ITU-R

ITU-R Radiocommunication Study Groups

2016

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ITU-R Study Groups

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Bringing the benefits of ICT to all the world's inhabitants

ITU is the leading United Nations agency for information and communication technology (ICT) and the global focal point for governments and the private sector in developing networks and services. Founded in 1865, the International Telecommunication Union (ITU) became a specialized agency of the United Nations in 1947, providing an international forum for 193 Member States and more than 700 Sector Members and Associates from industry, international and regional organizations, as well as more than 100 academia to collaborate for the worldwide improvement and rational use of telecommunications and radiocommunications.

ITU fulfils this fundamental mission through its three Sectors: the Radiocommunication Sector (ITU-R), the Telecommunication Standardization Sector (ITU-T) and the Telecommunication Development Sector (ITU-D).

ITU's work in the sphere of radiocommunications is focused in the ITU-R Sector, which works towards a worldwide consensus in the use of space and terrestrial radiocommunication services and a vast and growing range of wireless services and applications, including popular new mobile communication technologies.

ITU-R plays an essential custodian role in the management of the radio-frequency spectrum and satellite orbits, finite natural resources that are increasingly in demand from a large number of services such as fixed, mobile, broadcasting, amateur, space research, meteorology, and global positioning. These include systems monitoring and communication services that ensure safety of life on land, at sea and in the skies.

Improving communications and the use of ICTs amongst the peoples of the world by harmoniously developing telecommunication and radiocommunication tools and processes lies at the heart of the work of ITU.

The ITU vision

By connecting the world and fulfilling everyone's fundamental right to communicate, we strive to make the world a better and safer place

For over 150 years ITU has worked to improve telecommunication infrastructure in the developing world, establishing the worldwide standards that foster seamless interconnection of a vast range of communications systems. Since the start of international radio usage it has coordinated the shared global use of the radio spectrum and satellite orbits. Now it is addressing the global challenges of our times, such as mitigating climate change and strengthening cybersecurity.

ITU also organizes worldwide and regional exhibitions and forums, such as ITU TELECOM WORLD, bringing together the most influential representatives of government and the telecommunications and ICT industry to exchange ideas, knowledge and technology for the benefit of the global community, and in particular the developing world.

From broadband Internet to latest-generation wireless technologies, from aeronautical and maritime navigation to radio astronomy and satellite-based meteorology, from convergence in fixed-mobile telephony, Internet access, data, voice and TV broadcasting to next-generation networks, ITU is committed to connecting the world.

www.itu.int/go/about

ITU and Radiocommunications

www.itu.int/go/itu-r

Since the last decade of the 20th century the world has witnessed extraordinary growth in the use of wireless communication systems, from cellular and cordless phones and radio-based fleet management systems to radio and television broadcasting, cognitive radio, spectrum monitoring and International Mobile Telecommunications. At the same time, radio has become a vital technology for a growing number of essential public services such as satellite navigation and intelligent transport systems, global positioning systems, environmental monitoring, emergency radiocommunication systems and even deep-space research.

At the heart of this wireless world, the ITU Radiocommunication Sector (ITU-R) is mandated by ITU Membership to determine the technical characteristics and operational procedures for a huge and growing range of wireless services and systems. ITU-R also plays a vital role in the preparation of standards presented in “ITU-R Recommendations” for the management of the radio-frequency spectrum – a finite natural resource that is increasingly in demand due to the rapid development of new radio-based services and technologies, such as the enormous growth of mobile and related communications. As such, the Radiocommunication Assembly 2015(RA-15) approved a series of Recommendations and Resolutions for new and emerging technologies; initiated further studies for the development of global mobile broadband communications (IMT-2020)and studies related to wireless systems and applications for the development of the Internet of Things (IoT) as well as ways to improve the dissemination of knowledge concerning the applicable regulatory procedures for small satellites, including nanosatellites and picosatellites.

