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Radio Astronomy at the ITU

(WRC-11 Issues)

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Presentation to CORF

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WORLD RADIOCOMMUNICATION CONFERENCES

- Countries Are Sovereign With Regard to Use of the Radio Spectrum (And Regulations) Within National Borders
- International Uses of Radio Spectrum (9 kHz to 275 GHz) Regulated Through WRCs, Held Under the International Telecommunication Union (ITU)
- New International Regulations (in Particular Frequency Allocations) Are Adopted at and by WRCs
- The Outcome Is An International Treaty
- Held Regularly Every 3-4 Years

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WRC- /12

- Next WRC to be held in Geneva, January 23- February 17, 2012
- Agenda of WRC-11, adopted at WRC-07 (now confirmed) consists of ~ 30 items; some 15 have varying degrees of relevance to radio astronomy
- Preceded by the Conference Preparatory Meeting (CPM); date ?

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The main course (for radio astronomy)

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, in accordance with Resolution **950 (Rev.WRC-07)**, and to consider possible procedures for free-space optical-links, taking into account the results of ITU-R studies, in accordance with Resolution **955 (WRC-07)**;

AI 1.6 Revision of footnote 5.565, based on ITU-R "studies"

- Revise the listing of bands in the 275 - 1000 GHz range, currently in the footnote
- Extend the range of the footnote, to cover up to 3000 GHz

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Footnote 5.565 (Current)

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.

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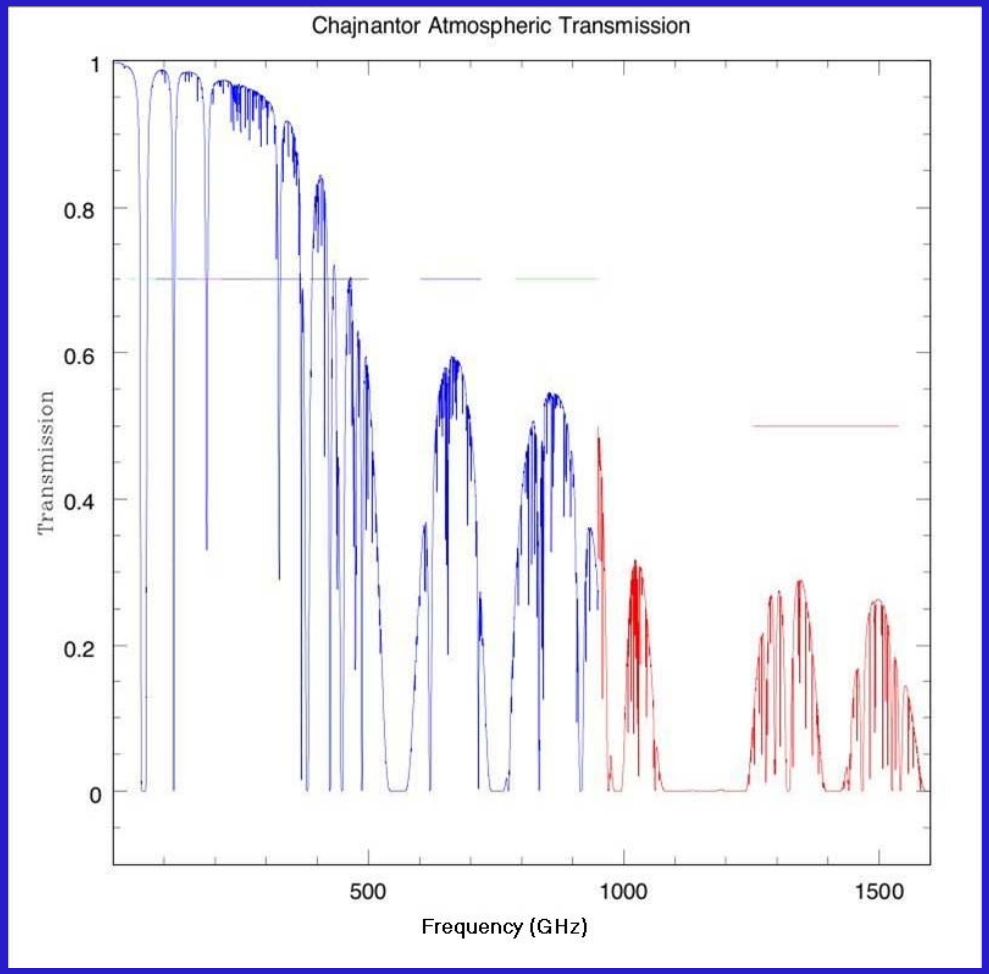
Atmospheric transmission at the ALMA site



