

# **International Spectrum Management: NASA's Perspective**

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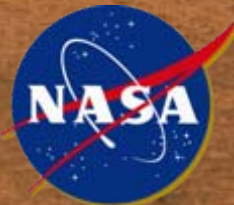
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# Overview

- Missions
  - Current
  - Near Term
- Comm. Architecture
  - Near earth
  - Deep space
- NASA & NASA Centers
- NASA Spectrum Management Process
- ITU-R / WRC-07
- Propagation
  - ACTS
  - ITU-R SG 3
- Pop Quiz





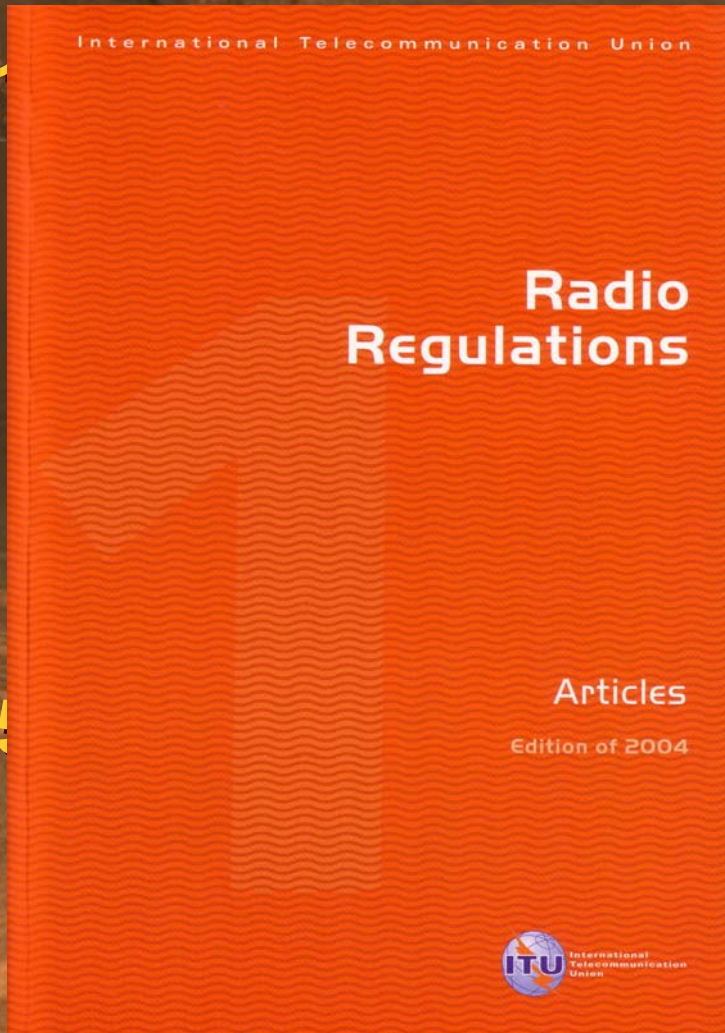
# Types of Missions

- Space Science
  - Hubble Space Telescope & other space telescopes
  - Gravity Probe-B
- Earth Exploration
  - Landsat, Terra, Aqua,
  - Tropical Rainfall Measuring Mission
- Manned Missions
  - International Space Station
  - Space Shuttles
- Deep Space
  - Mars Odyssey, Spirit/Opportunity, etc.
  - Cassini (Currently orbiting Saturn)
- Communication
  - Tracking Data Relay Satellite System (TDRSS)
  - Deep Space Network: U.S., Spain, & Australia



# Special Considerations: Definitions

1.51



1.51

*telescope service:* A service...relating to the Earth and its natural resources, including data relating to the state of the environment, which is obtained from passive sensors on Earth

## Article 1

*space service:* A radiocommunication service by means of spacecraft or other objects in outer space for scientific or technological purposes





# More Definitions

- 1.177** *deep space*: Space at distances from the Earth equal to, or greater than,  $2 \times 10^6$  km.
- 1.182** *active sensor*: A measuring instrument in the *earth exploration-satellite service* or in the *space research service* by means of which information is obtained by transmission and reception of *radio waves*.
- 1.183** *passive sensor*: A measuring instrument in the *earth exploration-satellite service* or in the *space research service* by means of which information is obtained by reception of *radio waves* of natural origin.



# Other Definitions

- 1.13** *radio astronomy*: Astronomy based on the reception of *radio waves* of cosmic origin.
- x.xx** *radar astronomy* – Not defined
- 1.43** *radionavigation-satellite service*: A *radiodetermination-satellite service* used for the purpose of *radionavigation*.
- 1.52** *meteorological-satellite service*: An *earth exploration-satellite service* for meteorological purposes.





# Current Missions

*(i.e., Flying now)*

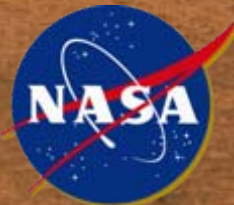
<b>ACE</b>	<b>GALEX</b>	<b>MRO</b>	<b>TDRSS</b>
<b>ACRIMSAT</b>	<b>GENESIS</b>	<b>NEW HORIZONS</b>	<b>TERRA</b>
<b>AQUA</b>	<b>GRACE</b>	<b>POLAR</b>	<b>THEMIS</b>
<b>AURA</b>	<b>GRAVITY PROBE-B</b>	<b>QUIKSCAT</b>	<b>TIMED</b>
<b>BIGELOW</b>	<b>HETE-2</b>	<b>RHESSI</b>	<b>TOMS-EP</b>
<b>CASSINI</b>	<b>HST</b>	<b>SAMPEX</b>	<b>TOPEX/POSEIDON</b>
<b>CHANDRA</b>	<b>ICESAT</b>	<b>SEASTAR</b>	<b>TRACE</b>
<b>CHIPSAT</b>	<b>IMAGE</b>	<b>SHUTTLE</b>	<b>TRMM</b>
<b>CLOUDSAT</b>	<b>ISS</b>	<b>SIRTF</b>	<b>UARS</b>
<b>DEEP IMPACT</b>	<b>LANDSAT</b>	<b>SORCE</b>	<b>VOYAGER-1</b>
<b>EO-1</b>	<b>MARS ODYSSEY</b>	<b>STARDUST</b>	<b>VOYAGER-2</b>
<b>ERBS</b>	<b>MER</b>	<b>STEREO</b>	<b>WIRE</b>
<b>FAST</b>	<b>MESSENGER</b>	<b>SWAS</b>	<b>WMAP</b>
<b>FUSE</b>	<b>MGS</b>	<b>SWIFT</b>	<b>XTE</b>

