National Science Foundation

CORF Meeting

May 20, 2008

Tomas E. Gergely

Electromagnetic Spectrum Manager

National Science Foundation

tgergely@nsf.gov

703-292-4896

National Science Foundation

WRC – 07 Report

Agenda Items of Interest to Radio Astronomy

- 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);
- 1.21 to consider the results of studies, regarding the compatibility between the radio astronomy service and the active space services in accordance with Resolution 740 (WRC-03), in order to review and update, if appropriate, the tables of threshold levels used for consultation that appear in the Annex to Resolution 739 (WRC-03);
- A smattering of other issues….For a complete report, please see :

http://tinyurl.com/5e95hm

National Science Foundation

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!
- First attempts date back to 1995!
- Some theoretical studies carried out - mostly positive, but
- Sole proponent (Final Analysis)- went bankrupt
- CITEL, CEPT, APT Proposals to Suppress Allocation
- As expected, the allocation was suppressed!
- National implementation in progress

National Science Foundation

AI 1.21 Regulation of Unwanted Emissions of Satellite Downlink Near Radio Astronomy Bands (Pre WRC-07)

Mandatory limits:

- for unwanted emissions from satellites near three radio astronomy bands (5 GHz, 15.4 GHz, 43 GHz)
- Attenuation of Spurious emissions (43 + 10 log (*P*), or 60 dBc, whichever is less stringent w/r to power supplied to the antenna) – Not sufficient for radio astronomy purposes
- No limits for Out-of-band emissions

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 essentially the Rec. ITU-R RA.769 levels)

National Science Foundation

AI 1.21 Band pairs in which consultations may have been triggered Prior to WRC-07 if the threshold levels (Rec. ITU-R RA.769) are not met by GEO and non-GEO satellite systems, respectively

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

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

National Science Foundation

AI 1.21 - Continuation of Unwanted Emissions Study

Resolution 740 (WRC-03) called for compatibility studies to review and update the Tables in Res. 739, based on ITU-R studies, limited only to the band pairs in the Table in Resolution 740, based on the work performed in TG 1/9

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

National Science Foundation

Issue: GLONASS

- GLONASS (- The Russian equivalent of GPS - a non-GEO system) operates in the top portion of the 1559-1610 MHz band, where GPS, Galileo, etc. also operate or intend to operate
- In 1992 GLONASS Administration agreed (Agreement with IUCAF) to:
  - Operate below the 1610.6-1613.8 MHz band, allocated to radio astronomy (shared)
  - Reduce unwanted emissions of single satellites to below Rec. 769 levels in the 1610.6-1613.8 and 1660-1670 MHz bands
- Currently:
  - All GLONASS satellites operate below 1610 MHz
  - Unwanted emissions of single satellites are below Rec. 769 level in 1660-1670 MHz band;
  - Some satellites about 12 dB above that level in 1610.6-1613.8 Hz band (satellites closest in frequency), RF promise to reduce unwanted emissions further to below the Rec. 769 levels
- Other non-GEOs (GPS and Galileo) reduce their unwanted emission in the 1610.6-1613.8 MHz band to the *epfd* (aggregate) interference level, derived from Rec. 769 and willing to accept such a threshold level in the Table
- GLONASS (Russian Administration) refused to discuss further reductions (to epfd levels), arguing that:
  - GLONASS is disadvantaged, by operating closest to RA band
  - Further reductions of unwanted emissions would result in unacceptable reduction in signal strength that would affect a safety service

National Science Foundation

WRC-7 Action

- AI 1.21 - discussed in a subgroup of ~ 50 people
- US, Canada proposed to adopt the appropriate aggregate power level threshold for ALL non-GSO systems, including (RNSS)
- Europe, led by Russia proposed that an exception be made for this band – Separate Table for RNSS band –
- Single satellite threshold, ~ 15 dB less stringent than aggregate level
- Six sessions (~ 2 weeks) and LOTS of negotiations to resolve the issue
- Solution: adopted the aggregate threshold level for the band, but explicitly excepted GLONASS through a note.

National Science Foundation

Note to Resolution 739 (WRC-07) Annex 1, Table 1-2

This Resolution does not apply to current and future assignments of the radionavigation-satellite system GLONASS/GLONASS-M in the band 1 559-1 610 MHz, irrespective of the date of reception of the related coordination or notification information, as appropriate. The protection of the radio astronomy service in the 1 610.6-1 613.8 MHz band is ensured and will continue to be in accordance with the bilateral agreement between the Russian Federation, the notifying administration of the GLONASS/GLONASS-M system, and IUCAF, and subsequent bilateral agreements with other administrations.

