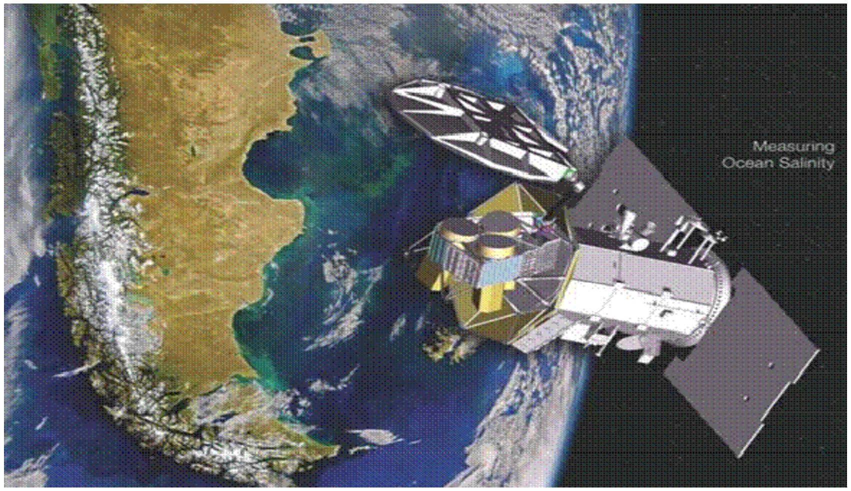
- All NASA space and sub-orbital missions require spectrum to support command and control of the spacecraft and data download

Science: Collecting Data

- Mission instruments, both passive and active, use the spectrum to measure the Earth, planets, Sun and other phenomena of the universe

Spectrum Challenges

- Limited spectrum allocations for science activities including communications
- NASA missions may be near Earth/deep space; human/robotic; long term/brief
- Weak-signal nature of many space-based radiocommunications can make sharing with terrestrial services challenging



NASA Communication Networks

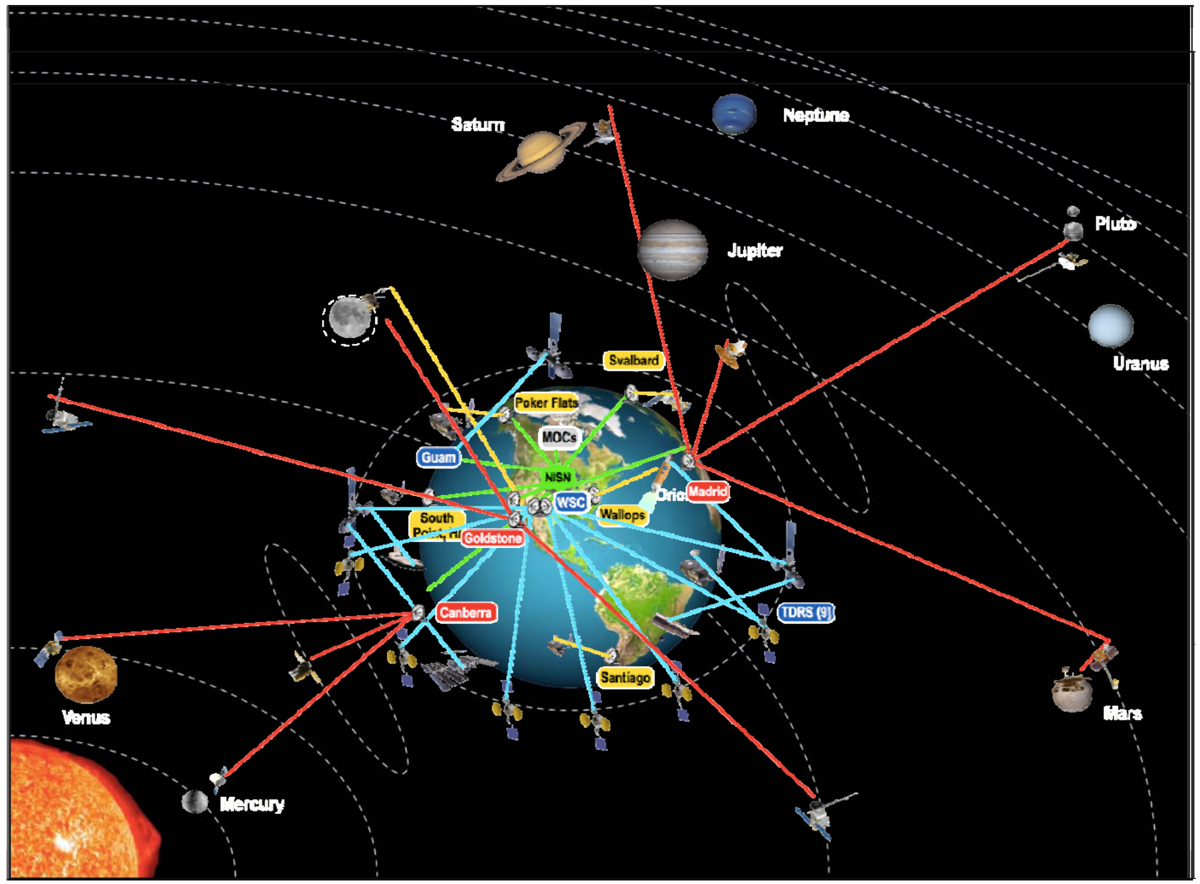
The NASA space communications architecture provides communications services to supported missions using space-based and ground-based assets