1,700+ Frequency assignments



# Near-Term Missions

- AIM (Mesospheric ice): Apr 2007
- DAWN (Solar system evolution): June 2007
- PHOENIX (Mars surface probe): Aug 2007
- GLAST (Space telescope): Oct 2007
- SHUTTLE (ISS construction): × 5 missions
- 2008
  - GLORY (Earth energy budget)
  - IBEX (Solar system boundary)
  - KEPLER (Extra-solar planets)
  - LRO (Lunar exploration)
  - OCO (Atmospheric chemistry)
  - SDO (Sun structure)
- 2009+
  - AQUARIUS (Ocean sensing)
  - MSL (Mars surface probe)
  - WISE (Infrared astronomy)
  - JUNO (Jupiter exploration)
  - GPM (Precipitation)
  - JWST (Astronomy)



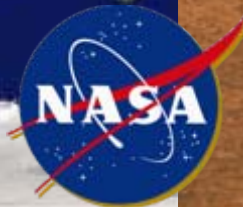
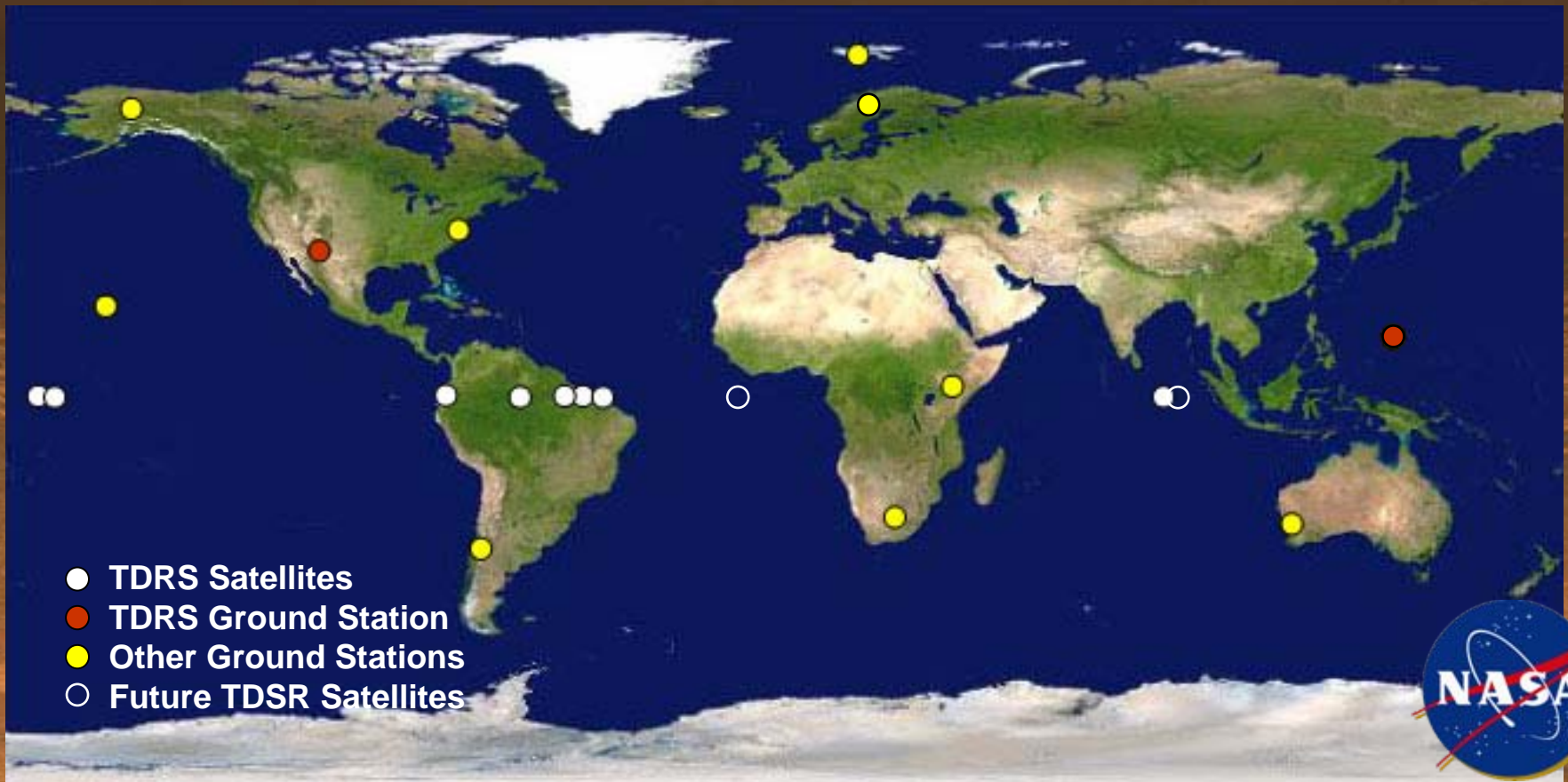




