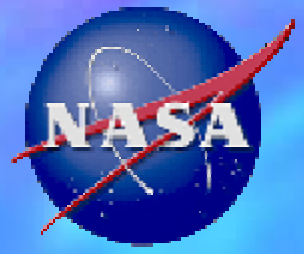


NASA Spectrum Management and Planning

John E. Zuzek

NASA Remote Sensing Spectrum Program Manager

Presentation to CORF

25 April 2007

Contents

- WRC-07 Issues Related to Remote Sensing
- Lunar-Mars Exploration Issues
- Other Issues

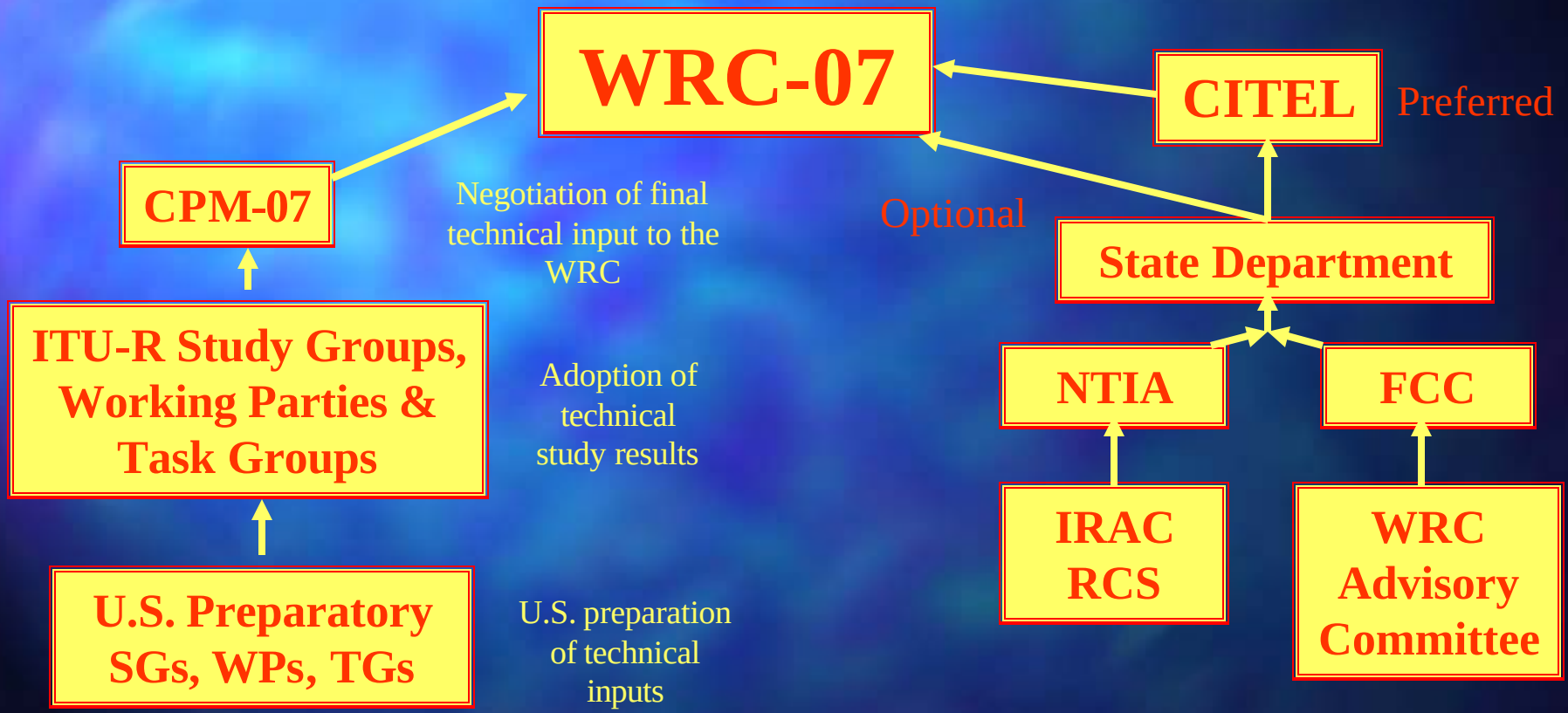
World Radiocommunication Conferences (WRC)

- Review and revise the international Radio Regulations based on an agenda set by the previous WRC
- Previous WRCs held in 1995, 1997, 2000 & 2003, now held every 4 years, and may be extended further to every 5 years
- Operates by consensus, voting on rare occasions
- Recently a greater emphasis on consolidated regional positions and proposals
- Next WRC is scheduled for 23 October

U.S. Preparatory Process

- NTIA - Federal Government Agencies
  - The RCS of the IRAC develops preliminary views and draft proposals
  - NTIA forwards views and proposals to the FCC
- FCC – Commercial Sector
  - The WAC develops preliminary views and proposals and advises the FCC on them
  - FCC Bureaus analyze & modify proposals and forwards them to NTIA
- NTIA & FCC coordinate and reconcile proposals
- State Dept. submits proposals to CITEL

U.S. Preparatory Organization



U.S. Proposals

- NTIA WRC Web Page

  http://www.ntia.doc.gov/osmhome/wrc/index.html
- U.S. Proposals and NTIA Documents

  http://www.ntia.doc.gov/osmhome/wrc/documents.html
- FCC WRC Web Page

  http://www.fcc.gov/ib/wrc-07/

Primary WRC-07 Remote Sensing Agenda Items

- Agenda Item 1.2: Passive sensing sharing conditions in 10.6-10.68 and 36-37 GHz
- Agenda Item 1.3: Active sensing allocation extension of 200 MHz near 9.5 GHz
- Agenda Item 1.12: Possible changes to coordination and notification procedures for satellite networks

