

**WRC-07 Radio Astronomy Preparations
CORF Meeting
October 15, 2006**

**Tomas E. Gergely
Electromagnetic Spectrum Manager
National Science Foundation**

tgergely@nsf.gov

703-292-4896



WRC-07 Preparations

- **WRC-07 Agenda contained in Resolution 802 (WRC-03)**
- **Conference Preparatory Meeting (CPM-07)
February 19 – March 2, 2006, Geneva**
- **WRC-07 Scheduled to Be Held October 22 -
November 16, Geneva, Preceded by the
Radiocommunications Assembly
(15-19 October)**



WRC-07 Agenda Items of Interest to Radio Astronomy

- **Being on the Agenda is a Condition for an Issue to be Treated**
- **WRC-07 Radio Astronomy issues**
 - **Allocations near 1.4 GHz for satellite up and downlinks (AI 1.17)**
 - **Continuation of unwanted emissions study (AI 1.21)**
 - **Future Development of IMT-2000 and beyond (AI 1.4)**
 - **Consider additional allocations for aeronautical telemetry and telecommand (AI 1.5)**
 - **Consider additional allocations for aeronautical mobile (R)service between 108 MHz and 6 GHz (AI 1.6)**
 - **Sharing with MES in the 1668-1670 MHz range (AI 1.7)**
 - **Continuation of regulatory studies of HAPS (AI 1.8)**
 - **Future Agenda Items (AI 2.2)**
- **WRC-10**
 - **Allocations between 275-1000 GHz (AI 2.2)**
 - **Sharing with the Fixed Service at 81-86 and 92-100 GHz (AI 2.7)**
 - **Allocations to the Radiolocation Service at 15.4 –15.7 GHz (new US Proposal)**



AI 1.17 - 1.4 GHz Allocations for Satellite Up and Downlinks

- **WRC-03 allocated the 1390-1392 MHz and 1430-1432 MHz bands to feeder links (up and down, respectively) for non-GEO systems in the mobile-satellite service**
 - > On a secondary basis
 - > Subject to ITU-R studies on compatibility between the fixed-satellite service and other services (including passive services) around 1.4 GHz [in accordance with Resolution 745 (WRC-03)]
 - > Not to be used, until ITU-R studies reviewed at WRC-07!
- Some studies carried out - mostly positive, but
- Sole proponent company is out of business
- Draft CPM report lists only one method to satisfy the AI: suppress allocation
- US, Canada, Europe, Asia-Pacific Draft Proposals: Suppress allocation
- **The bottom line: Unless something unexpected happens, the allocation will be suppressed!**



Regulation of Unwanted Emissions of Satellite Downlinks Near Radio Astronomy Bands

Mandatory Limits

RR N°	Space Service	Sat Band	RA Band	PFD/epfd level	Remarks
5.443B	RNSS	5010 - 5030 MHz	4990 - 5000 MHz	-171 dB(W/m ²) in a 10 MHz band -245 dB(W/m ²) in a 10 MHz band	(pfd – GSO) (NGSO- epfd) (Res. 741)
5.511B	FSS	15.43-15.63 GHz	15.35 - 15.4 GHz	-156 dB(W/m ²) in 50 MHz	pfd - FSS allocation was suppressed
5.551H	FSS, BSS	42.0 - 42.5 GHz	42.5 - 43.5 GHz	-230 dB(W/m ²) in 1 GHz; - 246 dB(W/m ²) in any 500 kHz	NGSO limit (epfd)
5.551 H	FSS, BSS	42.0 - 42.5 GHz	42.5 - 43.5 GHz	-137 dB(W/m ²) in 1 GHz ; -153 dB(W/m ²) in any 500 kHz	GSO limit (pfd)



Limitations

SITE RELATED

- Levels to be complied with at the site of RA stations
- RA station **MUST** be registered with ITU
- Administrations to certify compliance with limits (*Still* no accepted tool in ITU to compute aggregate emissions)
- Bureau checks only Administration certification of compliance

TIME RELATED

- Level not to be exceeded for more than 2% of 2000 second integrations (ITU-R Rec. RA.1513)
- Prior systems grandfathered



Regulation of Unwanted Emissions of Satellite Downlink Near Radio Astronomy Bands Non- Mandatory Levels for Consultation