Atmospheric transmission at Cerro Chajnantor, at approximately 5000 m altitude.

0.5mm PWV v<950 GHz
0.2mm PWV v>950 GHz

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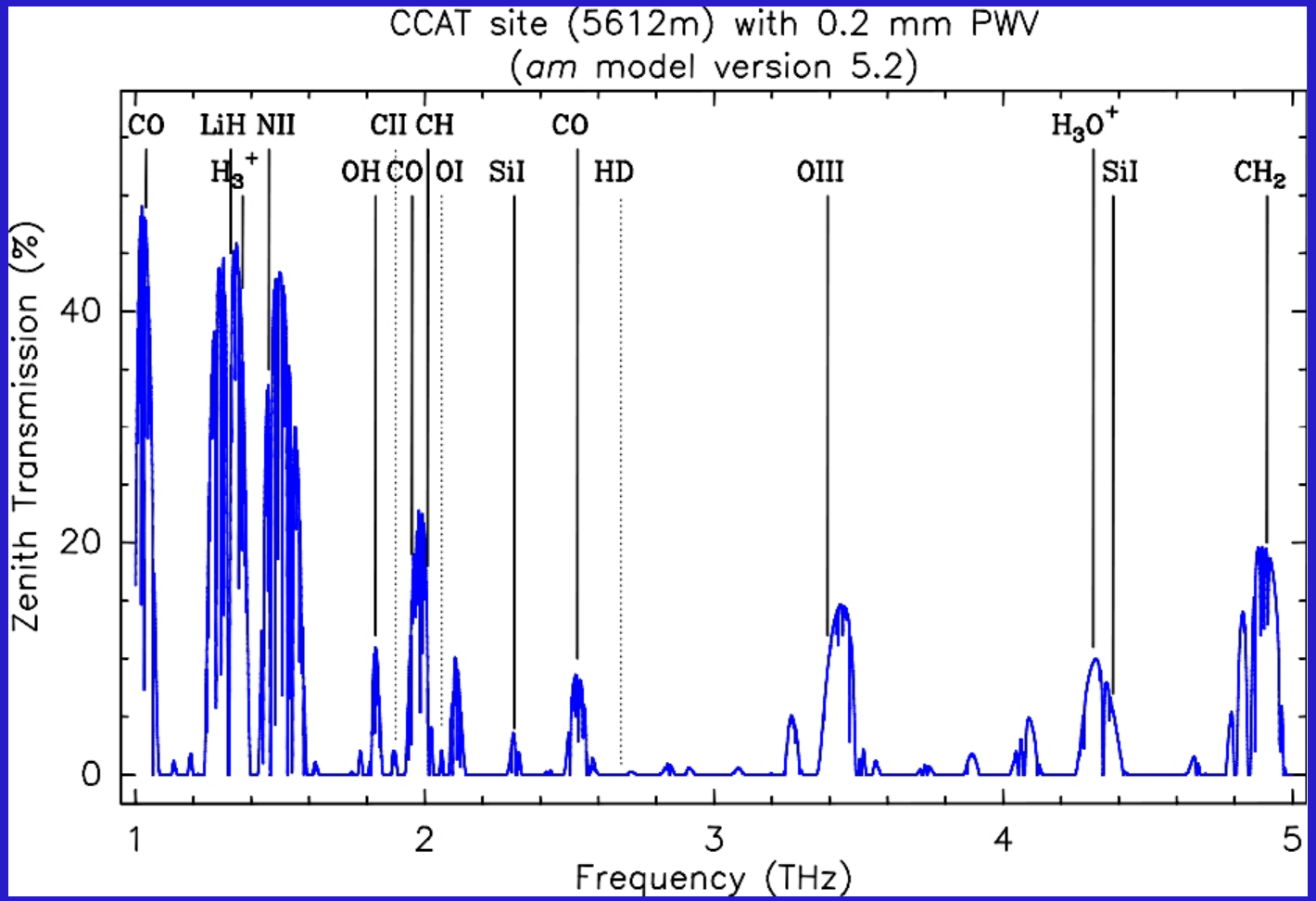
Atmospheric Transmission at CCAT site