Primary WRC-07 Remote Sensing Agenda Items (continued)

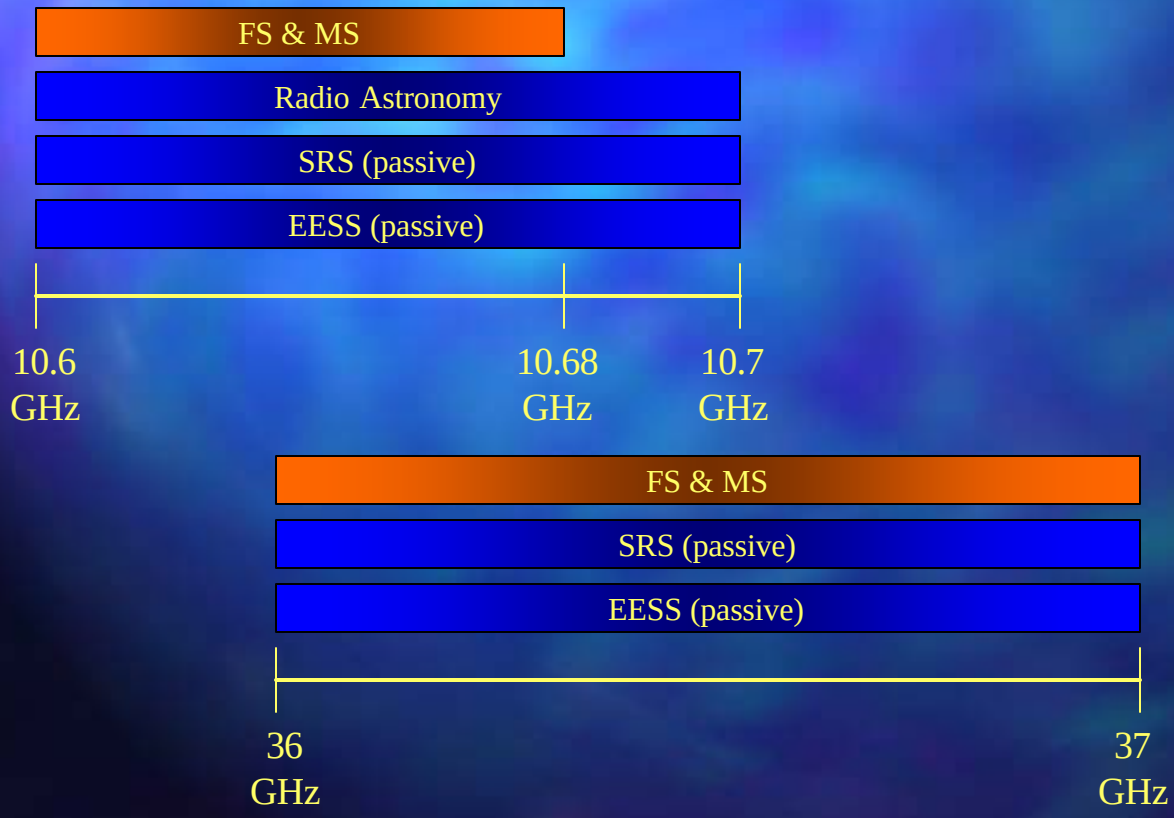
- Agenda Item 1.17: MSS feederlinks near 1400-1427 MHz and protection of passive services in this band
- Agenda Item 1.20: Protection of passive sensors from unwanted emissions
- Agenda Item 7.2: Future WRC agenda items

Secondary WRC-07 Remote Sensing Agenda Items

- Agenda Item 1.4: Frequency-related matters for IMT-2000 and beyond
- Agenda Item 1.8: HAPS near 30 and 50 GHz
- Agenda Item 1.18: Review PFD limits for HIO FSS systems in 17.7-19.7 GHz
- Agenda Item 1.19: Global harmonization of broadband FSS allocations for Internet access

Agenda Item 1.2

- Considers sharing conditions between FS/MS and passive sensors in the bands 10.6-10.68 GHz and 36-37 GHz



Agenda Item 1.2

to consider allocations and regulatory issues related to the Earth exploration-satellite (passive) service, space research (passive) service and the meteorological satellite service in accordance with Resolutions **746 (WRC-03)** and **742 (WRC-03)**;

For the 10.6-10.68 GHz band:

- Method B1: Reduce mandatory maximum transmitter power limit from -3 dBW to -15 dBW for the FS and -17 dBW for MS
- Method B2: Keep existing mandatory maximum power limit but impose EIRP limit for FS and MS systems
- Method B3: Encourage administrations to take all practicable steps to limit the transmitter power to -15 dBW for the FS and -17 dBW for MS systems

Agenda Item 1.2

For the 36-37 GHz band:

- Method C1: Impose mandatory maximum transmitter power limit of -10 dBW for the FS and MS in new footnote in RR
- Method C2: Encourage administrations to take all practicable steps to limit the transmitter power to -10 dBW for the FS and MS systems and to apply other mitigation techniques to protect passive sensors in new footnote in RR

Agenda Item 1.2

IRAC Proposals:

- Keep existing -3 dBW mandatory power limit on FS and MS in 10.6-10.68 GHz band and encourage reduction of power to -10 dBW in future systems
- Impose -10 dBW maximum power limit on all terrestrial systems in the 36-37 GHz band

FCC/WAC Proposals:

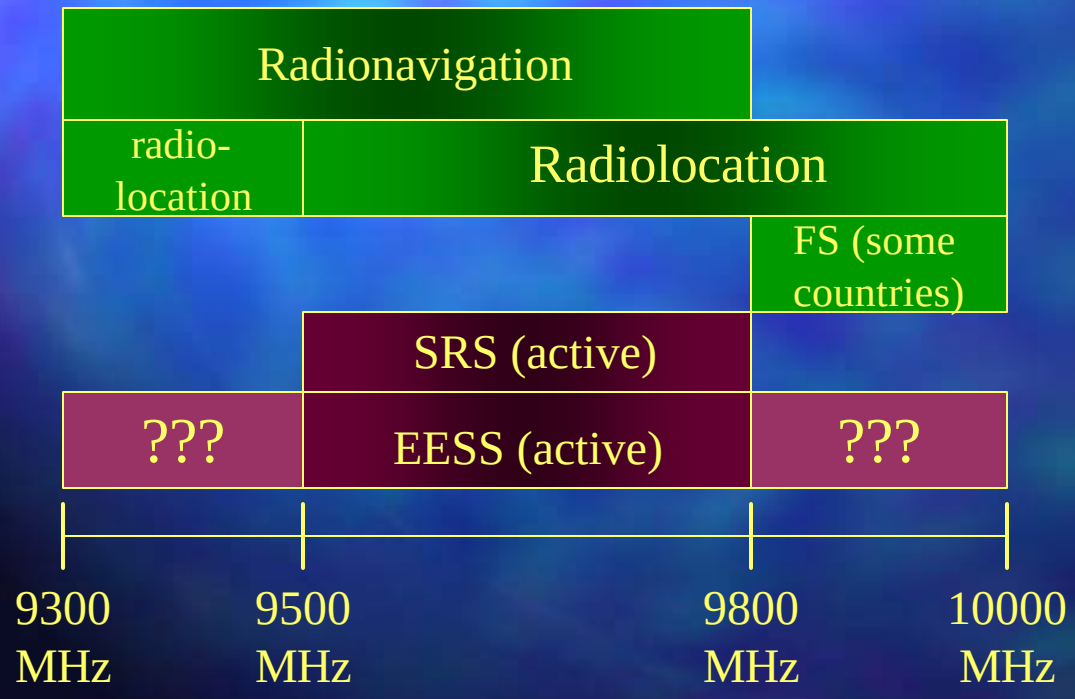
- No changes to regulations

Foreign Views:

- CEPT: European proposal for mandatory limits given in Methods B1 and C1 of the CPM Report
- APT: No proposals as yet but has generally supportive views.
- CITEL: Proposal from Canada for mandatory limits given in Method B1 of CPM Report (10.6-10.68 GHz); no proposal for 36-37 GHz

Agenda Item 1.3

- Considers an extension of 200 MHz to existing active sensing allocation from 9500-9800 MHz



Agenda Item 1.3

in accordance with Resolution **747 (WRC-03)**, consider upgrading the radiolocation service to primary allocation status in the bands 9 000-9 200 MHz and 9 300-9 500 MHz and extending by up to 200 MHz the existing primary allocations to the Earth exploration-satellite service (active) and the space research service (active) in the band 9 500-9 800 MHz without placing undue constraint on the services to which the bands are allocated;

For the EESS (active) and SRS (active) extension:

- Method B1: Extend EESS (active) and SRS (active) into the 9.3-9.5 GHz band limited to wideband (>300 MHz) systems
- Method B2: Extend EESS (active) and SRS (active) into the 9.8-10.0 GHz band

Agenda Item 1.3

U.S. Proposal:

- Extend the EESS (active) and SRS (active) allocation to the 9.3-9.5 GHz band resulting in a contiguous allocation from 9.3-9.8 GHz; extension to allocation is limited to wideband systems (>300 MHz)

Foreign Views:

- CEPT: Proposal for extension of EESS (active) allocation to the 9.3-9.5 GHz band AND 9.8-9.9 GHz band, limited to wideband systems
- CITEL: Proposal for extension to EESS (active) in 9.3-9.5 GHz band limited to wideband systems
- APT: No proposals to date, but has generally supportive views

Agenda Item 1.12

to consider possible changes in response to Resolution **86 (Rev. Marrakesh, 2002)** of the Plenipotentiary Conference: "Coordination and notification procedures for satellite networks" in accordance with Resolution **86 (WRC-03)**;

- NASA has been working with the ITU-BR since 1997 to attempt to make it easier to advance publish and notify active and passive sensors so that these systems will be listed in the Master International Frequency Registry (MIFR) and can get international recognition that the sensor allocations are being used. Such recognition also would also help protect sensor systems under the Radio Regulations.
- In order to make the registration process easier, it is necessary to modify Appendix 4 of the RR.