National Science Foundation

Other WRC-07 Agenda Items of Interest to Radio Astronomy

- 1.4 to consider frequency-related matters for the future development of IMT-2000 and systems beyond IMT-2000 taking into account the results of ITU-R studies in accordance with Resolution 228 (Rev.WRC-03);
- 1.7 to consider the results of ITU-R studies regarding sharing between the mobile-satellite service and the space research service (passive) in the band 1 668-1 668.4 MHz, and between the mobile-satellite service and the mobile service in the band 1 668.4-1 675 MHz in accordance with Resolution 744 (WRC-03);
- 1.8 to consider the results of ITU-R studies on technical sharing and regulatory provisions for the application of high altitude platform stations operating in the bands 27.5-28.35 GHz and 31-31.3 GHz in response to Resolution 145 (WRC-03), and for high altitude platform stations operating in the bands 47.2-47.5 GHz and 47.9-48.2 GHz in response to Resolution 122 (Rev.WRC-03);
- 1.9 to review the technical, operational and regulatory provisions applicable to the use of the band 2 500-2 690 MHz by space services in order to facilitate sharing with current and future terrestrial services without placing undue constraint on the services to which the band is allocated;
- 1.11 to review sharing criteria and regulatory provisions for protection of terrestrial services, in particular terrestrial television broadcasting services, in the band 620-790 MHz from BSS networks and systems, in accordance with Resolution 545 (WRC-03);
- FUTURE Agendas

National Science Foundation

WRC-11

- Next WRC is tentatively scheduled for 2011
- Dates TBD
- Location TBD (probably Geneva, but might be Abu Dhabi)
- Approximately 12 items of interest to radio astronomy on preliminary WRC-11 agenda
- Items will be worked on in appropriate ITU Study Groups between now and then
- It will be a busy conference

National Science Foundation

WRC-11 Agenda Items of Interest to CORF

- Spectrum above 275 GHz
- Enhancing the international regulatory framework – Band segmentation
- Fixed service in the range 71 – 238 GHz
- Needs of passive systems for lightning detection below 20 kHz
- Spectrum for unmanned aircraft
- Additional spectrum for aeronautical mobile (route) service
- Additional spectrum for aeronautical mobile-satellite (route) service
- Radiolocation service in the 30 – 300 MHz range
- Oceanographic radar in the range 3 – 50 MHz
- Software defined radio and cognitive radio systems
- High altitude platform station link in the range 5850 – 7500 MHz
- Primary radiolocation service allocation in the band 15.4 – 15.7 GHz
- Short-range devices
- Additional spectrum for the mobile-satellite service

National Science Foundation

Above 275 GHz

- The International (and U.S.) Table of Frequency Allocations presently extends to an upper limit of 275 GHz
- Definition of “radio waves” (ITU, NTIA, FCC) :
  - Electromagnetic waves of frequencies arbitrarily lower than 3,000 GHz, propagated in space without artificial guide.
    - Although not allocated, the bands between 275 – 3000 GHz are therefore the purview of the ITU-R (the Radiocommunication Sector of the ITU), NTIA, & FCC
- WRC-11 Preliminary Agenda Item 1.6
  - to review No. 5.565 of the Radio Regulations in order to update the spectrum use by the passive services between 275 GHz and 3 000 GHz…
- Footnote 5.565 to the Table (ITU and U.S.) notes the interest of the radio astronomy and EESS services in frequencies between 275 and 1000 GHz