- **Resolution 739 (WRC-03) calls for**
 - > Administrations to take all reasonable steps to ensure that space stations, being designed, constructed or operating in some bands, do not exceed unwanted emission threshold levels in certain radio astronomy bands, at the site of observatories (see Tables 739-1 and 739-2)
 - > the administration operating the satellite system, and the one operating the radio astronomy station to enter into consultations to identify all practicable steps to be taken if the threshold levels are exceeded,
 - > with the aim of reaching a mutually acceptable solution,
 - > using as guidance Rec. ITU-R SM.1633 (essentially the Rec. ITU-R RA.769 levels)



Limitations

SITE RELATED

- Trigger levels reference site of RA stations
- RA station **MUST** be registered with ITU
- RA station must have been registered before satellite system was advance published

TIME RELATED

- Level not to be exceeded for more than 2% of 2000 second integrations (ITU-R Rec. RA.1513)

REGULATORY

- No examination or certification by Bureau (Strictly bilateral consultation, with no ITU intervention)
- *The epfd* methodology to be used to calculate unwanted emissions by NGSO systems (Rec. ITU-R M.1583 and ITU-R S.1586), along with a specific radio astronomy antenna model (Rec. ITU-R RA.1631)



Table Res. 739-1

Band pairs where Rec. 769 threshold levels are recommended and consultations may be triggered if the levels are not met by GEO satellite systems .

Space service	Space service Band (MHz)	Radio astronomy Band (MHz)
BSS (s-to-E) MSS (s-to-E)	1 452-1 492 1 525-1 559	1 400-1 427
MSS (s-to-E) MSS (s-to-E)	1 525-1 559 1 613.8-1 626.5	1 610.6-1 613.8
BSS (s-to-E) FSS (s-to-E)	2 655-2 670	2 690-2 700
FSS (s-to-E)	2 670-2 690	2 690-2 700 (in Regions 1 and 3)
	GHz	GHz
BSS (s-to-E)	21.4-22.0	22.21-22.5



Table Res. 739-2

Band pairs where Rec. 769 threshold levels are recommended and consultations may be triggered if the levels are not met by non-GEO satellite systems

Space service	Space service band	Radio astronomy band
	MHz	MHz
MSS (s-to-E)	1 613.8-1 626.5	1 610.6-1 613.8



AI 1.21 - Continuation of Unwanted Emissions Study

Resolution 740 (WRC-03) calls for compatibility studies to review and update:

- 1. Recommendation ITU-R SM.1633 (and others, if appropriate)**
- 2. The Tables in Res. 739, based on ITU-R studies, limited only to the band pairs in the Table in Resolution 740**

Task Group 1/9 established to carry out the studies

- > Task 1 is to be finished in ITU-R Study Group 1**
- > Task 2 to be carried out at WRC**



Band-pairs considered (Table-Res. 740)

Space service band MHz/GHz	Space service	Radio astronomy service band MHz/GHz
137-138	MSS (space-to-Earth)	150.05-153.0
387-390	MSS (space-to-Earth)	322-328.6
400.15-401	MSS (space-to-Earth)	406.1-410
620-790(No. 5.311) see Resolution 545 (WRC-03)	BSS (space-to-Earth)	608-614
1 452-1 492	BSS (space-to-Earth) (non-GSO systems only)	1 400-1 427
1 525-1 559	MSS (space-to-Earth) (non-GSO systems only)	1 400-1 427
1 525-1 559	MSS (space-to-Earth) (non-GSO systems only)	1 610.6-1 613.8
1 559-1 610	RNSS (space-to-Earth)	1 610.6-1 613.8
2 655-2 670	BSS (space-to-Earth)	2 690-2 700
2 655-2 670	FSS (space-to-Earth) (Region 2)	2 690-2 700
2 670-2 690	FSS (space-to-Earth) (Region 2)	2 690-2 700
10.7-10.95	FSS (space-to-Earth)	10.6-10.7
21.4-22.0	BSS (space-to-Earth)	22.21-22.5 12



Possible Outcomes

(Methods to Satisfy the Agenda)

- 1. Incorporate the Band Pairs Studied into the Tables of Res. 739**
- 2. Incorporate the Band Pairs Studied into the Tables of Res. 739, with the Exception of the 1.6 GHz RNSS/RAS band pair –GLONASS Issue**
- 3. Do not Incorporate Any New Levels into the Res. 739 Tables.**



AI 1.4 –Frequency Matters Related to IMT-2000 (and beyond)

- Long term (2020) requirements ~ 1500 MHz
- Bands under study, of interest to radio astronomy include:
 - > 470 - 806/862 MHz
 - > 4400 – 4990 MHz
- Satellite component may include the 1668-1675 MHz band