Agenda Item 1.12

US Proposal:

- Modify Appendix 4 of the Radio Regulations to include new data elements with appropriate descriptions for active and passive sensor systems

ITU-BR Actions:

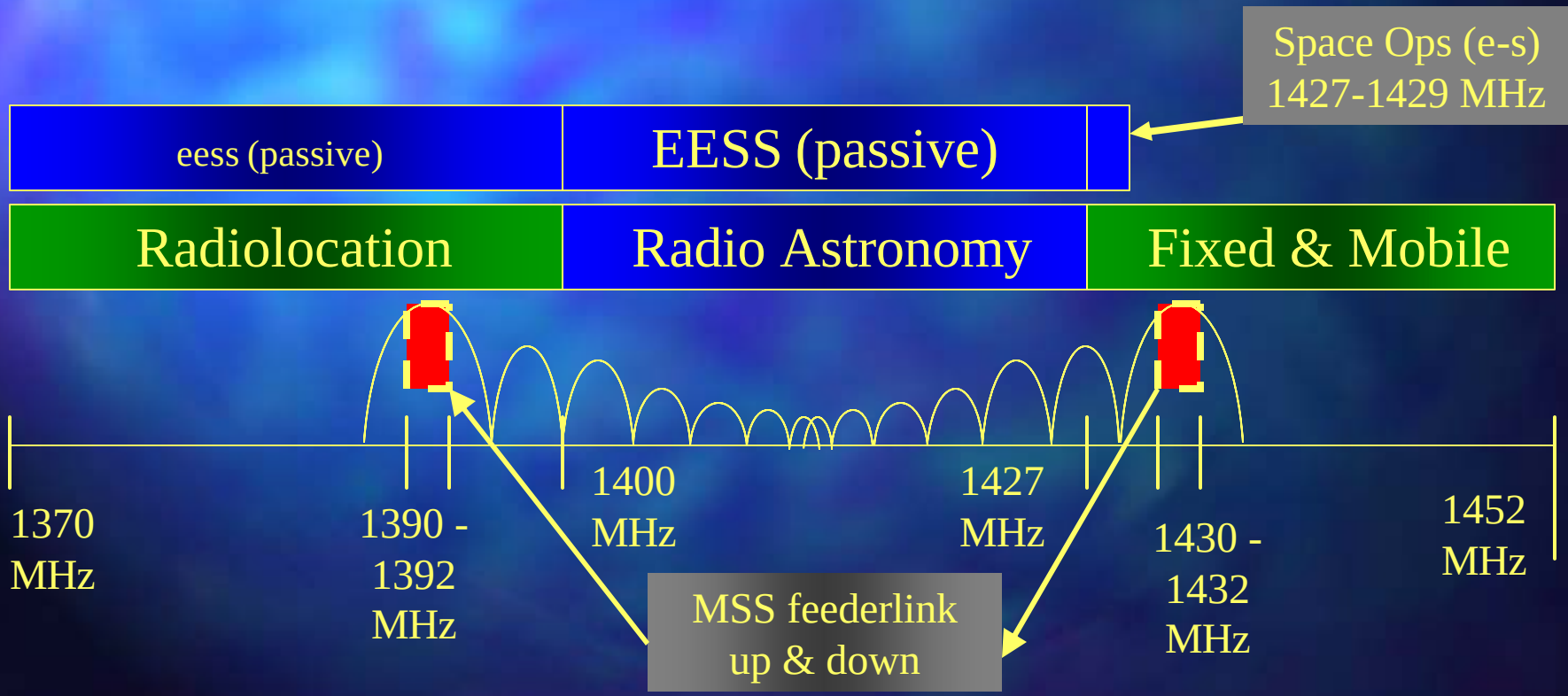
- Created 4 new “station classes” for active and passive sensors of the EESS and SRS.

Foreign Views:

- CEPT: Proposal for modification of Appendix 4 of the RR to allow for registration of active and passive sensors
- CITEL: Proposal for modification of Appendix 4 of the RR to allow for registration of active and passive sensors
- APT: No view on this specific topic but will probably follow the lead of CEPT and CITEL

Agenda Item 1.17

- Considers protection of existing services (including passive services in 1400-1427 MHz band) from MSS feederlink allocations in 1390-1392 MHz and 1430-1432 MHz bands



Agenda Item 1.17

to consider the results of ITU-R studies on compatibility between the fixed-satellite service and other services around 1.4 GHz, in accordance with Resolution **745 (WRC-03);**

- CPM Report provides only one method to satisfy the Agenda Item which is to suppress the secondary FSS allocation for MSS feeder links in the frequency bands 1390-1392 MHz (Earth-to-space) and 1430-1432 MHz (space-to-Earth) which was enacted by WRC-03

Agenda Item 1.17

U.S. Proposal:

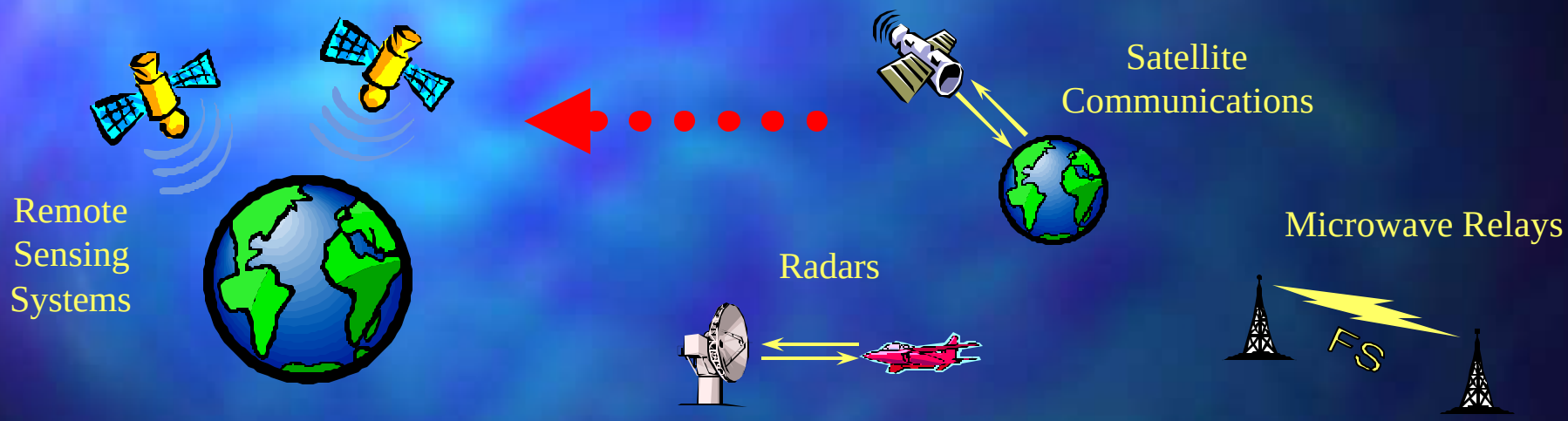
- Suppression of the secondary FSS allocation for MSS feeder links in the frequency bands 1390-1392 MHz (Earth-to-space) and 1430-1432 MHz (space-to-Earth)