In its role as global spectrum coordinator, the Radiocommunication Sector develops and adopts the “ITU Radio Regulations” – a voluminous set of rules that serve as a binding international treaty governing the use of radio-frequency spectrum and satellite orbits adopted by more than 190 Member States. The international treaty, known as the Radio Regulations, was revised and updated by the World Radiocommunication Conference 2015 (WRC-15) to achieve the global connectivity goals of the 21st century. WRC-15 addressed issues related to frequency allocation and frequency sharing for the efficient use of spectrum and orbital resources, thus ensuring high quality radiocommunication services for mobile broadband and satellite communications, maritime and aeronautical transport as well as for scientific purposes related to the environment, meteorology and climatology, disaster prediction, mitigation and relief. The next World Radiocommunication Conference 2019 (WRC-19) is planned to be held during the 4th Quarter of 2019.

The Sector also operates, through its Radiocommunication Bureau, as a central registrar on the right to international recognition to use the radiofrequency spectrum, maintaining the “Master International Frequency Register” (MIFR) that currently includes around 2 500 000 terrestrial frequency assignments, 445 000 frequency assignments servicing 1 490 satellite networks and another 57 700 frequency assignments related to 5790 satellite earth stations.

In addition, ITU-R is responsible for coordinating efforts to ensure that the communication, broadcasting and meteorological satellites in the world's increasingly crowded skies can co-exist without causing harmful interference to one another's services. In this role, the Union facilitates agreements between both operators and governments and provides practical tools and services to help national frequency spectrum managers carry out their day-to-day work.

www.itu.int/go/itu-r

Radiocommunication Sector

The Mission

www.itu.int/go/itu-r

The ITU Radiocommunication Sector specializes in facilitating international collaboration to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum and satellite orbits, by:

- holding World and Regional Radiocommunication Conferences and Seminars to expand and adopt Radio Regulations and Regional Agreements covering the use of the radio-frequency spectrum;
- approving ITU-R Recommendations, developed by ITU-R Study Groups (SG) in the framework set by Radiocommunication Assemblies, on the technical characteristics and operational procedures for radiocommunication services and systems;
- coordinating activities to eliminate harmful interference between radio stations of different countries;
- maintaining the Master International Frequency Register (MIFR); and
- offering tools, information and seminars to assist national radio-frequency spectrum management.

Radiocommunication Bureau

www.itu.int/go/itu-r

The Radiocommunication Bureau (BR) is the executive arm of the Radiocommunication Sector, and is headed by an elected Director who is responsible for the coordination of the work of the Sector. The Director of the BR is assisted by a team of high-calibre engineers, computer specialists and managers who, together with administrative staff, make up the Radiocommunication Bureau.

The Radiocommunication Bureau:

- provides administrative and technical support to Radiocommunication Conferences, Assemblies and Study Groups, including Working Parties and Task Groups;
- applies the provisions of the Radio Regulations and various Regional Agreements;
- records frequency assignments for all services and associated orbital characteristics for space services, and maintains the Master International Frequency Register;
- provides advice to Member States on the equitable, effective and economical use of the radio frequency spectrum and satellite orbits, and investigates and assists in resolving cases of harmful interference;
- coordinates the preparation, editing and dispatch of circulars, documents and publications developed within the Sector;
- provides technical information, organizes regional seminars and workshops on national frequency management and radiocommunications, and works closely with the ITU Telecommunication Development Bureau in assisting developing countries.

World Radiocommunication Conferences

www.itu.int/go/itu-r/wrc

World Radiocommunication Conferences (WRCs) review and revise the Radio Regulations, the international treaty governing the use of the radio frequency spectrum and the satellite orbit. Revisions are made on the basis of an agenda determined by the ITU Council, which takes into account recommendations made by previous world radiocommunication conferences.

