9. SHARING THE RADIO SPECTRUM

R. J. Cohen (NRAL Jodrell Bank)

The radio spectrum is a common resource like air or water which can be used in many ways and for many purposes. Similarly it must be shared equitably. International use of radio is regulated by the International Telecommunications Union (ITU). The scientific use of radio for passive measurements such as radio astronomy or remote sensing (passive) was introduced into the ITU regulations at a late stage, and does not fit naturally into the framework. The needs of radio astronomy are inherently different from those of most other radio users.

The power levels reaching Earth from cosmic sources are generally very low and they are beyond the astronomer's control. Large antennas and sensitive receivers are needed to detect and measure them. This makes radio astronomy particularly vulnerable to interference from man-made emissions. The cosmic emissions are often of unknown character, such is the nature of research, and this can make it difficult to distinguish the wanted signal from interference. Radio astronomy needs quiet frequency bands in which to conduct measurements of the highest sensitivity. This is best achieved by world-wide allocations of passive frequency bands. Yet many other frequency bands are also of scientific interest. Only 2% of the radio spectrum below 50 GHz is allocated to radio astronomy, and only 30allocations are passive.

As the worldwide use of radio expands, radio astronomy is increasingly going to be confined to the officially allocated bands. Concern is now mounting at the state of those bands. Real transmitters cannot confine their emissions to sharply-defined frequency bands like those allocated by the ITU. Inevitably there are unwanted emissions which spill into other frequency bands, creating a type of radio pollution. The ITU has been slow to address this growing problem of unwanted emissions. Emissions from satellites are a particular concern for radio astronomy. Just one satellite can affect radio observatories all around the world, however isolated geographically and however well-shielded from terrestrial transmitters. The ITU has no regulations on the unwanted emissions from satellite transmitters.

Examples of interference to radio astronomy from satellites are growing steadily. In the 1980s the global satellite navigation systems GPS and GLONASS became well known to radio astronomers through their unwanted emissions into the frequency bands around 1.6 GHz used to observe spectral lines of OH. The solution to such problems takes many years to negotiate and to implement, once the system is already flying. This year the Iridium communications satellite system looks set to cause interference in the very same OH band, despite the experiences of GLONASS and despite efforts to avoid a similar problem with Iridium. At higher frequencies we have the Astra satellite over Europe interfering at 10.7 GHz with observations in a passive band.

My great concern is for the future. Altogether 80% of radio astronomy bands with a worldwide primary allocation are immediately adjacent to bands allocated for satellite downlinks! GLONASS and Astra may be only the beginning. The low Earth orbitting satellites (LEOs) of the future will fly in large constellations like Iridium, so that many will be visible simultaneously. The challenge will need to be addressed at many levels, from technical to regulatory. We are not opposed to satellite systems, but we do not want their downlinks right next to our spectral lines. We cannot stop the telecommunications revolution, but we must find ways to reduce its impact on radio astronomy.

10. KEEPING THE RADIO WINDOWS OPEN

W. A. Baan (Arecibo Observatory, IUCAF Secretariat Barrio Esperanza)

Passive scientific use of the radio spectrum has become more difficult due to harmful interference from active users in other spectral bands. The time has come for national administrations and spectrum managers to re-consider the protection afforded the non-profit passive services from market-oriented commercial users. The following urgent issues need to be addressed in order to assure adequate protection for the passive users operating in the Radio Astronomy and Earth Exploration services:

1. The Radio Regulations of the International Telecommunication Union —The Radio Regulations (RR) afford protection of all spectrum users on an equal basis and do not allow preferential treatment of one particular service. However, the passive Radio Astronomy and Earth Exploration users of the spectrum only observe natural emissions that are significantly weaker than the vast majority of man-made signals. Therefore, this "equality for all" rule from the RR cannot

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reasonably be interpreted as equal interference levels for all. It is essential that the ITU modernize and improve its protection standards for the passive services as it introduces and regulates existing and new space-based telecommunications industries.

2. Limits of Unwanted Emissions—Unwanted emissions from other spectrum users in adjacent or far-removed bands have become a limiting factor for the use of many passive bands. Passive users are intend on lowering the limits for out-of-band and spurious emissions. Although the protection of the passive services was one of its principal objectives, ITU-R Task Group 1-3 on "Spurious Emissions" has recommended standards for WRC-97 that do little to protect the passive services. Continued efforts within a new Task Group 1-5 are required to bring the standards for unwanted emissions in line with current radio technology.

3. Space Services—The explosive growth of the use of satellites by various services offers great benefits to mankind yet the current growth in number poses an ominous threat for scientific spectrum users. Downlink emissions can be particularly damaging for ground-based astronomical telescopes and already the emissions of GLONASS and ASTRA-1D have severely curtailed observations. The new IRIDIUM system poses a similar threat. In building space vehicles the highest engineering standards should not be sacrificed in favor of economic arguments. In particular, electro-magnetic environmental impact statements and extensive testing must be required before launching space-borne transmitter systems.

4. Spectrum Bands Above 30 GHz—The increasing commercial use of frequency bands above 30 GHz poses new problems for the scientific spectrum users. In particular, the protection of spectral neighbors will require higher engineering standards and vastly improved filter technology. Regulations for high frequency bands up to and beyond 1000 GHz should take into account the lessons learned at lower frequencies to prevent similar shortcomings.

5. Spectrum Splintering—The ITU Allocation Table contains spectrum designations for many "unlike" services with different operational standards in adjacent bands. Many of these bands are rather narrow and extensive coordination is required for these users to operate together and not interfere. Even today about seventy percent of all radio astronomy bands are threatened by satellite links and still new satellite downlink allocations are sought next to passive bands. Administrations need to strive to allocate 'like" services to broader band sections and avoid further splintering of the spectrum in increasingly narrow bands.

6. Sharing Considerations—Creative time sharing and geographical sharing schemes may provide limited access to certain bands, which are allocated to other services but have scientific potential. Geographical sharing schemes will require the creation of coordination zones or quiet zones by national administrations to provide local protection from ground-based services for sensitive observatories.

Peaceful coexistence in the spectrum for passive and active services is possible and depends on mutual respect for each other's activities. As spectrum occupation increases, the need to protect all passive and active spectrum users becomes more urgent. Only by mutual understanding and cooperation can we keep the radio windows to the Universe open and clean and in reserve for passive use by future generations.

11. THE SPACE DEBRIS ENVIRONMENT OF THE EARTH, AMOUNTS AND GROWTH

W. Flury (ESA/ESOC)

Since 1957, more than 3800 launches have led to more than 8000 trackable objects currently in orbit around the Earth. Surveillance, that is detecting and tracking space objects with radar, optical and infra-red sensors, is carried out by the space surveillance networks of the United States and Russia. The trackable objects have typically a minimum size of about 10 cm at low altitude and about 1 m at the geostationary orbit. Of the large number of catalogued objects fewer than about 500 are operational satellites. The remainder are abandoned satellites (21%), upper stages (16%), fragments of satellites and upper stages (45%), and mission-related objects (12%) such as lens covers, separation bolts or clamp-bands. A much larger number of smaller objects—unobservable by routine space surveillance—maybe 100,000 to 150,000 larger than 1 cm and thus capable of damaging a spacecraft, is in orbit. With special campaigns of powerful radar facilities,

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