AI 1.5 –Consider Additional Spectrum for Aeronautical Telecommand and High-bit Rate Aeronautical Telemetry

- Requirement: additional 650 MHz of spectrum for aeronautical telemetry for flight testing
- The 4900-4990 MHz band is already allocated to the mobile service, footnote sought to designate it as “suitable” for T&T applications
- Candidate bands studied are: **4 400-4 940 MHz**, 5 925-6 700 MHz, 5 030-5 091 MHz, 5 091-5 150 MHz and 5 150-5 250 MHz
- 4825-4835 MHz band allocated to radio astronomy on a primary basis in Argentina, Australia and Canada, however, US 203 provides only all practicable steps protection
- Studies show large separation distances required with radio astronomy stations in all parts of the band



AI 1.5 –Consider Additional Spectrum for Aeronautical Telecommand and High-bit Rate Aeronautical Telemetry (2)

- Draft proposal:
 - ✓ Footnote 1 The bands 4 400-4 940 MHz and 5 925-6 700 MHz are suitable for the implementation of aeronautical mobile telemetry applications for flight testing by aircraft stations.
 - ✓ Modify 5.442, by adding: In the band 4 825-4 835 MHz, applications in the aeronautical mobile service are limited to aeronautical mobile telemetry for flight testing in the air-to-ground direction. Resolution X shall apply.
 - ✓ Resolution X takes care of radio astronomy concerns by coordinating within a distance of 450 km of the station
- Such coordination distance is not sufficient for high flying aircraft



AI 1.6 –Consider Additional Allocations for the Aeronautical Mobile (R) Service in Bands between 108 MHz and 6 GHz

- **Spectrum required (approx 60-100 MHz) for:**
 - a) Surface applications at airports (short range, highly reusable spectrum), and
 - b) Communications with UAVs (longer range, out to radio line-of-sight)

The bands 5000-5010 MHz and 960-1164 MHz are the prime candidates considered, for applications a) and b) respectively

Issue a) presents problem(s) due to compatibility issues with radio astronomy, (and sharing and/or compatibility with RNSS)



AI 1.6 –Consider Additional Allocations for the Aeronautical Mobile (R) Service in Bands between 108 MHz and 6 GHz (cont)

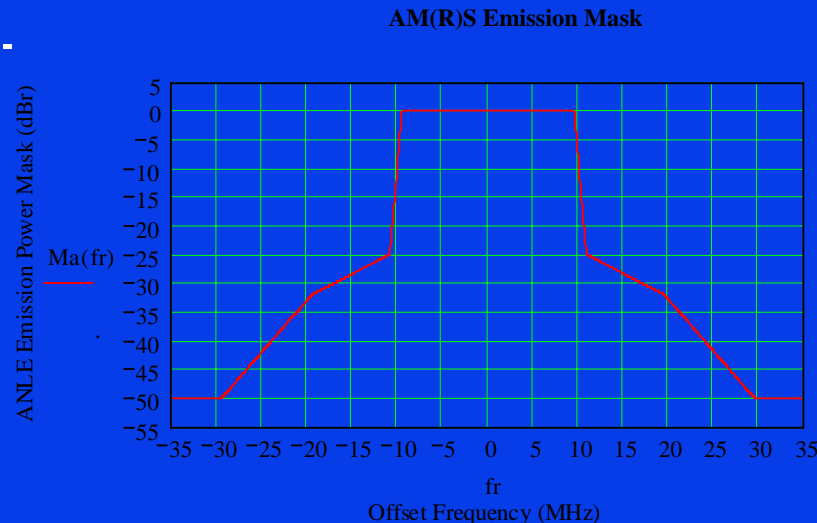
Proposal still being finalized

Radio astronomy issue dealt with by:

- a) *constraining applications to Earth's surface,*
- b) *at airports only*
- c) *local coordination, if necessary (possibly through a Resolution)*

Possible characteristics of system (IEEE 802.16e):

$P_t = 34.6$ dBm; Omnidirectional antenna



AI 1.7 - Sharing with MES in the 1668-1670 MHz Range

- **AI: Consider the results of sharing in the 1668-1668.4 MHz band between space research service (passive) and the mss (Earth to space)**
- **WRC-03 added MSS (Earth-to-space) allocations to the 1668-1675 MHz band(s)**
- **Also added footnote 5.379C**