WRCs consider the results of the studies on options to improve the international spectrum regulatory framework based on the effectiveness, appropriateness and impact of the ITU Radio Regulations with respect to the evolution of existing, emerging and future applications, systems and technologies. WRCs make decisions on the most profitable and efficient ways to exploit the limited resource of radio frequency spectrum and manage satellite orbits, which will be critical and increasingly valuable for the development of the global economy in the 21st Century.

WRCs also address any radiocommunication matter of worldwide character, instruct the Radio Regulations Board and the Radiocommunication Bureau, and review their activities, and determine the topics for study by Radiocommunication Assemblies and the Study Groups in preparation for future radiocommunication conferences.

Radiocommunication Assemblies

www.itu.int/go/itu-r/ra

Radiocommunication Assemblies (RAs) are responsible for the structure, programme and approval of radiocommunication studies. They are normally convened every four years and may be associated in time and place with World Radiocommunication Conferences (WRCs). The Assemblies provide the necessary technical basis for the work of WRCs, respond to other requests from ITU conferences, and suggest suitable topics for the agenda of future WRCs. They also approve and issue ITU-R Recommendations and Questions developed by the Study Groups, set the programme for and disband or establish Study Groups according to need.

Radiocommunication Advisory Group

www.itu.int/go/itu-r/rag

The Radiocommunication Advisory Group (RAG) is tasked to:

- review the priorities and strategies adopted in the Sector;
- monitor progress of the work of the Study Groups;
- provide guidance for the work of the Study Groups;
- recommend measures to foster cooperation and coordination with other organizations and with the other ITU Sectors.

The RAG provides advice on these matters to the Director of the Radiocommunication Bureau (BR). Radiocommunication Assemblies (RAs) may refer specific matters within its competence to the RAG. The RAG may be authorized to act on behalf of the RA between two Assemblies.

Regional Radiocommunication Seminars and Workshops

www.itu.int/go/itu-r/seminars

The Radiocommunication Bureau (BR) organizes world seminars on spectrum management every two years in Geneva, as well as regional seminars aiming at the particular needs of developing countries.

The main objectives of BR seminars and workshops are:

- to provide assistance to Member States in spectrum management activities, e.g. through training, information meetings, seminars, development of handbooks and the provision of tools for automated spectrum management; and

- to expand the assistance offered to Member States in coordinating and registering frequency assignments and in applying the Radio Regulations, with special attention to developing countries and Member States that have recently joined the Union.

One of the objectives pursued by the BR is to hold regional seminars in a way to equitably cover all ITU Regions. Administrations that are interested in hosting a regional seminar may contact the BR and, subject to availability of time and resources, the BR undertakes all the necessary steps to organize the event. The BR also organizes, upon request, individual training sessions in Geneva. This training is usually held in conjunction with important ITU-R meetings and the BR tries to regroup them over a one-week period.

ITU Membership

www.itu.int/go/join

Member States of ITU and Sector Members participate actively in the work of the Radiocommunication Sector. Since its opening to the private sector, the ITU membership represents a cross-section of the industry, from the world's largest manufacturers, carriers, operators and system integrators to small, innovative players of the new information and communication technology field.

Current members include:

- 193 ITU Member States, which constitute the Union, set its mandate and contribute to the work of ITU as a whole;
- More than 700 ITU Sector Members (which participate in the work of a defined Sector (R, T or D))and ITU Associates (which work within the framework of a specific Study Group). These include operating agencies, scientific or industrial organizations, financial and developmental institutions, other entities dealing with telecommunication matters, regional and other international telecommunication, standardization, financial or developmental organizations;
- More than 100 academia members.

In its efforts to ensure the widest participation in the enhancement of worldwide communications and that the interests of all stakeholders are taken into consideration, ITU encourages new entities and organizations to join the Union as Sector Members or Associates. In addition, ITU seeks to further develop intellectual cooperation with educational institutions and universities.

ITU-R Study Groups

ITU-R Study Groups are established and assigned study Questions by a Radiocommunication Assembly (RA) to prepare draft Recommendations, etc. for approval by ITU Member States.

