

The SKA, RFI and ITU Regulations

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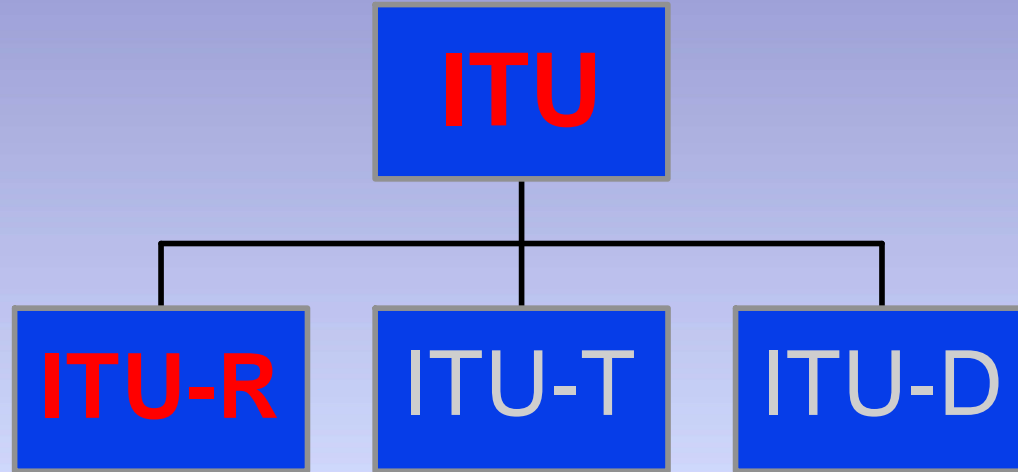
USA



RFI2004 Penticton 16-18 July 2004



The ITU



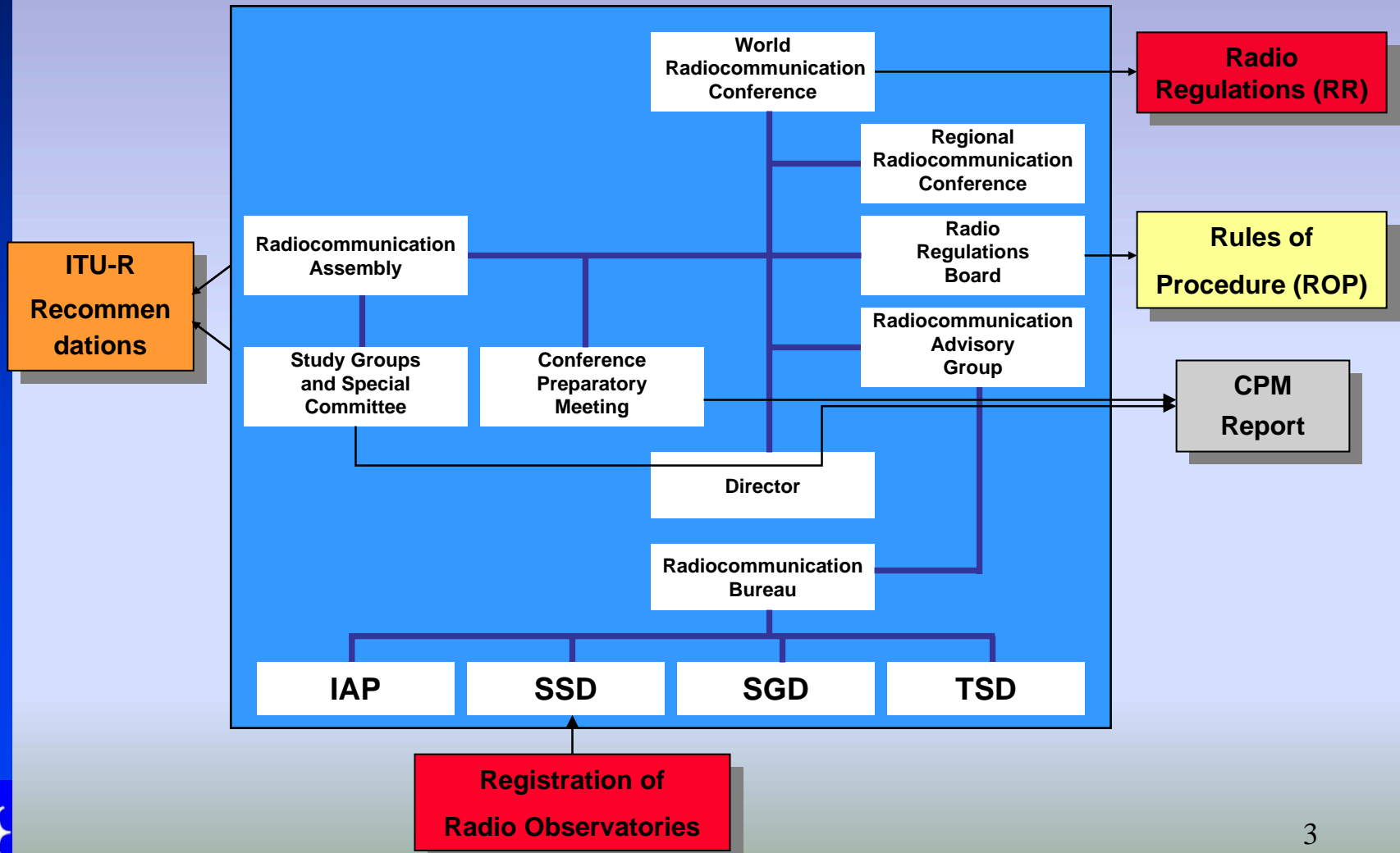
ITU-R Mission: to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum and the geostationary satellite orbit