# Near Earth Comm

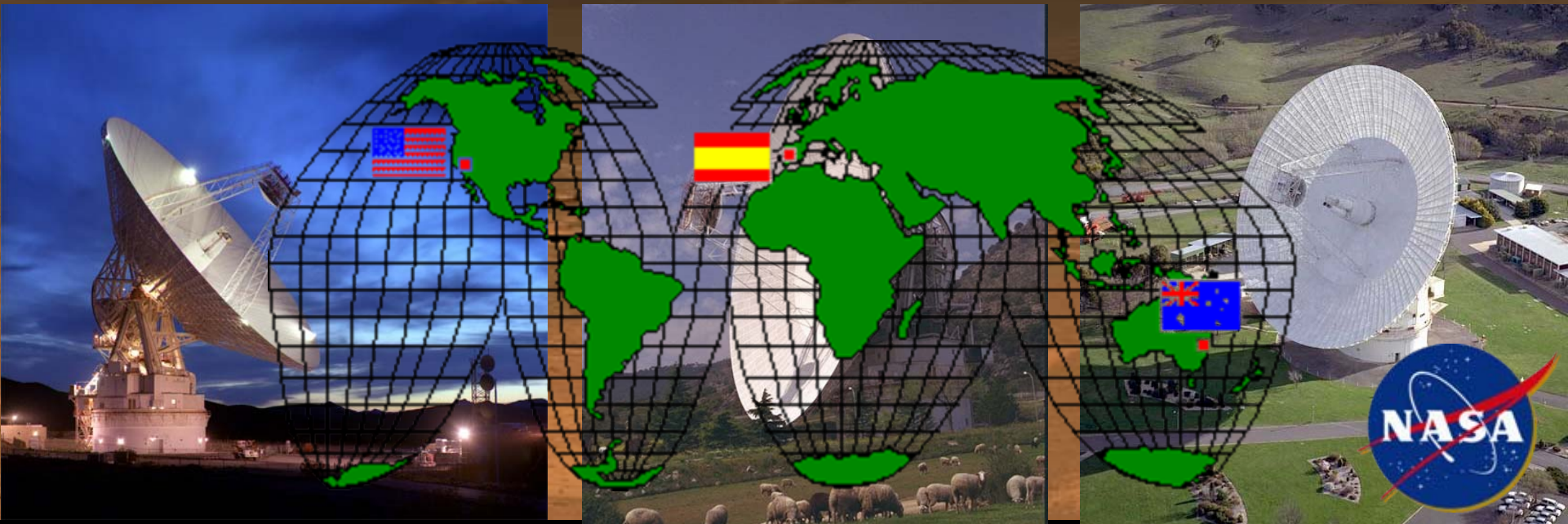


- TDRS:
  - “Switchboard in the sky...”
  - 85% coverage for near-Earth missions
- Misc. Additional ground stations



# Deep Space Network

- Goldstone, USA; Robledo, Spain\*, Canberra, Australia
- Deep space: “Space at distances from the Earth equal to, or greater than,  $2 \times 10^6$  km.” (RR 1.177)
- Dish sizes up to 70 m
- All frequencies for U.S. and non-U.S. missions using the DSN selected by NASA/JPL





# Communication Bands Currently in Use

- S-Band
  - 2025-2110 GHz: E→S and S→S (Fwd)
  - 2110-2120 GHz: Deep Space S→E
  - 2200-2290 GHz: S→E and S→S (Rtn)
  - 2290-2300 GHz: Deep Space E→S
- X-Band
  - 7145-7190 GHz: Deep Space E→S
  - 8025-8400 GHz: EESS S→E
  - 8400-8450 GHz: Deep Space S→E
- Ku-Band
  - 13.4-14 GHz: TDRSS S→E
  - 13.77-13.78 GHz: S→S (Fwd)
  - 14.8-15.35\* GHz: S→S (Rtn)
- Ka- Band
  - 22.55-23.55 GHz: TDRSS S→S
  - 25.25-27.5 GHz: TDRSS S→S
  - 25.5-27.0 GHz EESS/SRS S→E
  - 31.8-32.3 GHz: Deep Space S→E
  - 34.2-34.7 GHz: Deep Space E→S

\* Secondary allocation

Other bands also used for short range/duration communication



# Principle Sensing Bands Currently in Use

- Active
  - 1215-1300 MHz
  - 5250-5460 MHz
  - 9500-9800 MHz
  - 13.25-13.75 GHz
  - 35.5-36 GHz
  - 94-94.1 GHz
- Passive
  - 10.6-10.7 GHz
  - 13.4 GHz
  - 18.6-18.7 GHz
  - 21.2-21.4 GHz
  - 22.21-22.5 GHz
- (Passive cont.)
  - 23.6-24 GHz
  - 31.3-31.8 GHz
  - 36-37 GHz
  - 50.2-50.4 GHz
  - 52.6-59.3 GHz
  - 86-92 GHz
  - 105-122.25 GHz
  - 148.5-151.5 GHz
  - 174.8-191.8 GHz
  - 200-202 GHz
  - 240, 640 & 2400 GHz\*