With the exception of ITU-R Recommendations incorporated by reference in the ITU Radio Regulations, compliance with ITU-R Recommendations is not mandatory. However, all ITU-R Recommendations are developed by world experts in radiocommunications, thereby enjoying a high reputation and worldwide implementation, having the status of international standards in their domain of application.

Studies focus on the following:

- efficient management and use of the spectrum/orbit resource by space and terrestrial services;
- characteristics and performance of radio systems;
- operation of radio stations;
- radiocommunication aspects of distress and safety matters.

Furthermore, ITU-R Study Groups carry out preparatory studies for World and Regional Radiocommunication Conferences (WRCs, RRCs). On the basis of the input material from the Study Groups, alongside any new material submitted by ITU Member States and ITU-R Sector Members, the Conference Preparatory Meeting (CPM) prepares a Report on the technical, operational and regulatory or procedural matters to be considered by a given Conference.

Study Groups accomplish their work in cooperation with other international radiocommunication organizations. Particular attention is paid to the radiocommunication needs of developing countries.

More than 5000 specialists, representing ITU Member States, Sector Members, Associates and Academia throughout the world, currently participate in the work of ITU-R Study Groups.

16 At present, there are six Study Groups (SGs) specializing in the following areas:

SG 1	Spectrum management	www.itu.int/ITU-R/go/rsg1
SG 3	Radiowave propagation	www.itu.int/ITU-R/go/rsg3
SG 4	Satellite services	www.itu.int/ITU-R/go/rsg4
SG 5	Terrestrial services	www.itu.int/ITU-R/go/rsg5
SG 6	Broadcasting service	www.itu.int/ITU-R/go/rsg6
SG 7	Science services	www.itu.int/ITU-R/go/rsg7

Subgroups, known as Working Parties (WPs) and Task Groups (TGs) are established to study the Questions assigned to the different Study Groups.

Study Group 1

Spectrum management

www.itu.int/go/itu-r/sg1

Spectrum management is the combination of administrative and technical procedures necessary to ensure the efficient utilization of the radio-frequency spectrum by all radio-communication services defined in the ITU Radio Regulations and the operation of radio systems, without causing harmful interference.

Scope

Spectrum management principles and techniques, general principles of sharing, spectrum monitoring, long-term strategies for spectrum utilization, economic approaches to national spectrum management, automated techniques and assistance to developing countries in cooperation with the Telecommunication Development Sector.

Structure

Three Working Parties (WPs) carry out studies on Questions assigned to Study Group (SG) 1:

- WP 1A Spectrum engineering techniques
- WP 1B Spectrum management methodologies and economic strategies
- WP 1C Spectrum monitoring

The goals of ITU-R Working Parties 1A, 1B and 1C activities are to develop and maintain ITU-R Recommendations, Reports and Handbooks relevant to spectrum engineering techniques, spectrum management fundamentals and spectrum monitoring, respectively.

ITU-R Working Party 1A – Spectrum engineering techniques

Spectrum engineering techniques, including unwanted emissions, frequency tolerance, technical aspects of sharing, computer programs, technical definitions, Earth-station coordination areas and technical spectrum efficiency.

Current study topics include:

- Wireless power transmission;
- Coexistence of wired telecommunication with radiocommunication systems;
- Definition of the spectral properties of transmitter emissions;
- Impact on radiocommunication systems from wireless and wired data transmission technologies used for the support of power grid management systems;
- Technical and operational characteristics of the active services operating in the range 275-1 000 GHz;
- Characteristics for use of visible light for broadband communications.

Amongst those items on which Working Party 1A is engaged in preparation for WRC-19 are the studies towards an identification of frequency bands for use by administrations for the land-mobile and fixed services applications operating in the frequency range 275-450 GHz, while maintaining protection of the passive services.

ITU-R Working Party 1B – Spectrum management methodologies and economic strategies

Spectrum management fundamentals, including economic strategies, spectrum management methodology, national spectrum management organization, national and international regulatory framework, alternative approaches, flexible allocations and long-term strategies for planning.