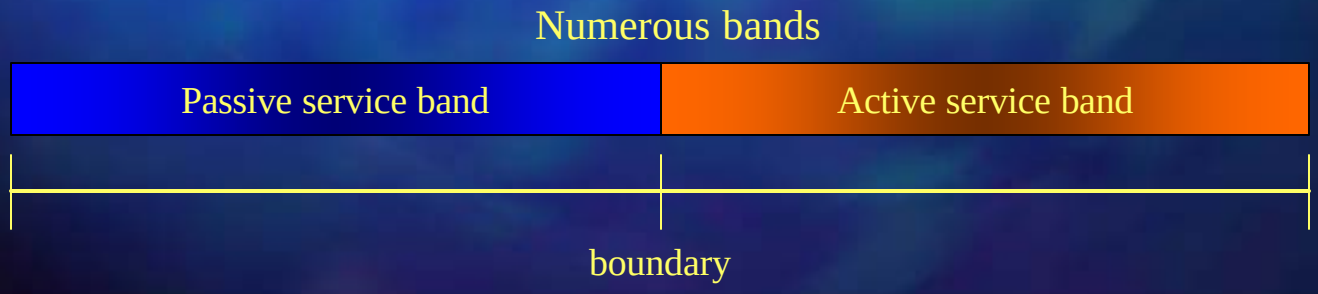
Foreign Views:

- CEPT: Proposal to suppress the FSS allocation for MSS feeder links near 1400-1427 MHz
- CITEL: Proposal to suppress the FSS allocation for MSS feederlinks near 1400-1427 MHz
- APT: No proposals but generally supportive of suppressing the FSS allocation for MSS feederlinks

Agenda Item 1.20

- Considers protection of passive sensors from unwanted/out-of-band emissions in specified bands (i.e., 1400-1427 MHz, 23.6-24 GHz, 31.3-31.5 GHz, 50.2-50.4 GHz and 52.6-54.25 GHz)





Agenda Item 1.20

to consider the results of studies, and proposals for regulatory measures regarding the protection of the Earth exploration-satellite service (passive) from unwanted emissions of active services in accordance with Resolution **738 (WRC-03);**

The intent of the CPM Report is that each band pair could be treated separately

- Method 1: Establish, in an EESS (passive) band, a mandatory power limit for unwanted emissions from a single

Agenda Item 1.20

- Method 2: Establish, in an EESS (passive) band, a non-mandatory power limit for unwanted emissions from a single transmitter of a specified service in an adjacent or nearby band.
- Method 3: Strongly encourage administrations to take all practicable steps to limit unwanted emissions in EESS (passive) bands from active services in adjacent and nearby frequency bands (similar to radio astronomy footnote 5.149)

Agenda Item 1.20

EESS (passive) band	Active service band	Active service
1 400-1 427 MHz	1 350-1 400 MHz	FS, MS and RLS
1 400-1 427 MHz	1 427-1 429 MHz	FS, MS and SOS (E-s)
1 400-1 427 MHz	1 429-1 452 MHz	FS and MS
23.6-24 GHz	22.55-23.55 GHz	ISS
31.3-31.5 GHz	30-31 GHz	FSS E-s
31.3-31.5 GHz	31-31.3 GHz	FS (except HAPS)
50.2-50.4 GHz	50.4-51.4 GHz	FSS (E-s)
50.2-50.4 GHz	47.2-50.2 GHz (Regions 2 & 3) 49.44-50.2 GHz (Region 1)	FSS
52.6-54.25 GHz	51.4-52.6 GHz	FS

Agenda Item 1.20

IRAC Proposal:

- Offers band-by-band solutions ranging from NOC in some bands to limits on unwanted emissions for certain active services in certain passive bands. Some bands require mandatory unwanted emission limits, such as for the FSS (E-s) near 50.2-50.4 GHz.

FCC/WAC Proposals:

- FCC opposes any limits on unwanted emissions, either mandatory or non-mandatory, that are different from US regulations. WAC supported non-mandatory limits in most bands.
- Foreign Views:
- CEPT: Proposal for mandatory unwanted emission limits in all relevant band pairs based on ITU-R studies
- APT: No proposals as yet but is of the view that limits on unwanted emissions could be supported if such limits do not create an undue burden on the active services
- CITEL: Canada proposed mandatory limits for the FS in all bands being considered.