\* Used but not allocated



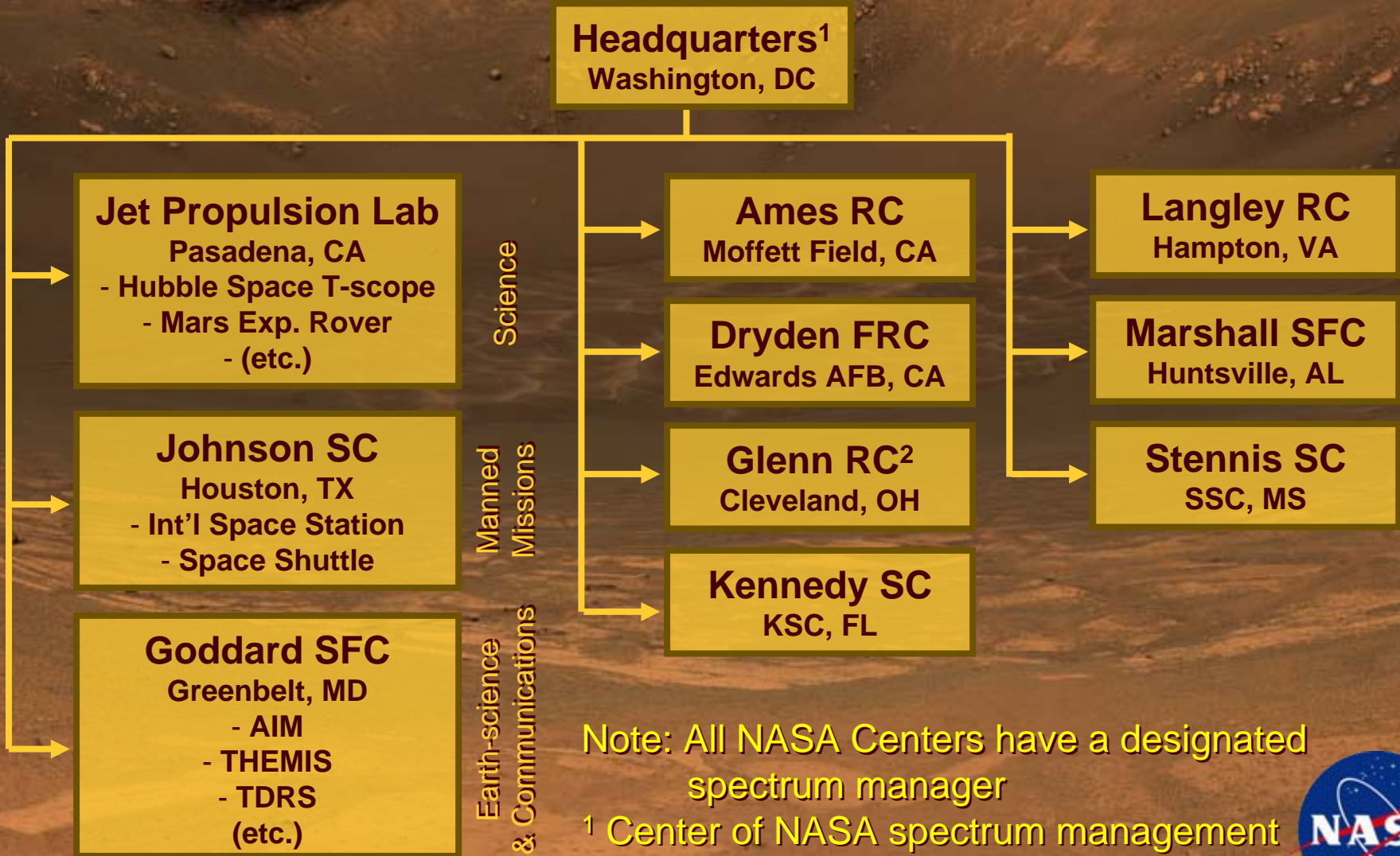


# Special Frequencies

- Frequencies in **RR 5.340**
  - “All emissions are prohibited”
- Frequencies in **RR 5.565 (275-1000 GHz)**
  - The frequency band 275-1 000 GHz may be used by administrations for experimentation with, and development of, various active and passive services.
- Frequencies between 275 and 3000 GHz
  - Recordable for information under ITU-R Resolution **950** (e.g., Microwave Limb Sounder on AURA: 640/2400 GHz)
- Frequencies above 3000 GHz as per ITU Res **118**
  - Not “radio” but under the purview of ITU-R



# NASA & NASA Centers



Note: All NASA Centers have a designated spectrum manager

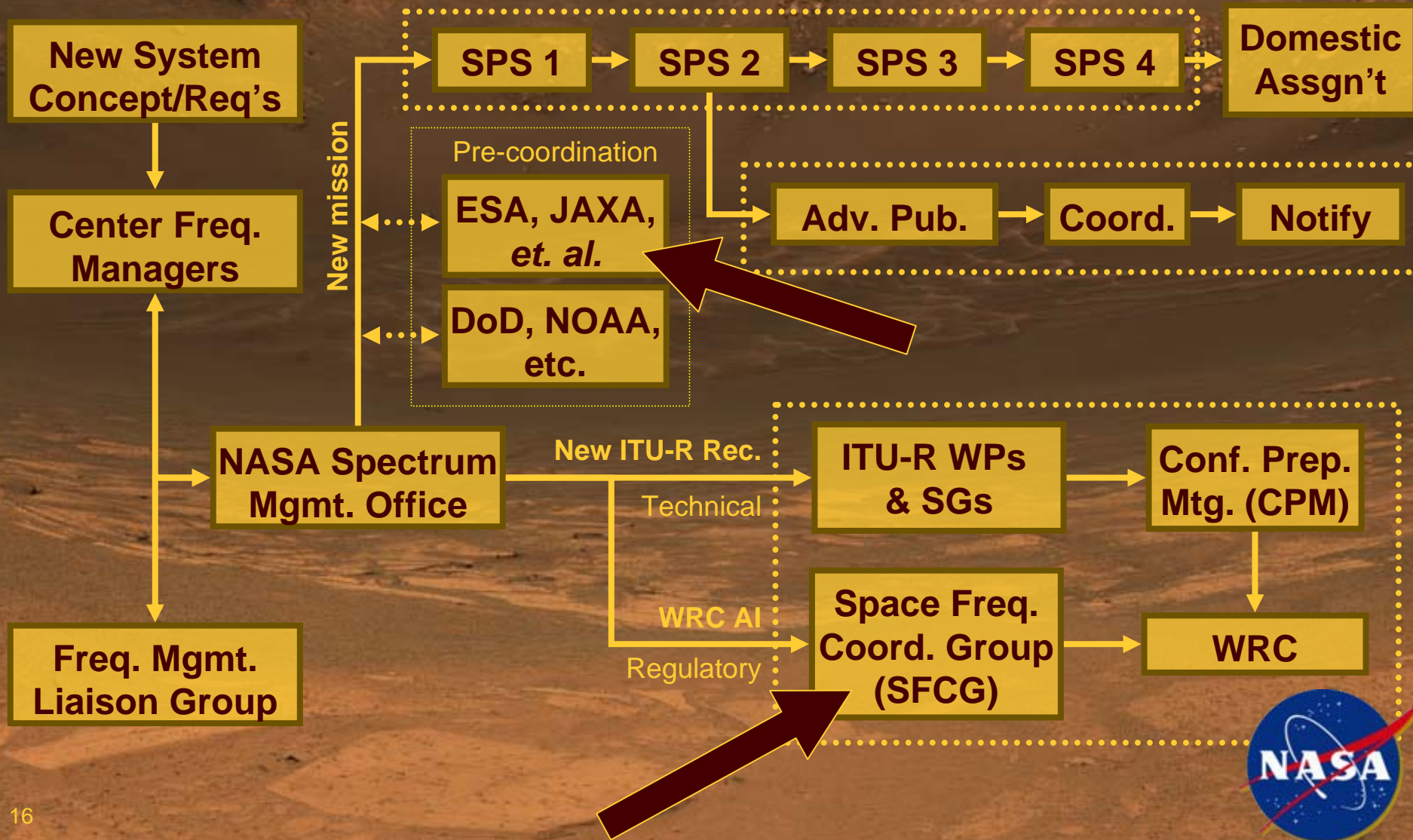
<sup>1</sup> Center of NASA spectrum management