The ITU-R:

- draws up the technical characteristics of terrestrial and space-based wireless services and systems,
- develops recommendations and operational procedures.
- undertakes technical studies which serve as a basis for the regulatory decisions made at radiocommunication conferences.



Radio Astronomers' Interaction with the ITU-R



The Hierarchy of ITU-R Output

**Radio
Regulations (RR)**
International Treaty

**ITU-R
Recommendations**
Non-mandatory, but generally followed

Rules of Procedure
RRB interpretation of the RR's
Highly changeable



The Radio Regulations

Provisions Referencing Radio Astronomy

- **Art. 1 (Definitions): 1.7,1.13, 1.16, 1.58, 1.61 and 1.97**
 - > Define radio astronomy, radio astronomy service and radio astronomy station
 - > Radio astronomy is defined as a *service*, but not as a *communication service*, setting it apart from other services
- **Art. 4 (Assignment and use of frequencies) 4.6**
 - > For the purpose of resolving cases of harmful interference, the radio astronomy service shall be treated as a radiocommunication service. However, protection from services in other bands shall be afforded the radio astronomy service only to the extent that such services are afforded protection from each other
- **Art. 5 (Frequency Allocations) 5.149, 5.208A, 5.225, 5.304, 5.305, 5.306, 5.307, 5.372, 5.376A, 5.379A, 5.385, 5.402, 5.413, 5.443, 5.443B, 5.458A, 5.511A, 5.551G, 5.555, 5.556, 5.562A, 5.562B, 5.562D, 5.565**
 - > Spells out the status of the radio astronomy service in the various frequency bands allocated to it and specified in the Table of Frequency Allocations
- **Art. 11 (Notification and Recording of Frequency Assignments) 11.12, 11.31.3**
 - > RR 11.12 states that any frequency used by a radio astronomy station can be registered, but that in non-allocated bands registration is for information purposes only



The Radio Regulations (cont.)

Provisions Referencing Radio Astronomy

- **Art. 20 (Service Documents) 20.13**
 - > Instructs the RB to publish the list of (registered) radio astronomy stations
- **Art. 22 (Space Services) 22.22 - 22.25**
 - > Prohibits emissions causing harmful interference to radio astronomy in the Shielded Zone of the Moon, except for certain transmissions. Leaves the determination of what constitutes harmful inference to agreements between Administrations.
- **Art. 29 (Radio Astronomy Service) 29.1 – 29.13**
 - > Instructs Administrations to cooperate in protecting the radio astronomy service
 - > Lists measures to be taken by radio astronomy stations to minimize their susceptibility to interference, and
 - > Urges protection of the radio astronomy service in accordance with the RR and applicable recommendations
- **App. 3 (Table of maximum spurious emission levels)**
- **App. 4, Annex 2A (Characteristics of satellite networks' earth stations or radio astronomy stations)**
 - > Lists the characteristics of radio astronomy stations required for registration and the compliance of satellite systems operating in some bands with pfd limits protecting radio astronomy in adjacent/nearby bands
- **App. 4, Annex 2B (Table of characteristics to be submitted for space and radio astronomy services)**



Registration of Radio Astronomy Stations

Registration provides:

- > (limited) protection in allocated bands
- > Alerts others to the presence of the telescope in non-allocated bands

Should be done as soon as site and configuration have been decided

Parameters Required:

- ✓ Country or geographical location where located
- ✓ Geographical Coordinates (Longitude, Latitude)
- ✓ Date of bringing into use
- ✓ Antenna type and dimensions
- ✓ Frequency Band Observed
- ✓ T_{sys}

- Outlying portions of the SKA may be registered as separate VLBI telescopes
- Registration process does not currently provide for a distributed telescope
- It may be useful to think about how to register such an instrument
- While this may seem to be trivial, it does require WRC action
- Long lead time is needed



Observing outside allocated bands

- **RR 29.8** The status of the radio astronomy service in the various frequency bands is specified in the Table of Frequency Allocations (**Art. 5**). Administrations shall provide protection from interference to stations in the radio astronomy service in accordance with the status of this service in those bands (see also Nos. **4.6**, **22.22** to **22.24** and **22.25**).