Agenda Item 7.2

- to recommend to the Council items for inclusion in the agenda for the next WRC, and to give its views on the preliminary agenda for the subsequent conference and on possible agenda items for future conferences, taking into account Resolution **803 (WRC 03)**;
- United States:
  - Draft proposal to SUP AI 2.2 (allocations above 275 GHz) and ADD AI concerning possible revision of RR **5.565.**
  - Draft proposal to consider SRS (E-s) allocation within 22.55-23.05 GHz
- CEPT:
  - Draft proposal to keep AI 2.2 (allocations above 275 GHz) or, as an alternative, ADD AI concerning possible revision of RR **5.565**
  - Draft proposal to consider SRS (E-s) allocation within 22.55-23.55 GHz
- APT:
  - No proposals available at this time

Agenda Items of Secondary Concern to Remote Sensing

AI	Agenda Item Information	Concern
1.4	Frequency-related matters for IMT-2000 and beyond	No identification of bands affecting remote sensing
1.8	HAPS near 30 and 50 GHz	No change to footnote protecting 31.3-31.8 GHz passive sensing band from HAPs
1.18	Review PFD limits for highly inclined orbit FSS systems in 17.7-19.7 GHz	No relaxation of satellite downlink PFD limits in 18.6-18.8 GHz passive sensing band
1.19	Global harmonization of broadband FSS allocations for Internet access	No identification of satellite uplinks near remote sensing bands

Exploration Program

- President's Vision for Space Exploration
  - Complete ISS
  - Begin Lunar and Mars Exploration with Robotic Missions
  - Continue Manned presence from ISS to Moon, Mars and Beyond