<sup>2</sup> Home of NASA int'l spectrum managers





# NASA Spectrum Mgt Process



# Space Frequency Coordination Group

- Membership: Any national or international civil space agency which is interested in the cooperative development of recommendations for frequency management matters in the support of science services
  - 25 Members (Civil space agencies including NASA, ESA, and NOAA)
  - 5 Observers (Including WMO, ITU-R SG 7, IUCAF)
- Purpose:
  - Supplements the ITU-R process on matters related to national/international scientific space agencies
  - Pre-coordinate national activities related to science services



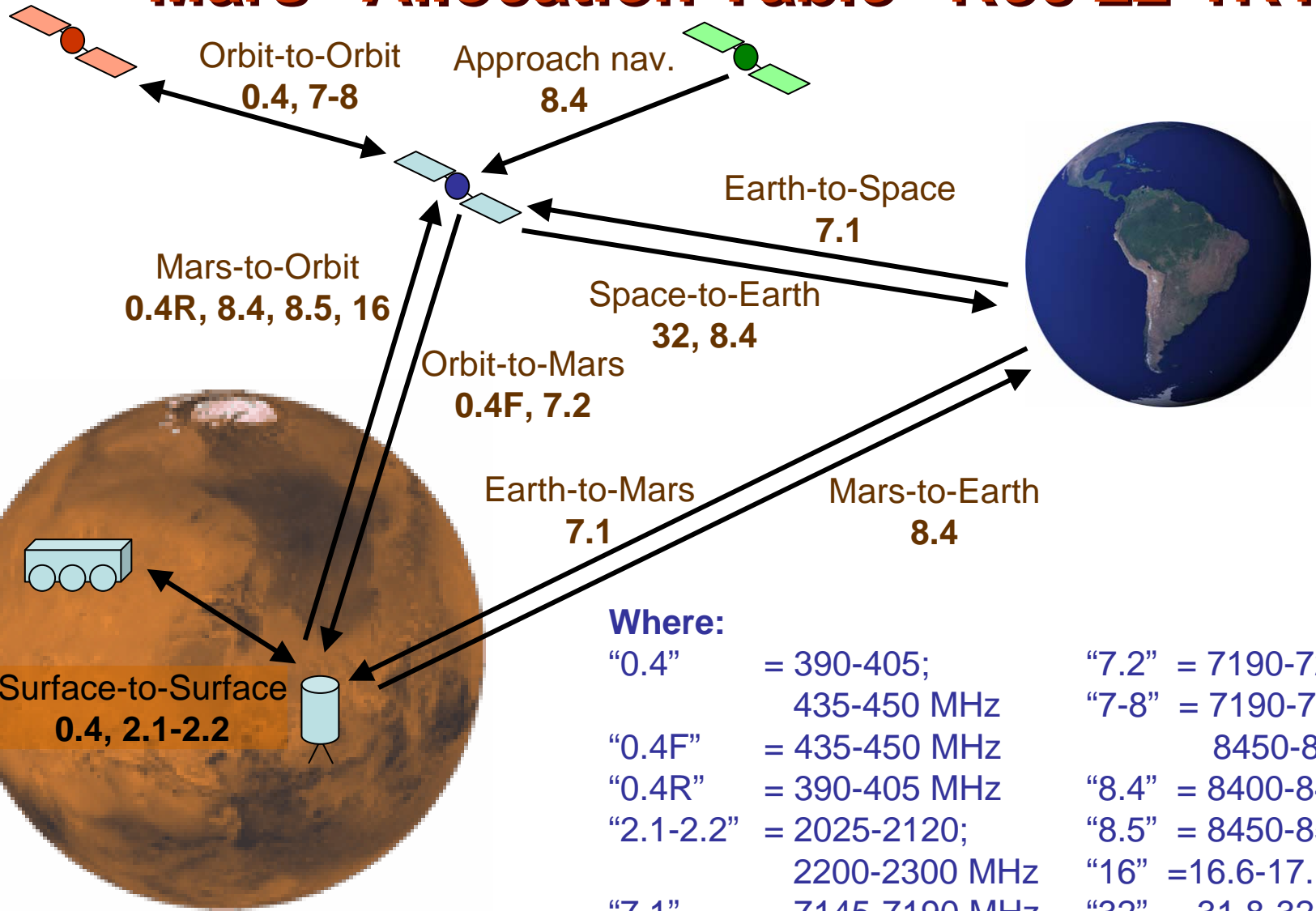


# SFCG Objectives

- “The SFCG was established in order to provide a less formal and more flexible environment, ... for the solution of frequency management problems encountered by member space agencies.”
- “The SFCG is concerned with the effective use and management of those radio frequency bands that are allocated by the Radio Regulations of the ITU to the Space Research, Space Operations, Earth Exploration Satellite, and Meteorological Satellite services.”
- “The principal result of SFCG meetings is the adoption of resolutions and recommendations which express technical and administrative agreements... to make best use of allocated bands and to avoid interference.”



# Example SFCG Output: Mars "Allocation Table" Rec 22-1R1



**Where:**

"0.4"	= 390-405; 435-450 MHz	"7.2"	= 7190-7235 MHz
"0.4F"	= 435-450 MHz	"7-8"	= 7190-7235; 8450-8500 MHz
"0.4R"	= 390-405 MHz	"8.4"	= 8400-8450 MHz
"2.1-2.2"	= 2025-2120; 2200-2300 MHz	"8.5"	= 8450-8500 MHz
"7.1"	= 7145-7190 MHz	"16"	= 16.6-17.1 GHz
		"32"	= 31.8-32.3 GHz



# SFCG Activities of Interest

- “Pre-Coordination” of space missions
  - Early exchange of technical parameters of missions
  - Establishing technical standards to minimize interference
  - Inter-operability to a lesser extent due to IOAG
- WRC Preparation
  - Updates on regional proposal developments
  - Development SFCG WRC objectives
- Corresponding with relevant agencies
  - New and existing Civil space agencies
  - How to interact with commercial EESS entities(?)



# ITU-R & Related Activities

- Strong Involvement
  - Study Group 7 (Science Serves)
  - Hosting US SG 7 Website
  - Chairmanships
    - US SG 7: Wayne Whyte
    - US WP 7B: Brad Kaufman
    - US WP 7C: John Zuzek
- Additional Participation