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AI 1.6 – Options under consideration

- Modify RR 5.565, eliminating the list of bands and simply refer to Resolutions addressing the use of 275-3000 GHz by radio astronomy and remote sensing (separate resolutions)
- Maintain 5.565, with appropriate modifications in the range currently covered. Refer use of 275-3000 GHz to Resolutions, possibly claiming that the passive services are interested in use of the full 1-3 THz range, and that this can be done without constraints on the active services (using the same range), because of:
  - Extremely high absorption
  - Very small beam sizes / probability of beam coupling
  - Low power generation capabilities in THz region

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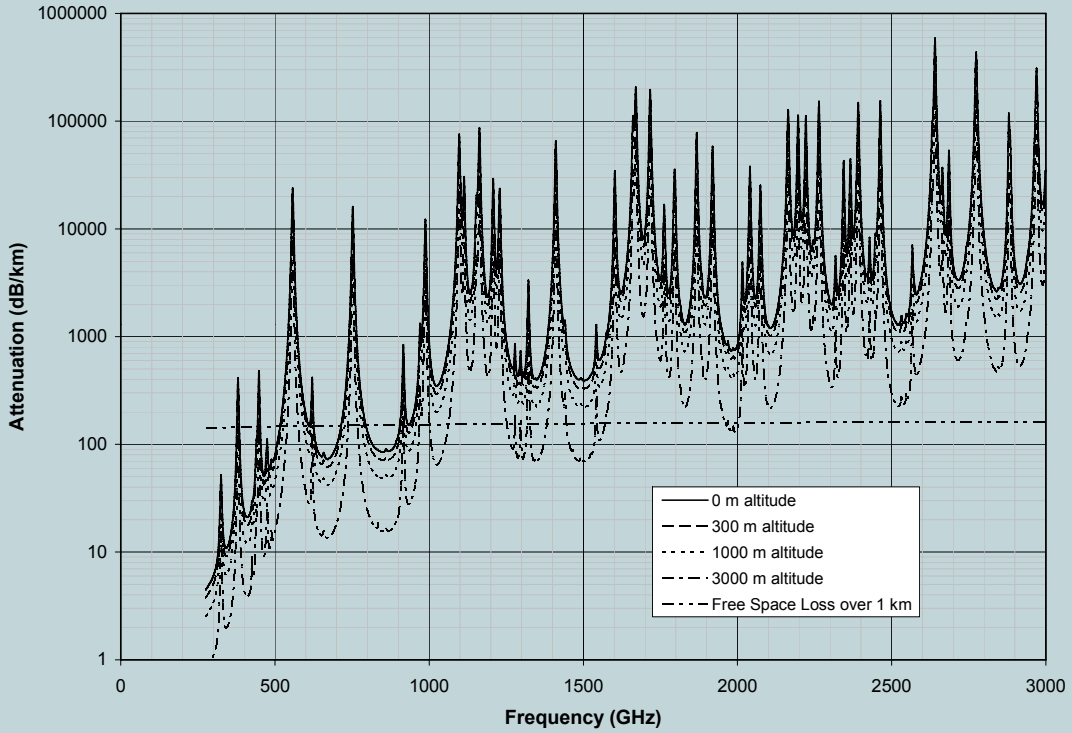
Atmospheric attenuation computed over horizontal paths of 1 km at four different altitudes; free space loss also plotted