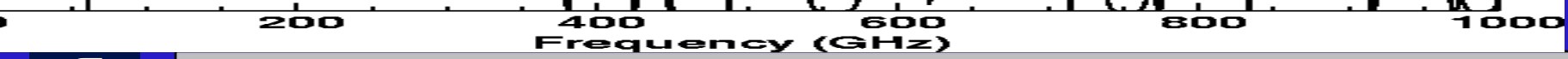
National Science Foundation

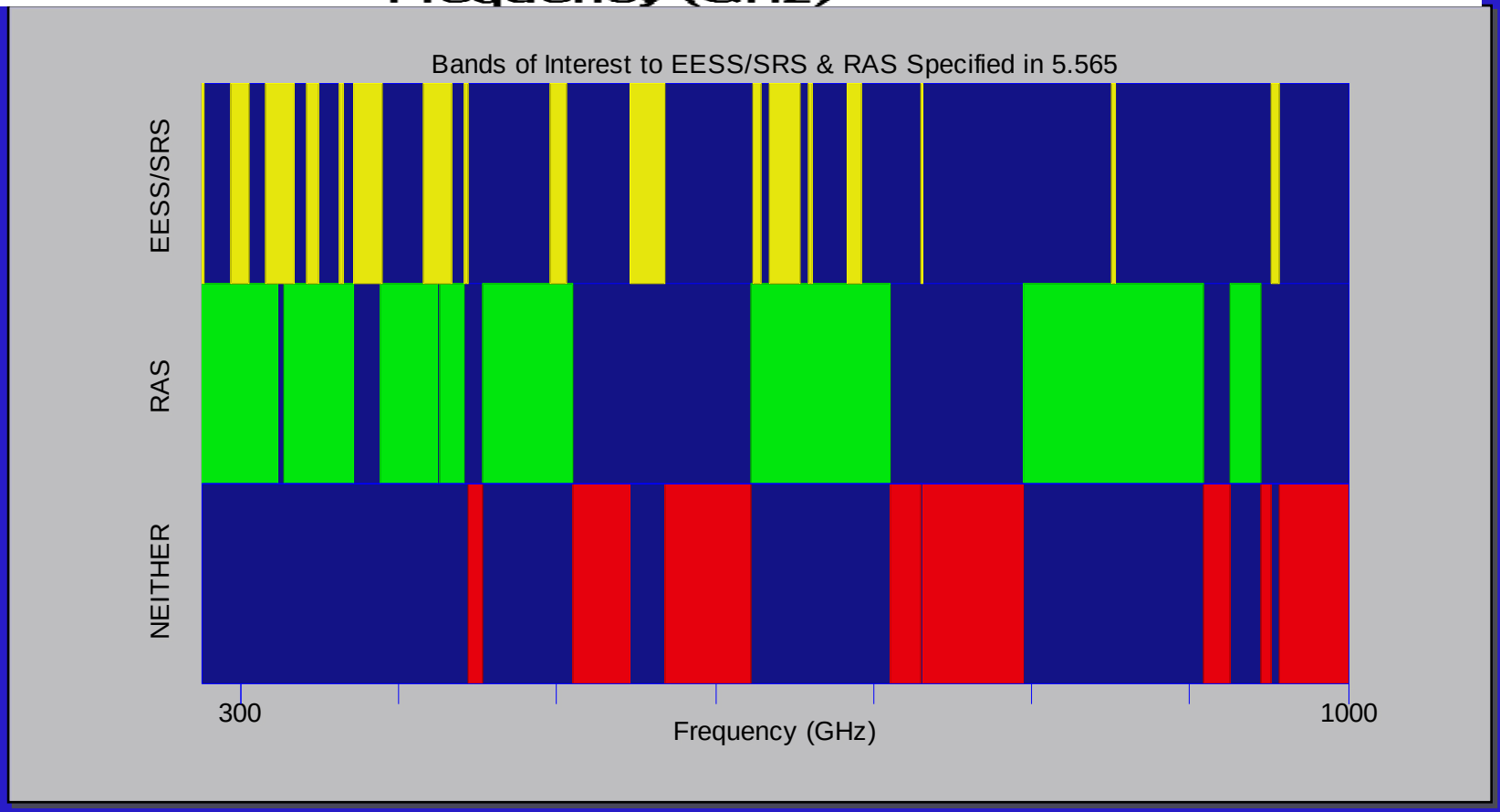
Footnote 5.565

"The frequency band 275-1000 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."





275 – 1000 GHz covered by 5.565:

- EESS: 155 GHz (21%)
- RAS: 422 GHz (58%)
- COMBINED: 476 GHz (66%)
- NEITHER: 249 GHz (34%)

Bands not Covered (GHz):

444 – 453	732 – 795
510 – 546	909 – 926
568 – 623	945 – 951
711 – 730	956 – 1000

Transmission measurements from Matsushita et al., PASJ, 51, 603 (1999)