NASA's Exploration Roadmap

05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

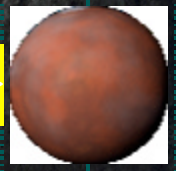
Initial Orion Capability

Lunar Outpost Buildup

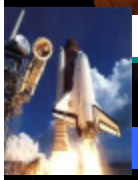
Lunar Robotic Missions

7th Human Lunar Landing

Science Robotic Missions



Mars Expedition Design



Commercial Crew/Ca

Space Shuttle Ops

Orion Development

Ares I Development

Orion Production and Operations

Early Design Activity

Lunar Lander Development

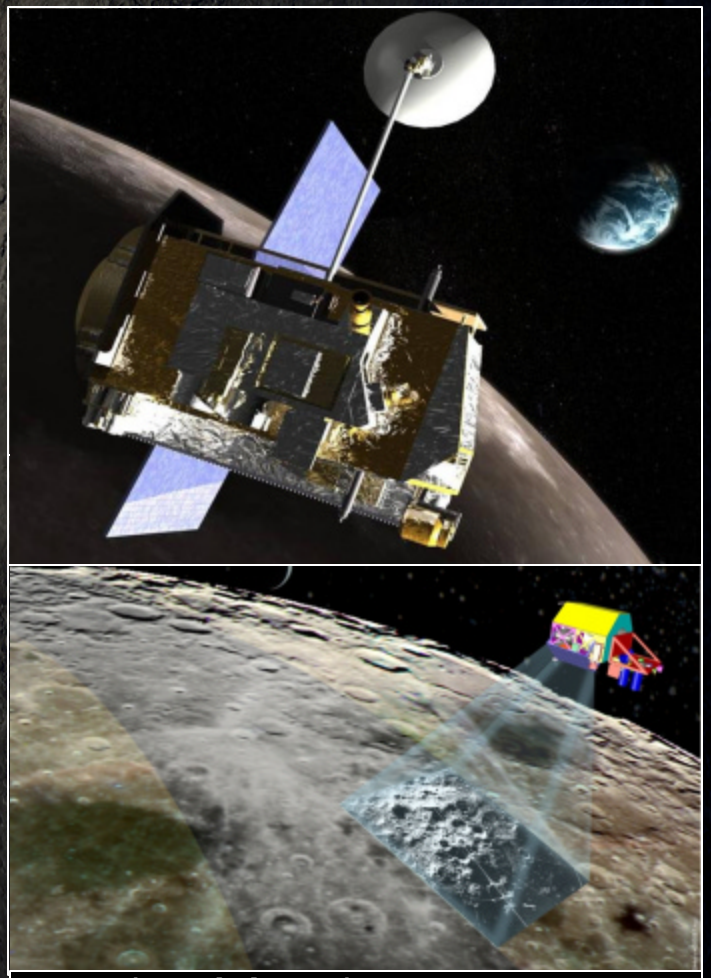
Ares V Development

Earth Departure Stage Development

Surface Systems Development

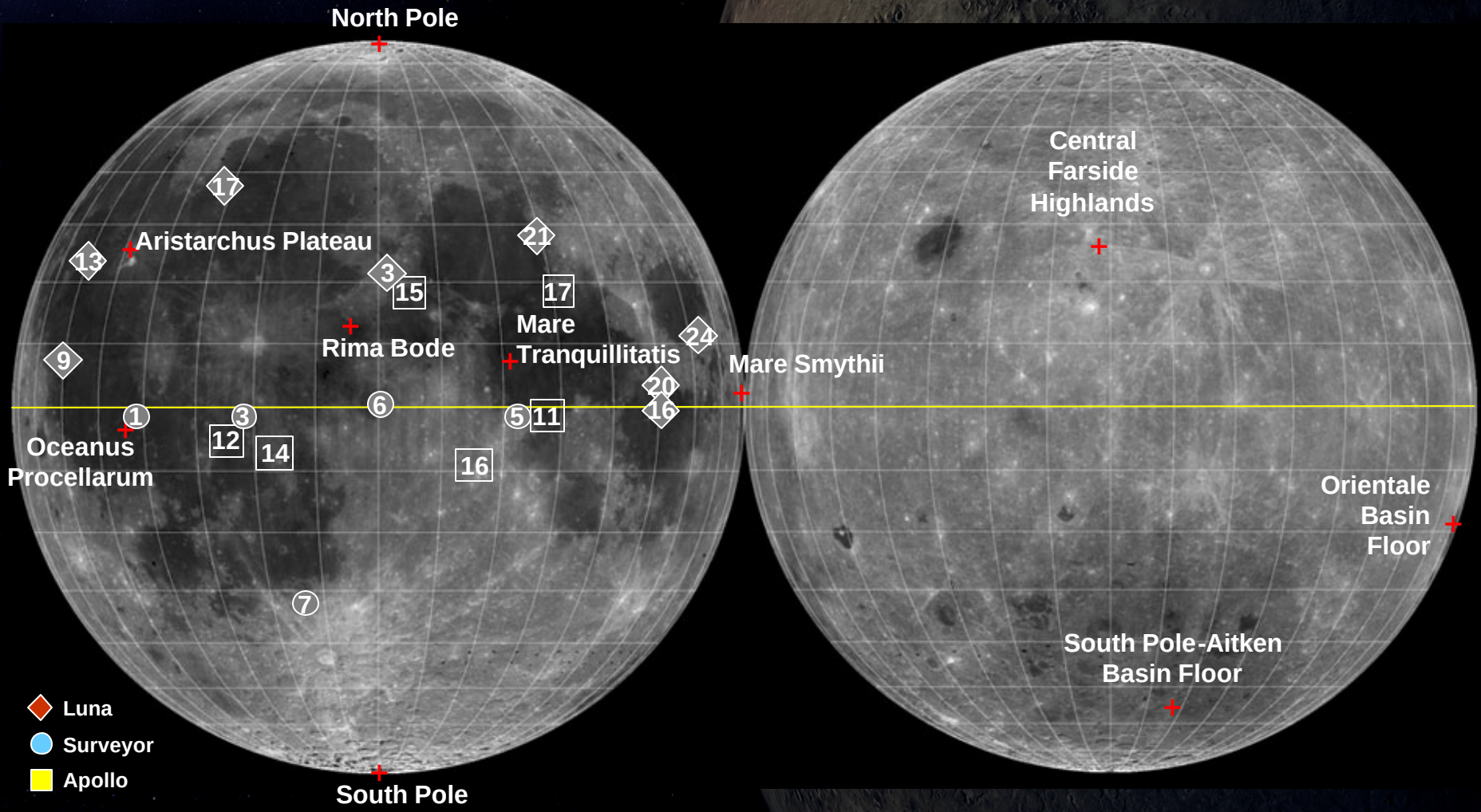
Lunar Reconnaissance Orbiter (LRO)

- **Launch in late 2008 on an Atlas 401-Centaur into a direct insertion trajectory to the moon. Co-manifested with LCROSS spacecraft.**
- **On-board propulsion system used to capture at the moon, insert into and maintain 50 km mean altitude circular polar reconnaissance orbit.**
- **1 year mission with extended mission options.**
- **Orbiter is a 3-axis stabilized, nadir pointed spacecraft designed to operate continuously during the primary mission.**
- **Investigation data products delivered to Planetary Data Systems (PDS) within 6 months of primary mission completion.**
- **Managed by Goddard (GSFC)**



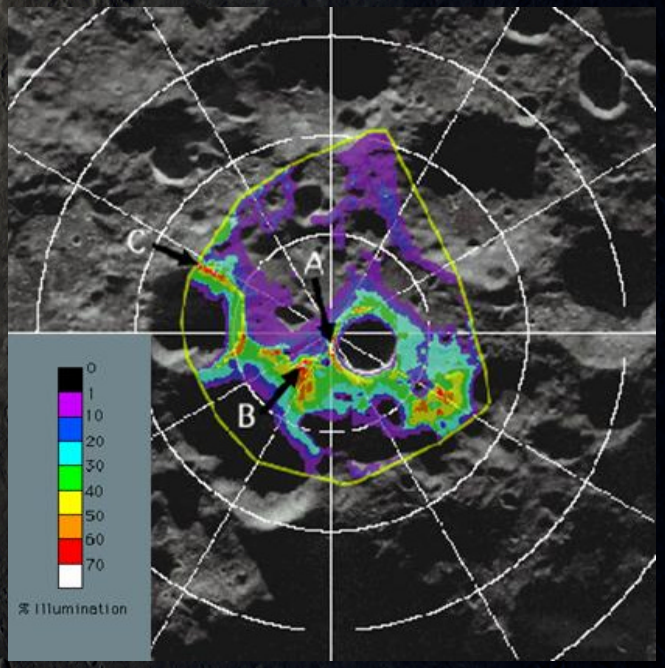
The **Mini-RF** demonstrates an Synthetic Aperture Radar (SAR) capable of measurements in X- and S-bands. It uses new comm technologies to locate potential water-ice.

High Priority Lunar Exploration Sites



Possible South Pole Outpost

- The lunar South Pole is a likely candidate for outpost site
- Elevated quantities of hydrogen, possibly water ice (e.g., Shackelton Crater)
- Several areas with greater than 80% sunlight and less extreme temperatures
- Incremental deployment of systems – one mission at a time
  - **Power system**
  - **Communications/navigation**
  - **Habitat**
  - **Rovers**
  - **Etc.**