Altitude (m)	Temperature (K)	Pressure (mbar)	Column Density of Dry Air (cm^{-2})	Column Density of Water Vapor (cm^{-2})
0	288.15	1013.25	2.55×10^{24}	3.34×10^{22}
300	286.20	977.73	2.47×10^{24}	2.87×10^{22}
1000	281.65	898.75	2.31×10^{24}	2.03×10^{22}
3000	268.65	701.09	1.89×10^{24}	7.45×10^{21}

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Probability that a random source of emission falls within the main beam of an antenna ($\Omega/4\pi$), and the probability that two identical antennas happen to be pointed directly within each other's beams, $P_{3D} = (\Omega/4\pi)^2$, as a function of frequency and antenna diameter. The gain of the antenna, $G = 10\log(4\pi/\Omega)$, is also listed.

Frequency (GHz)	Antenna Diameter (cm)	G (dB_i)	$\Omega/4\pi$	Probability of Main Beam Coupling (P_{3D})
1 000	5	54	4×10^{-6}	2×10^{-11}
1 000	10	60	1×10^{-6}	1×10^{-12}
1 000	30	70	1×10^{-7}	1×10^{-14}
2 000	5	60	1×10^{-6}	1×10^{-12}
2 000	10	66	3×10^{-7}	6×10^{-14}
2 000	30	76	3×10^{-8}	8×10^{-16}
3 000	5	64	4×10^{-7}	2×10^{-13}
3 000	10	70	1×10^{-7}	1×10^{-14}
3 000	30	79	1×10^{-8}	2×10^{-16}

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Maximum RF power level that can be generated (currently) between 1 – 3 THz :