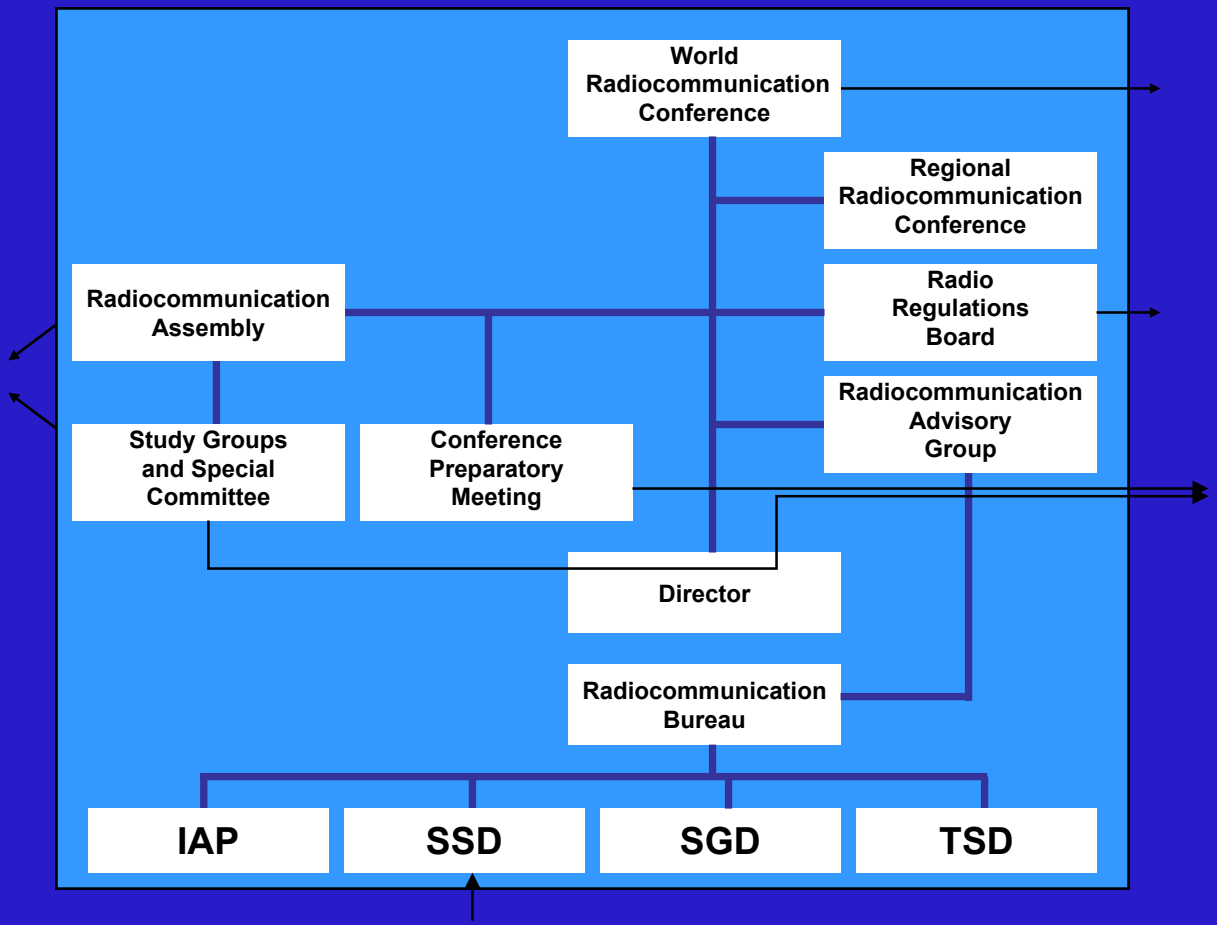
National Science Foundation

Above 275 GHz

- Bands of interest below 1000 GHz are based upon a list of spectral lines of astrophysical interest established in ITU-R Recommendation RA.314-10. This list is more specific than 5.565, and some lines outside of atmospheric transmission windows are included in Rec. 314.
- Spectral lines of interest above 1000 GHz have, to date, been based upon only limited input from relevant experts
  - IAU Division X Working Group on Astrophysically Important Spectral Lines (with considerable cross-membership with ITU WP 7D) meeting in Prague (August 2006) established a provisional list of astrophysically important spectral lines which was a list based simply on NIST web site data that was originally submitted by the U.S. to WP 7D to establish a dialog.
  - The list is missing important lines
- The input of astronomers actively involved in submm observational research is needed to refine the list of bands of astrophysical importance between 275 and 3000 GHz.