Current study topics include:

- Long-term strategies for spectrum utilization;
- Alternative methods of national spectrum management;
- Wireless power transmission;
- Spectrum redeployment as a method of national spectrum management;
- Innovative regulatory tools for shared use of spectrum;
- Economics aspects on spectrum management;
- Definition of use and efficiency of a radio system;

- Harmonization for short-range devices;
- Implementation and use of cognitive radio systems.

Amongst those items on which Working Party 1B is engaged in preparation for WRC-19 are the studies on:

- Wireless Power Transmission (WPT) for electric vehicles;
- Assisting administrations in the management of unauthorized operation of earth station terminals.

ITU-R Working Party 1C – Spectrum monitoring

Spectrum monitoring, including the development of techniques for observing the use of the spectrum, measurements techniques, inspection of radio stations, identification of emissions and location of interference sources.

Current study topics include:

- Methods and techniques used in space radio monitoring;
- Measurement of spectrum occupancy;
- Spectrum monitoring evolution;
- Direction finding.

National spectrum management comprises the structures, capabilities, procedures and regulations necessary for each country to fulfill its objective to control the use of the radio-frequency spectrum on its territory and within its geographical borders. Within the framework of international treaty agreements (Radio Regulations), each government has the flexibility and autonomy to regulate the spectrum and its usage. In this perspective, each administration must develop the relevant laws and carry out the duties of spectrum management. The usage of the frequency spectrum, which has increasingly important economic value, is best harmonized in an environment where a spectrum management system provides stability but, at the same time, facilitates user access to the spectrum.

Effective management of the limited spectrum resource encompasses the goals and objectives of a spectrum management system, a spectrum management structure and the spectrum management authority with responsibility to regulate spectrum use.

Handbooks

www.itu.int/pub/R-HDB

With a view to assisting ITU Members States in general and developing countries in particular, with their national spectrum management activities, Study Group 1 and its Working Parties developed a number of ITU-R Handbooks which are available free of charge in electronic format:

The **Handbook on National Spectrum Management** (www.itu.int/pub/R-HDB-21) covers spectrum management fundamentals, spectrum planning, spectrum engineering, frequency authorization, spectrum use, spectrum control and automation for spectrum management activities. The Handbook describes the key elements of spectrum management and is intended for the use by administrations of both developing and developed countries.

A very popular work is the **Handbook on Spectrum Monitoring** (www.itu.int/pub/R-HDB-23). It covers all essential features of spectrum monitoring techniques and activities, including the establishment of monitoring facilities. The principles governing this handbook show that spectrum monitoring requires equipment, personnel and procedures. The handbook is an essential accessory for all administrations and spectrum monitoring agencies in the world, both for developing and developed countries.

A complement to both above-mentioned handbooks is the **Handbook on Computer-aided Techniques for Spectrum Management (CAT)** (www.itu.int/pub/R-HDB-01). The topic of national spectrum management has evolved and become the central hot spot in the activities of all telecommunication administrations. This is particularly true for developing countries, where the dramatic development of ICT technologies and their wide application have led to a heavy increase in related spectrum usage. This handbook contains basic material and numerous models for developing efficient projects that will assist in implementing automated spectrum management as soon as possible.

Other deliverables from ITU-R Study Group 1

Study Group 1 and its Working Parties maintains a number of **Recommendations** (www.itu.int/pub/R-REC) and **Reports** (www.itu.int/pub/R-REP) in the SM series relating to Spectrum Management related topics.

In response to Resolution 9 of the ITU World Telecommunication Development Conference (WTDC), a Joint ITU-R/ITU-D Group on the issues in that Resolution 9 is continuing to assist developing countries in fulfilling their national spectrum management functions.

Study Group 3

Radiowave propagation

www.itu.int/go/itu-r/sg3

Scope

Propagation of radio waves in ionized and non-ionized media and the characteristics of radio noise, for the purpose of improving radiocommunication systems.