However:

- **RR 11.12** Any frequency to be used for reception by a particular radio astronomy station may be notified if it is desired that such data be included in the Master Register.





Recommendations in the ITU-R RA Series

<u>Number</u>	<u>Title</u>
Rec. ITU-R RA.314	Preferred Frequency Bands for Radioastronomical Measurements
Rec. ITU-R RA.1031	Protection of the Radioastronomy Service in Frequency Bands Shared with Other Services
Rec. ITU-R RA.517	Protection of the Radioastronomy Service from Transmitters in Adjacent Bands
Rec. ITU-R RA.611	Protection of the Radioastronomy Service from Spurious Emissions
Rec. ITU-R RA.1237	Protection of the Radioastronomy Service from Unwanted Emissions Resulting from Applications of Wideband Digital Modulation
Rec. ITU-R RA.769	Protection Criteria Used for Radioastronomical Measurements
Rec. ITU-R RA.1272	Protection of Radioastronomy Measurements Above 60 GHz from Ground Based Interference
Rec. ITU-R RA.479	Protection of Frequencies for Radioastronomical Measurements in the Shielded Zone of the Moon.
Rec. ITU-R RA.1417	A Radio-quiet Zone in the Vicinity of the L2 Sun-Earth Lagrange Point
Rec. ITU-R RA.1513	Levels of Data Loss Acceptable 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
Rec. ITU-R RA.	Technical and Operational Characteristics of Ground-based Astronomy Systems for Use in Sharing Studies with Active Services Between 10 THz and 1 000 THz

Observing outside allocated bands revisited- (Rec. ITU-R 314-9)

considering

- b) that the advancement of radio astronomy requires the protection of certain frequency bands from interference;
- d) that radio astronomers study spectral lines both in bands allocated to the radio astronomy service and, as far as spectrum usage by other services allows, outside the allocated bands, and that this has resulted in the detection of more than 3 000 spectral lines as illustrated in Fig. 1 of Annex 1;

recommends

- 3. that administrations be asked to provide assistance in the coordination of observations of spectral lines in bands not allocated to radio astronomy



Interference at Radio Telescopes

Depends On:

- **Bandwidth**
 - > 10 kHz; $f < 1$ GHz
 - > 20 kHz ; $f < 5$ GHz
 - > 50 kHz ; $f < 22$ GHz
- **Integration Time**
 - > 2000sec
- **System Temperature**
- **Antenna Response Pattern**
 - > $G = 32 - \log \phi$ dBi $1^\circ < \phi < 19^\circ$
 - > $G = 0$ dBi $19^\circ < \phi < 180^\circ$

Is Independent of:

- **Collecting Area**

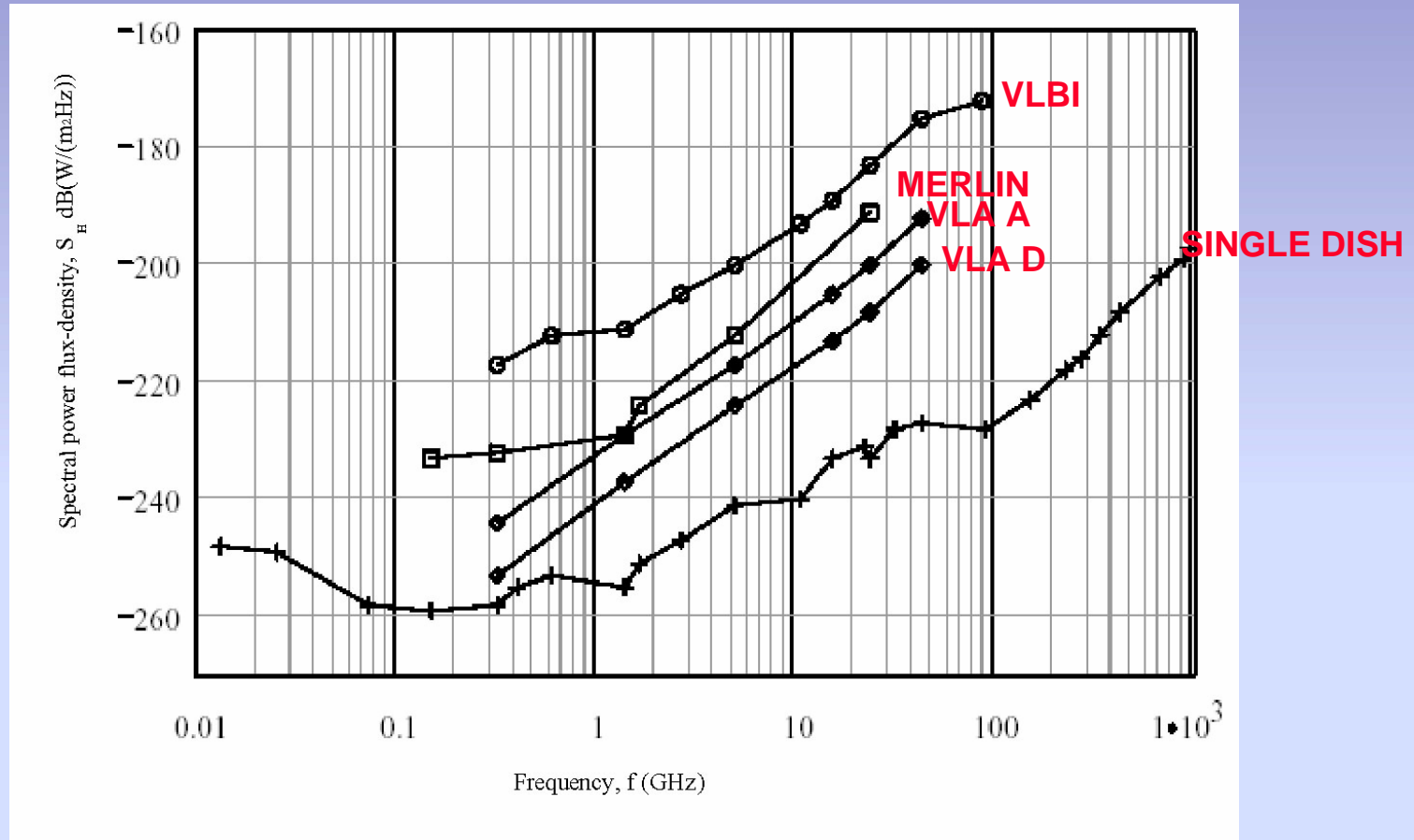


Interference to arrays

- **Interference at closely spaced arrays is determined by the frequency of fringe oscillations at the output of two antennas**
- **Decorrelation**
 - See: ITU Handbook on Radio Astronomy
or Interferometry and Synthesis in RA by
Thompson, Moran and Swenson
- **VLBI Interference is completely decorrelated**
- **For the SKA, that will consist of a compact core distributed between 1 km diameter and 150 km diameter, and of stations located up to 3000 km from the core, the detrimental interference threshold should be X dB less stringent than the 769 levels, computed for total power telescopes (X ~10-25 dBs)**



Detrimental thresholds of interference for continuum observations with several types of radio telescope systems



Threshold values of power flux density for continuum observations. Crosses are for total-power observations. Diamonds are for the VLA, lower curve for configuration D (longest antenna spacing 1 km) and upper curve for configuration A (longest antenna spacing 36 km). Squares are for the MERLIN array and open circles for VLBI.





IRQZs

- **Outlying components of SKA (up to 3000 km from core) could not be protected by an IRQZ)**
- **Existing QZs (e.g NRQZ) protects single dishes, not distributed arrays.**
- **At existing QZs, (e.g. the US NRQZ), the power density (due to fixed transmitters within the zone) is required to stay below a certain threshold, with respect to the focal point of the telescope.**
- **To establish a QZ for the benefit of a distributed array, covering a 1/5/150 km diameter area, is far more complicated**
- **At the US NRQZ only fixed transmitters are covered**
- **Mobile and aeronautical transmitters would need to be restricted over larger areas than fixed transmitters**
- **Satellites would need to be restricted over the horizon (and possibly beyond)**

Summary

- **Few of the existing ITU Regulations cover the SKA**
- **Once the site and a configuration have been selected, it will be advantageous to register the SKA with the ITU, as soon as possible. Even this relatively modest step may require changes in the radio regulations and these should be thought about asap**
- **A specific ITU-R Recommendation along the lines of Recommendation ITU-R RA.769 should be drafted to cover the SKA once a configuration is selected, taking into account the characteristics of the telescope's expected sidelobe structure, range of bandwidths and other parameters**
- **Consideration should be given to the kind of QZ/IRQZ that would be desirable for the SKA, and to how it could be set up. It is difficult to do so before the telescope is better defined**
- **By virtue of being a distributed array, the SKA may be considerably more resistant to interference than total power telescopes, in spite of its high sensitivity**