  - ITU-R TG 1/9: Protection of passive sensors
  - ITU-R WP 8B & 8D: Aeronautics and navigation
  - ITU-D SG 2: Disaster Management
- Study Group 3 (Propagation)
  - US WP 3M Chair: Glenn Feldhake
  - Hosting US SG 3 Web Site
- CITELE
  - U.S. Spksprson AI 1.2, 1.3
  - U.S. Alt-Spksprson AI 1.17
  - CITELE Rapporteur AI 1.3
  - CITELE Alt-Rap. AI 1.12
- WRC-07 Preparations





# WRC-07 AI's of Interest

- AI 1.2 – Sharing between EESS (passive) and the fixed and mobile services in the 10.6-10.68 GHz and 36-37 GHz bands
- AI 1.3 – Possible extension of 200 MHz to EESS (active) and SRS (active) to the existing 9.5-9.8 GHz allocations
- AI 1.5 – Seek additional aeronautical mobile telemetry spectrum to support future wideband flight test research
- AI 1.12 – Modify Appendix 4 of the RR to allow proper advance publication and notification of space science systems
- AI 1.17 – Protection of 1400-1427 MHz passive band from unwanted emissions from MSS feederlinks in the 1390-1392 MHz and 1430-1432 MHz bands
- AI 1.20 – Protection of EESS (passive) from unwanted emissions of active services in select bands as set forth in Resolution 738 (WRC-03)
- AI 7.2 – Ensure that WRC-2011 agenda contains items needed to accomplish President's Vision for Space Exploration (VSE)



# AI 1.2: *Sharing between EESS (passive) and the fixed and mobile services in the 10.6-10.68 GHz and 36-37 GHz bands*

## NASA Objectives:

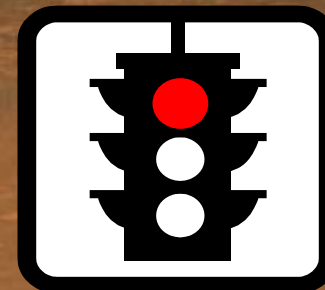
- Protect EESS (passive) operations in 10.6-10.68 GHz band
- Protect EESS (passive) operations in 36-37 GHz band

## US Proposal Status:

- In reconciliation
- RCS/IRAC Proposal: non-mandatory emission limits for FS/MS in 10.6-10.68 GHz and mandatory limits in 36-37 GHz
- FCC/WAC: NOC for 10.6-10.68 GHz band and non-mandatory emission limit for FS/MS in 36-37 GHz band

## Foreign Views:

- CITELE – Likely awaiting US input
- CEPT – Draft ECPs support mandatory emission limits in 10.6 and 36 GHz bands
- APT – Does not support “additional undue constraints” on FS/MS
- ASMG – Generally does not support constraints on FS/MS





## ***AI 1.3: Possible extension of 200 MHz to EESS (active) and SRS (active) to the existing 9.5-9.8 GHz allocations***

### **NASA Objectives:**

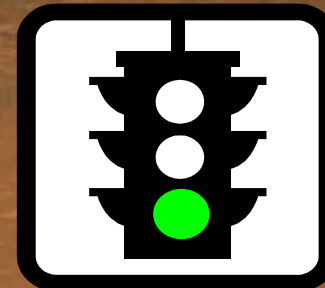
- Extension of 200 MHz to the existing 9.5-9.8 GHz EESS (active) and SRS (active) allocations to achieve a 500 MHz contiguous band