LUNAR-MARTIAN SPECTRUM COORDINATION MEETINGS
LUNAR VACINITY FREQUENCY PLAN

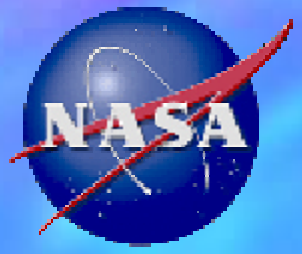
Band	Forward	Agency	Return	Agency	Notes
Operational direct from/to Earth (link 1)					
S-Band	2025-2110 MHz	All	2200-2290 MHz[5]	All	
X-band	7190-7235 MHz	Roskosmos ESA ISRO JAXA CNSA	8450-8500 MHz[1]	Roskosmos ESA ISRO JAXA CNSA	
Ka-Band	20/30 GHz[2]	NASA	25.5-27 GHz[3]	NASA	
Lunar Relay Trunk Line (link 2)					
Ka-Band	40-40.5 GHz	NASA	37-38 GHz	NASA	
Lunar relay to/from Orbiter or Surface (link 3) Orbiter to/from Surface (link 4) Orbiter to Orbiter (not shown)					
UHF	435-450 MHz[4]	JAXA ISRO	390-405 MHz[4]	JAXA ISRO	
S-Band	2025-2110 MHz	NASA JAXA	2200-2290 MHz[5]	NASA JAXA	
Ka-Band	22.55-23.55 MHz	NASA	25.5-27 GHz[3]	NASA	
Surface to Surface (link 5)[6]					
UHF	410-420 MHz	NASA	410-420 MHz	NASA	Under study
IEEE 802	868,915 MHz,2.4 GHz		868,915 MHz,2.4 GHz		Under study
Lunar Relay to Lunar relay Cross link (not shown)					
Ka-Band	37-38 GHz	NASA	40-40.5 GHz	NASA	

Notes: 1. Stress is put on the respect of the 10 MHz/mission SFCG limit (Recommendation 5-1R5) as a prerequisite to be able to share the band.
2. To be proposed as new ITU allocation at WRC-10. Exact frequency still under discussion.
3. Coordination required among all different users of the band: SRS for lunar missions, SRS for non-lunar missions, EESS. The specific issue of manned missions protection criteria will be discussed at SFCG.
4. Sharing with Earth-based radars needs to be checked.
5. Suitable for interoperability, but the band needs to be used wisely, since it is widely used for nearly all the space missions. Application of the SFCG Resolution 24-1 is necessary (6 MHz/spacecraft limit and no emission when it is not necessary to transmit).
6. Bands selection still to be discussed at a later stage.

LUNAR-MARTIAN SPECTRUM COORDINATION MEETINGS
MARS VACINITY FREQUENCY PLAN

Band	Forward	Agency	Return	Agency	Notes
Operational direct from/to Earth (link 1)					
S-Band	2110-2120 MHz[1]	ESA ISRO? CNSA?	2290-2300 MHz	ESA ISRO? CNSA?	Not for new missions TBC TBC
X-band	7145-7190 MHz	All	8400-8450 MHz	All	TBC for CNSA and ISRO
Ka-Band	34.2-34.7 GHz	NASA	31.8-32.3 GHz	NASA	
Mars Relay Trunk Line (link 2)					
X-band	7145-7190 MHz	NASA ESA	8400-8450 MHz	NASA ESA	
Ka-Band 1	34.2-34.7 GHz	NASA	31.8-32.3 GHz	NASA	Now to 2025. .
Ka-Band 2	40-40.5 GHz[2]	NASA	37-37.5 GHz[2]	NASA	Beyond 2025.
Mars relay to/from Orbiter or Surface (link 3) Orbiter to/from Surface (link 4)					
UHF	435-450 MHz	NASA ESA ISRO	390-405 MHz	NASA ESA ISRO	
X-Band	Near 7145-7190 MHz[3]	NASA	Near 8400-8450 MHz[3]	NASA	
Ka-Band	Near 34.2-34.7 GHz[3]	NASA	Near 31.8-32.3 GHz[3]	NASA	
Surface to Surface (link 5)					
UHF	435-450 MHz		390-405 MHz		
IEEE 802	868,915 MHz,2.4 GHz[4]		868,915 MHz,2.4 GHz[4]		Under study

Notes:
1. The IMT-2000 allocation in this band creates usage problems in a number of countries.
2. These bands have generic SRS allocations and therefore the deep-space protection levels may not be achievable (Utilization of these bands is subject to SFCG Recommendation. 14-2R5).
3. to communicate with Earth and the relay. These bands are separated from the allocated bands to prevent self interference on the relay. These bands need to be chosen among those listed in SFCG Recommendation 22-1R1
4. The use of terrestrial Short-Range IEEE bands is still to be discussed at a later stage. No critical sharing situation.



Other Issues

94 GHz Cloud Profiling Radar

- CLOUDSAT launched in April 2006 – cloud profiling radar operating in the 94.0-94.1 GHz EESS (active) allocation
  - Information on orbital parameters and ephemeris data can be found on the CLOUDSAT web site: http://cloudsat.atmos.colostate.edu/
  - Through agreement with IUCAF, orbital information is also available from the Space Frequency Coordination Group (SFCG) web site: http://sfcgonline.org

CLOUDSAT Characteristics

Nominal Frequency	94 GHz
Pulse Width	3.3 μsec
PRF	4300 Hz
Minimum Detectable Z	-26 dBZ
Antenna Size	1.95 m
Dynamic Range	70 dB
Integration Time	0.3 sec
Vertical Resolution	500 m
Cross-track Resolution	1.4 km
Along-track Resolution	2.5 km

Possible HF Radar

- There is currently a secondary EESS (active) allocation in the band 432-438 MHz for use in remote sensing of rain forests down to the ground through the vegetation canopy
- NASA is interested in flying a dual-band sensor called the Microwave Observatory of Subsurface and Subcanopy (MOSS) using 1 MHz bandwidth somewhere in the 100-150 MHZ frequency band (nominally at 137-