National Science Foundation

Radio Astronomers Interaction With the ITU-R



National Science Foundation

The ITU-R Study Groups

- Operate in cycles, between World Radiocommunications Conferences (WRCs)
- Cycles end with the Radiocommunications Assembly, nowadays held just before the WRC.
- The Study Group Structure revised by RA-07, that preceded WRC-07
- Study groups (of importance to radio astronomers):
  - SG 1 Spectrum management
  - SG 3 Radio wave propagation
  - SG 4 Fixed Satellites ☛ Satellites
  - SG 5 ☛ Terrestrial (includes some satellites, e.g.. AmatSat)
  - SG 6 Broadcasting ☛ Broadcasting
  - SG 7 Science Services
  - SG 8 Mobile/Mobile Satellites ☛ ☹
  - SG 9 Fixed Service ☛ ☹

National Science Foundation

WP 7D

- WP 7D (one of four WPs within SG 7)

  Mission:

  - Develop and maintain Radio Astronomy Related Recommendations, Reports and Handbook
  - Prepare input to draft CPM text

- 2 International meetings/yr, mostly at ITU Hqrs, Geneva
- Next meetings: Oct, 2008 Geneva
- Chaired by M. Ohishi (Japan)
- US WP 7 D ~60 members; ~15 active participants, less than half of whom are astronomers
- ~ 10 meetings/year (at NSF –accessible by phone)

National Science Foundation

WP 7D - Work In Progress (ITU)

- **Revision of Question on Space Radio Astronomy**
  - Q 241/7 suppressed at end of last cycle, as Questions 230/7 and 241/7 nearly identical; Q 230/7 revised to incorporate lost aspects from Q 2412/7
  - Status: awaiting further input from UK, attached to Chairman's Report
- **Comparison of Threshold Levels in Rec. ITU-R RA.769-1 and 769-2**
  - Also, other useful info, such as conversion of threshold level units to electric field dB (μV/m)
  - Status: approved by WP 7D, likely to be objected to at SG level

National Science Foundation

WP 7D - Work In Progress (ITU)

- **Review and Revise Recommendation 1237- Protection of RA observations from wideband digital modulation**
  - **Clarification and update of Recommendation**
  - **Deletion of part of attached Note: "The levels of the detrimental interference to the RAS referred to in Annex 1 to Recommendation ITU-R RA.769 are not accepted by the Arab Administrations, being unrealistic, as confirmed by previous Radiocommunication Conferences in 1995, 1997 and 2000 dealing with Recommendation ITU-R RA.769"**
  - **Status: Likely to be objected to by the Russian Federation on account of GLONASS, and possibly one (or more) Arab Adm.**
- **Draft New Report on THz Astronomy**
  - **Status: Awaiting further input from Canada**

National Science Foundation

WP 7D Work Planned for Cycle

- Recommendation on Damaging levels of Interference to Radio Astronomy (D. Thompson and H. Liszt)
- Review and Revise Recommendation 314 on "Preferred Frequency Bands for Radioastronomical Measurements"
  - Incorporate important Spectral Lines Above 275 GHz
  - Split Recommendation to Below and Above 275 GHz?
- Progress Work on Quiet Zones, in Response to Approved Question (Harvey Liszt)
- Progress Work on Channel Capacity Document, withdrawn last cycle (Darrel Emerson)
- Update Report on Mitigation Techniques in Radio Astronomy
- Work on Impact (and Opportunities) of Software Defined Radio (SDR) on Radio Astronomy
- Moon, Mars initiative
- Oceanographic radar in the range 3 – 50 MHz
  (M. Lewis- WP 7D liaison)
- Sharing with Fixed Service Above 71 GHz

National Science Foundation

US WP 7D

For Information About Current and Future Activities of US WP 7D (or, more broadly of US SG 7), see:

www.ussg7.org

To participate in the Work of US WP 7D, send an e-mail to:

aclegg@nsf.gov or

tgergely@nsf.gov

National Science Foundation

Bilateral Issues (1)

Exchange Of Views On The Use Of the 71-76 And 81-86 GHz Bands, Considering Mexico's Plans For A Near Term Auction Of The Band For New Broad-band Services (US-Mexico HLCC on Telecommunications Mtg., April 29, 2008)