### **US Proposal Status:**

- US Proposal for extension into 9.3-9.5 GHz band approved and sent to CITELE; reconciled with similar proposal from Canada
- US seeking approval as IAP

### **Foreign Views:**

- CITELE – Likely IAP from US/Canada
- CEPT – Draft ECP largely agrees with US proposal; known to oppose extension into 9.8-10 GHz
- APT – Supports extension; most prefer 9.3-9.5 GHz, but KOR supports 9.8-10 GHz
- ASMG – Not likely to support nor oppose 9.3-9.5 GHz extension; likely to oppose 9.8-10 GHz extension



# *AI 1.5: Seek additional aeronautical mobile telemetry spectrum to support future wideband flight test research*

## NASA Objectives

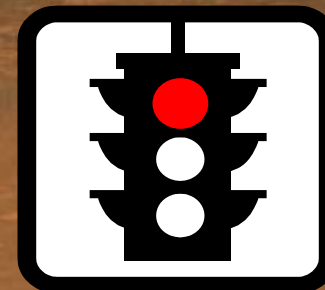
- Ensure sufficient flight test spectrum available for sub-orbital testing of Ares and Orion vehicle development
- Current allocation cannot meet long term U.S. requirements

## U.S. Proposal Status

- Approved U.S. proposal to allocate 4400-4940 MHz, 5091-5150 MHz, 5925-6700 MHz
- Support being sought in CITELE

## Foreign Views

- France has identified need for 60 MHz additional spectrum
- Europe considering spectrum requirements for UAV's (U.S. opposes)
- CEPT opposing 4 & 6 GHz allocations
- CITELE supporting 5091-5150 MHz





# *AI 1.12: Modify Appendix 4 of the RR to facilitate advance publication and notification of space science systems*

## NASA Objectives

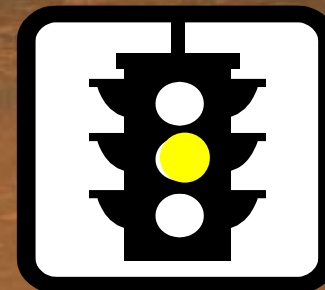
- Mandatory data elements at advance publication for NGSO not subject to coordination
- Allow means to properly advance publish and notify active and passive sensor systems in RR's

## U.S. Proposal Status

- U.S. proposal on mandatory data elements
- IRAC/RCS Proposal for mods to App 4 (sensor filing) awaiting reconciliation

## Foreign Views

- CEPT supporting both NASA objectives
- Syria expressed concern at Special Committee over possible cost impact to BR
- Canada generally supports mandatory data element proposal



# *AI 1.17: Protection of 1400-1427 MHz passive band from unwanted emissions from MSS feederlinks in the 1390-1392 MHz and 1430-1432 MHz bands*

## NASA Objectives

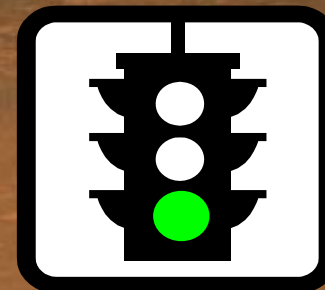
- Protection of the EESS (passive) operations in the 1400-1427 MHz band

## US Proposal Status:

- US Proposal for suppression of footnote allocation to MSS feederlinks around 1400-1427 MHz band; reconciled with similar Canadian proposal at CITEL
- US seeking approval as IAP

## Foreign Views:

- CITEL – Likely IAP from US/Canada
- CEPT – Draft ECP largely agrees with US proposal
- APT – Supports suppression of MSS feederlink allocation
- ASMG – Unknown





# ***AI 1.20: Protection of EESS (passive) from unwanted emissions of active services in select bands as set forth in Resolution 738 (WRC-03)***

## **NASA Objectives**

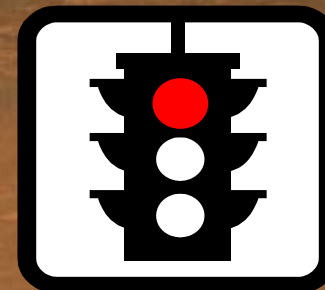
- Protection of the EESS (passive) operations in the 1400-1427 MHz, 23.6-24 GHz, 31.3-31.5 GHz, 50.2-50.4 GHz and 52.6-54.25 GHz bands from unwanted emissions from active services in nearby bands

## **US Proposal Status:**

- In reconciliation at Principals level
- RCS/IRAC proposal: proposes a mixture of NOC in some bands and mandatory unwanted emission limits in other bands based on ITU-R studies;
- FCC/WAC: opposes mandatory unwanted emission limits

## **Foreign Views:**

- CITEI – No IAP as yet
- CEPT – Draft ECP supports mandatory unwanted emission limits across the board
- APT – Supports protection of EESS (passive) without undue burden
- ASMG – Known to oppose unwanted emission limits, particularly on the FS



# Future Conference AI's of Interest (AI 7.2)

## NASA Supported Future Conference Topics

- Space Research Service uplink allocation in 22.55-23.55 GHz to support lunar exploration
- Consideration to exclude Aeronautical Mobile from Mobile Service allocation in 37-38 GHz to protect exploration downlinks
- Space Operations Service allocation below 3 GHz to support space-based range for launch support
- Modify RR 5.565 in lieu of extending allocation table beyond 275 GHz to identify passive sensing uses in 275-3000 GHz

## U.S. Proposal Status

- All future conference agenda proposals still pending in U.S. WRC prep process





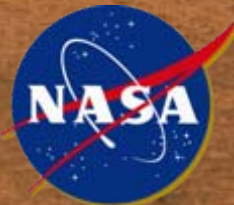
# ITU-R SG 3 & Propagation

- Advanced Communications Technology Satellite (ACTS)
  - Four years of propagation measurements at 20.135 GHz and 27.505 GHz in seven locations
  - Currently “electrically inert”
- Current attention
  - Facilitating U.S. preparations for ITU-R SG 3
    - Hosted Working Party meeting in 2005
    - <http://www.USSG3.org>
  - Improving the use of propagation models required for satellite coordination & interference assessments: See ITU-R Rec. 452-12
  - Planning for the Vision for Space Exploration