Near Earth Network - NASA, commercial, and partner ground stations and integration systems providing space communications and tracking services to orbital and suborbital missions

Space Network - constellation of geosynchronous relays (TDRSS) and associated ground systems

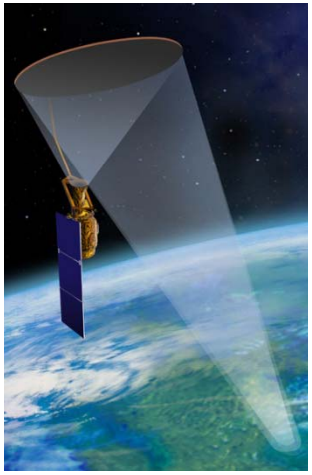
Deep Space Network – ground stations spaced around the world providing continuous coverage of satellites from Earth Orbit (GEO) to the edge of our solar system

NASA Integrated Services Network (NISN) – provides terrestrial connectivity



Using the Spectrum to Collect Science Data

- Mission instruments, both passive and active, use the spectrum to measure phenomena associated with various science activities:
  - Earth Science studies to develop a scientific understanding of Earth's system and its response to natural or human-induced changes, and to improve prediction of climate, weather and natural hazards
  - Heliophysics studies to understand the Sun, Heliosphere and Planetary Environments as a single connected system
  - Planetary Science studies to advance the knowledge of the origin and history of the Solar system and Earth
  - Astrophysics studies to understand the origin, evolution and structure of the Universe
- Example: Soil Moisture Active & Passive (SMAP)
  - First NASA Decadal Survey Mission, Launch 2013
  - L-band microwave radiometer and Synthetic Aperture Radar (SAR)



Example Advanced Radiocommunications Technology Development Activities

- NASA is developing dynamic spectrum and cognitive spectrum use capabilities for passive sensors to avoid interfering signals, which when combined with post-processing techniques, can produce useable data in the presence of interference
  - Example: SOE engineering approach for radiometers, etc.[1]
    - Survivability: Detect and avoid damage from RFI
    - Operability: Improve technology (e.g., receiver selectivity) to measure without error in the presence of interference
    - Excisability: Detect and excise interference through signal processing
- NASA is developing advanced radio and networking techniques such as adaptive transmission rates based on changing link parameters and mission requirements
  - Example: Advanced radio technology, such as Software Defined Radios, provide computing capabilities that can improve communication operations → CoNNeCT ISS Testbed for SDRs

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[1] Concept under development by Jeff Piepmeier, Goddard Space Flight Center