$$P = 0.01(1000 - f_{GHz}) \text{ dBm}$$

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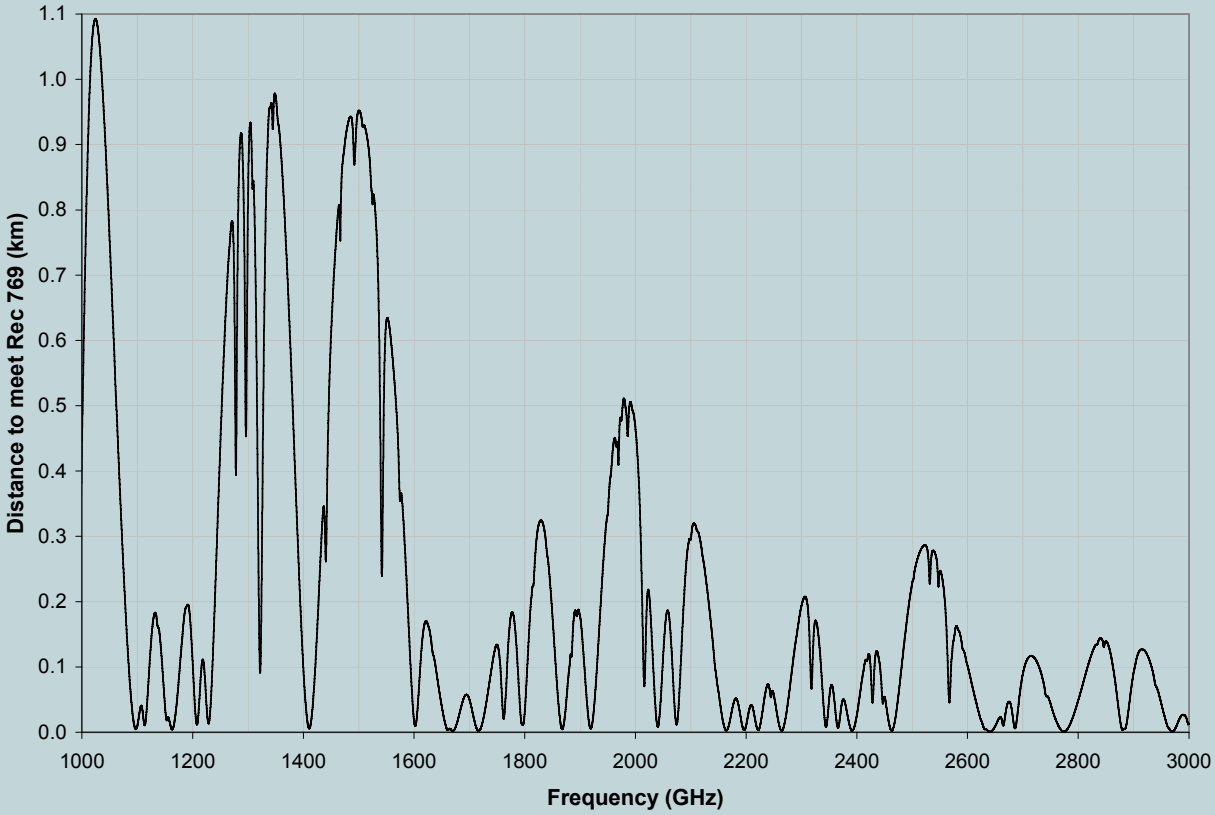
Distance beyond which a transmitted signal, using maximum achievable RF power and transmitting through a 30 cm diameter antenna pointed directly at a radio telescope, would reach levels that would not be detrimental to the radio astronomy service. The calculations assume free space loss and atmospheric attenuation at 3000 m altitude with a total of 2 cm precipitable WVP, scale height of 2 km and 50% atmospheric humidity at sea level, and are based upon radio astronomy interference objectives extrapolated from those in Rec. ITU-R RA.769



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Spectral Lines of Astrophysical Interest in the Range 275 – 1,000 GHz

- Working Party 7D (Radio Astronomy) of the ITU has developed a recommendation on spectral lines of astrophysical interest up to 1,000 GHz (Rec. ITU-R RA.314-10)
- This list of lines is considered relatively stable and vetted by the astronomical community, although feedback is always welcome
- Based upon the work of the IAU Division X's Working Group on Astrophysically Important Spectral Lines
- The Recommendation will be updated following the IAU GA, if the list is modified.

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Spectral Lines of Astrophysical Interest in the Range 1,000 – 3,000 GHz

- Working Party 7D developed a tentative list of spectral lines of interest in the 1 – 3 THz range
- The tentative list is very extensive. It is based on various sources, including spectral line surveys towards Orion and the Galactic center
- It is to be used in a new ITU-R Recommendation of astrophysically important spectral lines in the 1-3 THz range and, possibly, in the revision of 5.565

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Band Specific Issues (1)

AI s That May Impact the 4990-5000 MHz Band (1)

- **AI 1.4. "….to consider, …. further regulatory measures to facilitate introduction of new aeronautical mobile (R) service (AM(R)S) systems in the bands …5 000-5 030 MHz"**
  - **Issue: airborne transmitters operating next to the widely used primary 4990-5000 MHz radio astronomy band**
    - **Allocation to be used by surface LAN's at airports only, using very low power levels**
    - **As per a Resolution, coordination would be required with radio astronomy observatories within 150 km of airports using the allocation (e.g. Arecibo, Jodrell Bank)**

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Band Specific Issues (2)

AI s That May Impact the 4990-5000 MHz Band (2)