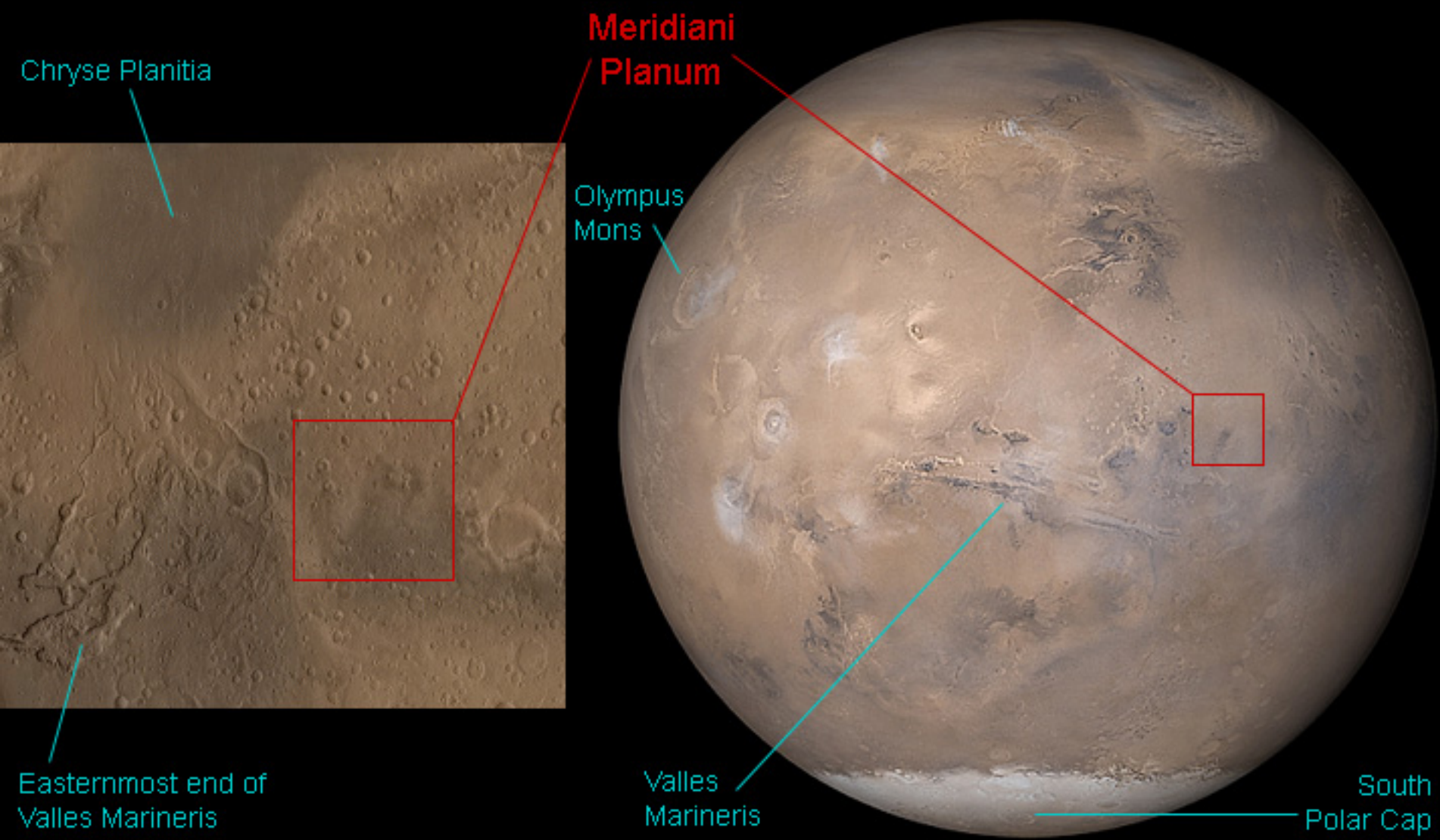


# Pop Quiz!

- By ITU-R definition, are the Mars Rovers (*i.e.*, Spirit & Opportunity) terrestrial stations (RR 1.162) or satellites (RR 1.179)?
  - Neither. They're spacecraft. (RR 1.178)
- Is communication with the moon considered deep space?
  - No. Distance to the moon = 384,402 km ( $< 2 \times 10^6$  km)
  - However, Mars: Yes. 60 million to 350 million km
- Is the space-based Hubble Space Telescope a “radio astronomy” station?
  - No. “Radio” stops at 3,000 GHz. Hubble is optical.
- Who registered the Int'l Space Station with the ITU-R?
  - U.S.A.
- Where was the photo in the slide background taken?
  - Endurance Crater in Meridiani Planum on Mars.  
Taken by Mars Rover Opportunity







Chryse Planitia

**Meridiani Planum**

Olympus Mons

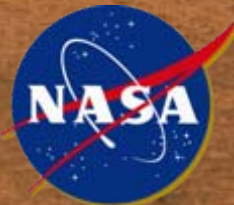
Easternmost end of Valles Marineris

Valles Marineris

South Polar Cap

# Pop Quiz – Name the service

- Space Shuttle communications?
  - Space research service
- Space-based passive sensors monitoring atmospheric water vapor at 190 GHz?
  - Earth exploration-satellite service (passive)
- Communication links relaying space-based water vapor sensor data to Earth?
  - Earth exploration-satellite service
- Communication links relaying Hubble Space Telescope data?
  - Space research service
- Mars Reconnaissance Orbiter downlink to Earth
  - Space research (deep space)





# Questions