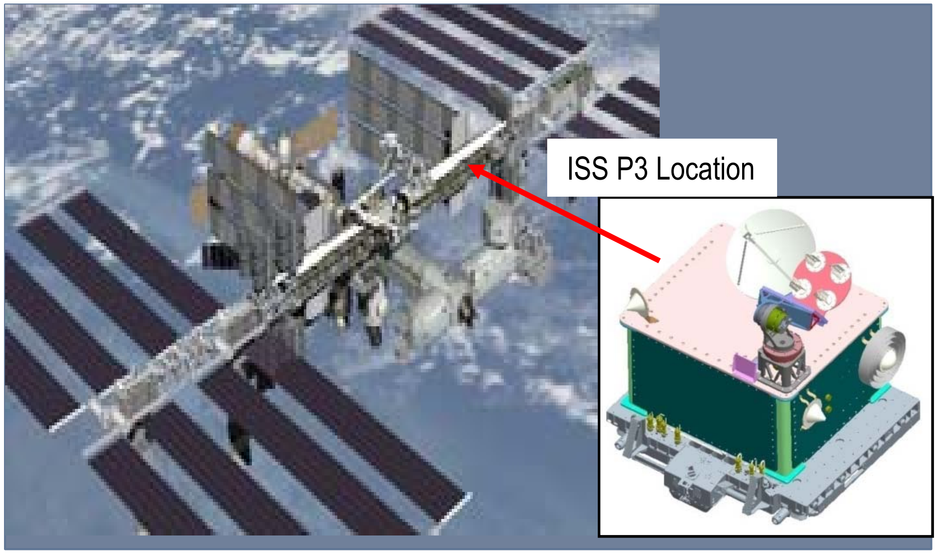
CoNNeCT ISS Testbed for SDRs

NASA SDR History and Roadmap:

- 2000 - JPL Blackjack reprogrammable GPS receiver
- 2003 - Low Power Transceiver Shuttle DTO demo of early SDR
- 2005 - MRO Electra now operating in Mars orbit
- 2005 - NASA establishes a Software Defined Radio Architecture Team to develop a standard open architecture – the Space Telecommunications Radio System (STRS)
- 2006 - STRS ver 1.0 released to gov't and industry for review
- 2007 - STRS ver 1.01 released
- 2008 - STRS ver 1.02 released, CoNNeCT flight version

Future:

- 2011 - CoNNeCT to launch July 2011 with three advanced SDRs
- 2016 - Proposed Ka-band Universal Space Transponder on Mars 2016
- 2018 - Proposed X/UHF Universal Space Transponder on Mars 2018



SDR and CoNNeCT Benefits:

- Single radio provides multiple functions
- Upgrades and fault corrections possible post launch (used on MRO)
- Development of STRS standard-compliant software libraries for lower cost of future radios with reuse
- Advancement of gov't and industry SDR expertise and STRS maturity with TRL 7 CoNNeCT radios
- ISS based testbed for on orbit development and demonstration
- Forms basis for future evolution (e.g. Mars 2016 Universal Space Transponder)

CoNNeCT ISS Testbed Features:

- SCaN Testbed available for NASA, University, Industry & other USG Agency experiments/ on orbit software development
- JPL Electra derived radio with S-band comm and GPS
  - 192 kbps / 72 kbps implemented, with 32 Mbps max transmit
  - GPS L1, L2c, L5 capable
  - Disruption Tolerant Networking capable
- General Dynamics StarLight derived radio for Fourth Gen TDRSS users
  - 192 kbps / 72 kbps implemented, with 24 Mbps max transmit
- Harris Ka band
  - 100 Mbps implemented, with 1.2 Gbps max transmit potential
- RF:
  - 40 W TWTA at Ka band
  - Half-meter gimbaled dish at Ka band
  - Two 10 watt S band transmitters
  - S band helix medium gain antenna
  - S band hemi antenna

Summary

- NASA systems operate in an environment that is particularly sensitive to interference
- NASA is developing advanced technologies and techniques to “work through” such challenging environments while accomplishing our scientific objectives
- NASA strives to be responsible stewards of the spectrum resources we have available and on which virtually all space-related activities depend