Structure

The following four Working Parties (WPs) carry out studies on the Questions assigned to Study Group (SG) 3:

- WP 3J Propagation fundamentals
- WP 3K Point-to-area propagation
- WP 3L Ionospheric propagation and radio noise
- WP 3M Point-to-point and Earth-space propagation

The principal aim of the Working Parties is to draft Recommendations in the ITU-R P Series for subsequent adoption by Study Group 3 and approval by the Member States. The Working Parties also develop Handbooks that provide descriptive and tutorial material, especially useful for developing countries. A further task of the Working Parties is to provide, through Study Group 3, propagation information and advice to other ITU-R Study Groups in their preparation of the technical bases for Radiocommunication Conferences. Such information typically concerns identifying relevant propagation effects and mechanisms and providing propagation prediction methods. The predictions are needed for the design and operation of radiocommunication systems and services and also for the assessment of frequency sharing between them.

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ITU-R Working Party 3J – Propagation fundamentals

WP 3J provides information and develops models describing the fundamental principles and mechanisms of radiowave propagation in non-ionized media. Such material is used as the basis of propagation prediction methods developed by the other Working Parties. Recognizing the natural variability of the propagation medium, WP 3J prepares texts describing the statistical laws relevant to propagation behaviour and the means of expressing the temporal and spatial variability of propagation data.

Propagation over terrain and obstacles involves methods for calculating diffracted fields over smooth and irregular earth, and quantifying the effect of vegetation along the propagation path. Maps of ground conductivity are maintained, as they are important for prediction procedures applying to frequencies at medium frequency (MF) and below.

One of the principal areas of study in WP 3J concerns propagation through the neutral atmosphere, encompassing the propagation effects both in the clear air and when precipitation is present. To this end, the WP devotes much effort to the global mapping of radiometeorological parameters used for quantifying such effects for prediction procedures. Clear-air effects include atmospheric refraction and attenuation due to atmospheric gases, these in turn requiring vertical profiles of temperature and water vapour with their spatial and temporal variation. Similarly, for the assessment of attenuation and depolarization due to precipitation, precise global mapping of rainfall intensity and rain height areis required, as well as models of specific attenuation of rain. WP 3J also studies the effects of cloud and fog.

Since an objective of Study Group 3 is to provide prediction procedures that are applicable worldwide, it is very important that any underlying radiometeorological data are representative of the different climates of the world and that their spatial and temporal resolution is adequate. Furthermore, inter-annual and seasonal variability becomes a critical issue as radiocommunication systems are more and more flexible.

In support of the development of mobile broadband systems, particularly for short-range urban environments and at higher frequencies, WP 3J also studies the effect of building materials on propagation. This supports studies in WPs 3K and 3M to predict both system performance and inter-system interference for indoor and outdoor radio services.

ITU-R Working Party 3K – Point-to-area propagation

WP 3K is responsible for developing prediction methods for terrestrial point-to-area propagation paths. In the main, these are associated with terrestrial broadcasting and mobile services, short-range indoor and outdoor communication systems (e.g. radio local area networks, RLAN), and with point-to-multipoint wireless access systems.

In the VHF and UHF bands, field strength prediction takes account of the effects of terrain in the vicinity of the transmitter and receiver, and of the refractive nature of the atmosphere. Allowance is also made for location variability for land area coverage prediction with account taken of local clutter surrounding the receiver. Consideration is also given to mixed paths crossing both land and sea. A consolidated prediction procedure has been developed – suitable for broadcasting, land mobile, maritime mobile and certain fixed services (e.g. those using point-to-multipoint systems) – that represents a major tool for the frequency planning of broadcasting and mobile services, particularly in the range 1-3 GHz, and for coordination when frequency sharing is involved.