In order to protect the radio astronomy service in the band 1 668-1 670 MHz, the aggregate power flux-density (pfd) values produced by mobile earth stations in a network of the mobile-satellite service operating in this band shall not exceed –
181 dB(W/m²) in 10 MHz and –194 dB(W/m²) in any 20 kHz at any radio astronomy station recorded in the Master International Frequency Register, for more than 2% of integration periods of 2 000 s. (WRC-03)

- **Allocation not implemented in U.S.**



AI 1.7 - Sharing with MES in the 1668-1670 MHz Range (2)

- Outstanding Issue: Sharing with the Space Research Service (SRS) *aka* Radio Astronomy from Space (Space VLBI) in the 1668-1668.4 MHz portion of the band
- HALCA no longer operating and Japan has no plans to observe in the band
- RadioAstron is interested in observations
- Proposed (and likely) Solution: Footnote limitation placed on transmitter power that would allow operations in highly elongated, elliptical orbits, such as RadioAstron
- Countries Behind Proposal: U.K (Inmarsat), Arab countries
- US draft proposal:
In order to protect the space research service (passive) in the band 1 668-1 668.4 MHz the maximum emission power density of any mobile earth station in a mobile satellite service network in the geostationary satellite orbit network operating in this band, shall not exceed -12.5 dBW/4 kHz in any part of the frequency band 1 668-1 668.4 MHz.



WRC-10 AI 2.2 - Allocations Between 275-3000 GHz

- WRC-03 adopted Resolution 950 that calls for:
 - Consideration of frequency allocations between 275 and 3000 GHz taking into account ITU-R studies
 - Voluntary registration of systems operating at the above frequencies in the MIFR
- U.S and others: Preliminary studies submitted to WP 7D, but the only other services to put forward requirements are the EESS and the Amateurs
- Characteristics for active services that would make use of this spectrum are unavailable at present
- Except for astronomers, consensus in U.S. is to postpone this AI
 - Active services not ready
 - VERY time consuming
- U.S. Proposal: Modify RR 565, as needed



RR 565

- The frequency band 275-1 000 GHz may be used by administrations for experimentation with, and development of, various active and passive services. In this band a need has been identified for the following spectral line measurements for passive services:
 - - Radio astronomy service: 275-323 GHz, 327-371 GHz, 388-424 GHz, 426-442 GHz, 453-510 GHz, 623-711 GHz, 795-909 GHz and 926-945 GHz.
 - - Earth exploration-satellite service (passive) and space research service (passive): 275-277 GHz, 294-306 GHz, 316-334 GHz, 342-349 GHz, 363-365 GHz, 371-389 GHz, 416-434 GHz, 442-444 GHz, 496-506 GHz, 546-568 GHz, 624-629 GHz, 634-654 GHz, 659-661 GHz, 684-692 GHz, 730-732 GHz, 851-853 GHz and 951-956 GHz.
 - - Future research in this largely unexplored spectral region may yield additional spectral lines and continuum bands of interest to the passive services. Administrations are urged to take all practicable steps to protect these passive services from harmful interference until the date when the allocation Table is established in the above-mentioned frequency band. (WRC-2000)



WRC-10 AI 2.2 - Allocations Between 275-3000 GHz (cont)

- If this issue is to become a future AI, the science community must contribute to studies in WP 7D, documenting the uses of bands above 275 GHz by radio astronomy
- Contact person: Andy Clegg
aclegg@nsf.gov
- Rec. ITU-R RA.314 lists the astrophysically important lines, based on those recommended by the IAU.
- WG (Div. X) on astrophysically important spectral lines of the IAU met during the Prague GA
- Some lines added to list, but attendance low



AI 2.7 - Sharing with the Fixed Service at 81-86 and 92-100 GHz

- **Consider the progress of studies concerning regulatory and technical issues relative to the fixed service in the bands 81-86 GHz and 92-100 GHz**
- **In accordance with Resolutions 731 and 732 (adopted at WRC-00 along with the reallocation of spectrum above 71 GHz)**
- **While there is now some use of these bands by the fixed service, there are no studies, except for a preliminary one in WP 7D**
- **U.S.: this is an ITU-R issue, not appropriate for WRC, delete AI**



Possible New Proposals

- Add Radiolocation Allocation to the 15.4 –15.7 GHz band?
- Radio astronomy Allocation in the neighboring 15.35 – 15.4 GHz band
- Would require compatibility studies
- Others?