- AI 1.18"… extending the existing …radiodetermination-satellite service (space-to-Earth) allocations in the band 2 483.5-2 500 MHz in order to make a global primary allocation, and determine the necessary regulatory provisions…."
  - Issue: 2nd harmonic of downlink falls on 4990-5000 MHz RA band, currently subject to footnote RR 5.402, that urges protection of RA
    - Terms of RR 5.402 should be maintained (or strengthened) if a worldwide primary allocation is made to the RDSS

  (Currently: R1: Primary in some countries (RR 5.400)
  R2: Primary
  R3: Secondary; primary in many countries (RR 5.400)

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Band Specific Issues (3)

- **AI 1.5 "to consider worldwide/regional harmonization of spectrum for electronic news gathering (ENG).."**

Candidate Band	Application	RA Band Potentially Impacted
470 – 790 MHz	SAB/SAP, radio microphones	608-614 MHz
1375 – 1400 MHz / 1427 – 1452 MHz	ENG	1400-1427 MHz
2500 – 2690 MHz	SAB/SAP (portable and mobile video links)	2690-2700 MHz
2700 – 2900 MHz / 2900 – 3100 MHz		2690-2700 MHz
4400 – 5000 MHz	SAB/SAP	4880-5000 MHz
10 – 10.68 GHz	SAB/SAP (Cordless cameras and portable video links in 10 – 10.60 GHz, Temporary point-to-point video links in 10 – 10.68 GHz).	10.60-10.68 GHz

See CRAF comments on the Draft CEPT Brief.

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Band Specific Issues (4)

- AI 1.13 " to ….decide on the spectrum usage of the 21.4-22 GHz band for the broadcasting-satellite service and the associated feeder-link bands in Regions 1 and 3"
  - Issue: Unwanted emissions from strong DTV Satellite Broadcasting signals into the 22.21-22.5 GHz primary radio astronomy band
    - The band pair 21.4-22 GHz/22.21-22.5 GHz is already included in Table 1 of Res. 739 (WRC-07). Additional regulatory measures are desirable, but unlikely. Assuming a maximum pfd level of -105 d(BW/m^2) at the Earth's surface, filtering of BSS emissions to the Rec. ITU-R RA.769 level should be possible (and not too difficult)
- AI 1.21. "to consider a primary allocation to the radiolocation service in the band 15.4-15.7 GHz…"
  - Issue: Strong, possibly airborne transmitters operating next to the 15.35-15.4 GHz passive band
    - Regulatory measures, based on studies, should limit unwanted emissions into the passive band.

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Band Specific Issues (5)

- AI 1.15 " to consider possible allocations in the range 3-50 MHz to the radiolocation service for oceanographic radar applications.."
  - Issue: potential for interference into 13.6 MHz, 26 MHz and/or 38 MHz radio astronomy bands. Impact on LWA, MWA, SKA…
- AI 1.20 "spectrum identification for gateway links for high altitude platform stations (HAPS) in the range 5 850-7 075 MHz in order to support operations in the fixed and mobile services"
  - Issue: Potential interference with observations of the 6650-6675.2 MHz band, identified for observations of the 6668 MHz methanol line
    - RR 5.149 All practicable steps, only..
    - WP 7D Liaison statement to WP 5C (Liszt) , noting astronomers interest in the 6650-6675.2 MHz band and requesting HAPS downlink to be located as far above 6675.2 MHz, as possible.

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Broad Issues (1) – AIs likely to result in NOC

- AI 1.2 "Taking into account ITU-R studies ….to take appropriate action with a view to enhancing the international regulatory framework"
  - Revise Service definitions, consider the possibility of merging some services
  - US: There appears to be no inclination to changes
- AI 1.19 to consider regulatory measures and their relevance, in order to enable the introduction of software-defined radio and cognitive radio systems
  - US: There appears to be no inclination to changes
- AI 1.22 "…examine the effect of emissions from short-range devices on radiocommunication services….."
  - Code for "Is International Regulation of Short Range Devices (e.g. RFID) Necessary?"