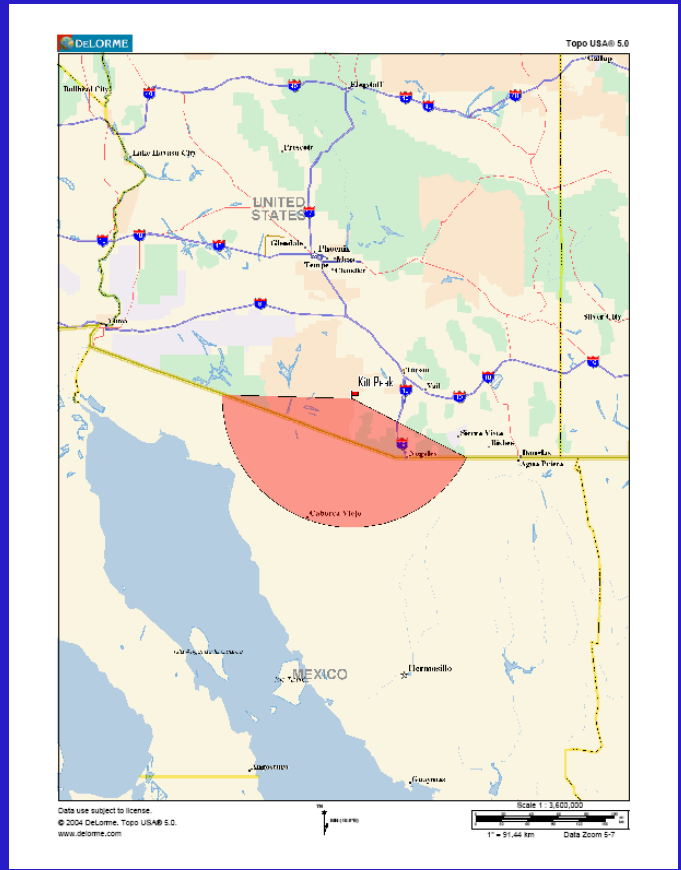
Radio Astronomy Observatories near the Common Border:

- Very Long Baseline Array station, Kitt Peak, AZ (31 57 23 North Latitude, 111 36 45 West Longitude, 1902 m elevation AMSL);
- Steward Observatory, Kitt Peak, AZ (31 57 12 North Latitude, 111 36 53 West Longitude, 1914 m elevation AMSL);
- Submillimeter Telescope Observatory, Mt. Graham, AZ (32 42 06 North Latitude, 109 53 28 West Longitude, 3186 m elevation AMSL).

National Science Foundation

Possible Protection Measure to US Observatories

- **Mexico might establish a protection zone, not allowing links in the 81-86 GHz band that:**
  - are located within 150 km of 31 57 23 North Latitude, 111 36 45 West Longitude
  - and whose beam would intersect the common border.



National Science Foundation

Bilateral Issues (2)

- WRC-07 designated the 4400-4940 MHz band for use by aeronautical mobile telemetry (AMT), subject to conditions in Resolution 416 (WRC-07) (WRC-07 Agenda item 1.5)
- In the US, observations in the 4825-4835 MHz band are on a unprotected basis
- In Canada the band 4825-4835 MHz is a primary radio astronomy band
- Res. 416 stipulates (*resolves 1*) that if AMT flight operations are planned within 500 km of the territory of an Administration where radio astronomy has a primary allocation in he band 4825-4835 MHz, the Adm. that operates the AMT station will consult with the Adm. that operates the telescope, to determine if special measures are needed to prevent interference
- In course of the national implementation of WRC-07 AI 1.5 action, NSF is trying to incorporate into the US rules coordination between the US and Canada in this band, for the protection of Penticton

National Science Foundation

BACKUP VIEWGRAPHS

National Science Foundation

Limitations of Regulations

SITE RELATED

- Trigger levels reference site of RA stations
- RA station MUST have been registered with the ITU 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)

National Science Foundation

GLONASS

GPS News

First Deputy PM Ivanov Slams Agency Over Glonass Failings

Staff Writers
Moscow (RIA Novosti) Jan 24, 2008

Russian space agency Roscosmos must take responsibility for the operational shortcomings of the Glonass satellite navigation system, a first deputy prime minister said on Wednesday. Glonass (Global Navigation Satellite System), Russia's equivalent of the U.S. Global Positioning System (GPS), is designed for both military and civilian use and allows users to identify their positions in real time.

Sergei Ivanov, who oversees the country's military-industrial complex, called for the agency's leaders to take "personal responsibility for the development of particular components of Glonass and the system as a whole."

The fully operational Glonass cluster will consist of 24 Glonass-M and Glonass-K satellites by 2010, with 21 used for transmitting signals and three for on-orbit spares, deployed in three orbital planes.