US favors (minimal) national regulations only

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Broad Issues (2)

- AI 1.8 " to consider the progress of ITU-R studies concerning the technical and regulatory issues relative to the fixed service in the bands between 71 GHz and 238 GHz…"
  - > Work to be performed in WP 5C – Very little activity
  - > France (Doc 5C/178): Issue is national, no international regulation is needed
- AI 1.3 "…to consider spectrum requirements and possible regulatory actions, including allocations, in order to support the safe operation of unmanned aircraft systems (UAS)…"
  - ➢ US: Use current AM(R)S, AMS(R)S, ARNS bands, new allocations only if those prove to be insufficient for the requirements...

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Broad Issues (3)

- AI 1.7 “to ensure long-term spectrum availability and …to meet requirements for the aeronautical mobile-satellite (R) service, and to take appropriate action on this subject, while retaining unchanged the generic allocation to the mobile-satellite service in the bands 1 525-1 559 MHz and 1 626.5-1 660.5 MHz”
- AI 1.14 consider requirements for new applications in the radiolocation service and review allocations or regulatory provisions for implementation of the radiolocation service in the range 30-300 MHz,
- AI 1.25 to consider possible additional allocations to the mobile-satellite service

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Future Issues

- **AI 8.2 "to recommend ….items for inclusion in the agenda for the next WRC" - (possibly 2015)**
  - > **Are There any Astronomy/Science Related Requirements? Allocation or Regulatory? (protection of the SKA?)**
    - **If there is, it's not too soon to start working on placing it on the Agenda.**
- **AI 1.6b "to consider possible procedures for free-space optical-links, taking into account the results of ITU-R studies"**
  - ➢ **Regulation (registration) of optical links on the current Agenda could be deleted, but**
    - ➢ **As optical links are used more and more, some minimal regulation could eventually come in the future**

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WP 7D Issues

- Structure of SG 7 (Science Services)
- Chair: V. Meens (France), Vice-chairs: J. Zuzek (USA), S. Lyubtchenko (Russia) and Hyun Soo Chung (Korea)
  - WP 7A (Time and Frequency Standards)
  - WP 7B (Space Radiocommunication Systems)
  - WP 7C (Remote Sensing Systems)
  - WP 7D (Radio Astronomy)
- Each WP has a chairperson
- International Chair of ITU-R WP 7D, Dr. Masatoshi Ohishi, resigned
- New Chair: Dr. Tasso Tzoumis, Australia
- Change will be effective at the next (September, 2009) meeting of WP 7D

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WP 7D Issues

- **Recommendations:**
  - Preferred Frequency Bands for Radio Astronomy in the 1-3 THz Range in the works (A. Clegg) – New
  - Rec. ITU-R RA.1237 Protection of the Radio Astronomy Service from Unwanted Emissions Resulting from the Applications of Wideband Modulation – (T. Gergely) Revision
  - Rec. ITU-R RA.1513 Levels of Data Loss to Radio Astronomy Observations and Percentage-of-Time Criteria Resulting from Degradation by Interference for Frequency Bands Allocated to the Radio Astronomy Service on a Primary Basis – Revision (Europe)

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WP 7D Issues

- Reports (New)
  - Radio Quiet Zones – C. Wilson (Australia)
    Intended to be mostly descriptive of what exists and common characteristics.
  - DTV transition – A. Clegg
    Impact on Radio Astronomy and State/Regulation of DTV in various countries
  - Astronomical Use of Frequency Bands 50-300 THz – K. Tapping (Canada) approved
  - Description of astronomical observations, anticipating that the ITU will play some role in this frequency range
  - Essential Role of Observations – Ch van Diepenbeck (The Netherlands)
    Importance of observations for passive services, investment in them and the benefits they offer to society
- Revision/update needed: Mitigation Methods in Radio Astronomy (S. Ellingson/M. Lewis)

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WP 7D Issues

TIES Users may find all of these at:

http://www.itu.int/md/R07-WP7D-C/en

If you want to participate in WP 7D activities please e-mail:

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