At higher frequencies (typically from around 1 to 100 GHz), the emphasis is on short-range systems, either indoor or outdoor, as might be used by RLAN and personal mobile communications. The WP develops Recommendations that describe relevant propagation mechanisms such as reflection, scattering and diffraction associated with buildings, or with obstacles within buildings, all of which give rise to effects such as attenuation and multipath. The latter plays a vital part in the channel modelling of a radio link, with which an assessment of performance quality may be obtained. For outdoor situations, models are developed describing different types of environment (urban to rural) and expressions are developed for quantifying the resulting path loss. Propagation into or out of buildings is also an important topic, with the growth of mobile broadband systems.

With the growing interest in delivery of broadband services through local access networks, WP 3K studies the propagation effects associated with millimetric radio systems (e.g. operating around 20-50 GHz) used for point-to-multipoint distribution. Prediction of area coverage has to address the effects of buildings, their spatial distribution, attenuation and scattering from vegetation, and attenuation by rain. Methods to quantify the relevant propagation effects such as attenuation and distortion due to multipath are a key area of study in WP 3K.

24 ITU-R Working Party 3L – Ionospheric propagation and radio noise

WP 3L studies all aspects of radiowave propagation in and through the ionosphere, as well as ground wave propagation at the lower frequencies and radio noise external to the receiver.. Recommendations are maintained describing a reference model of ionospheric characteristics and maximum usable frequencies associated with the various ionospheric layers. Short-term and long-term ionospheric forecasting, with guidance on the use of ionospheric indices, is addressed.

As regards propagation prediction methods, Recommendations are maintained containing prediction procedures for ionospheric propagation in bands from ELF to VHF. Those for computing skywave propagation at LF, MF and HF play an important role in frequency planning, both for quantifying the wanted signal as well as for interference assessment. At higher frequencies, there are also methods for computing the field strength due to meteor-burst propagation as well as propagation via sporadic E. The HF ionospheric propagation prediction procedure has been reviewed in detail and a new computer code (ITURHFPROP) has been developed and tested. This provides predictions of circuit performance and includes the effects of the ionosphere on digitally modulated transmissions.

With the increasing use of satellite systems, particularly for global navigation purposes and for those using low-Earth orbits, the effects of the ionosphere on slant propagation paths at VHF and UHF frequencies demand considerable attention. For example, the additional and variable time delay associated with propagation through the ionosphere is of major concern for navigation satellite systems; likewise, trans-ionospheric scintillation can be a significant factor on the link budget of systems operating well above 1 GHz. WP 3L is improving methods to quantify such effects, taking into account their temporal and geographical variability.

The Working Party studies ways for the improvement of the accuracy of ionospheric propagation prediction, taking account of long term changes in the ionosphere and of the current availability of data.WP 3L also addresses the topic of radio noise arising from both natural and man-made sources and provides information to quantify the effect of noise on the performance of radio systems.

At MF and lower frequencies ionospheric and ground wave propagation modes are both important. WP 3L also maintains the Recommendation on ground wave propagation and has provided advice in a new handbook on this same subject.

Radio noise received through the receiver antenna is of great importance in determining the performance of radio systems and WP 3L studies and maintains a measurement databank of radio noise arising from both natural and man-made sources.

ITU-R Working Party 3M – Point-to-point and Earth-space propagation

WP 3M addresses radiowave propagation over point-to-point terrestrial paths and Earth-space paths, both for wanted and unwanted signals.

The fundamental prediction methods of WP 3J, such as the refractivity of the atmosphere, gaseous attenuation or diffraction over irregular terrain, are used by WP 3M to develop prediction methods for specific types of radio links. For satellite propagation paths, use is also made of trans-ionospheric information developed in WP 3L.

For terrestrial paths, prediction methods are developed for both line-of-sight and over-the-horizon links, taking account of mechanisms that can give rise to fading, enhancement, or distortion of the wanted signal. The predictions, generally expressed in terms of a statistical distribution of propagation loss or outage, provide vital information for terrestrial link planning in the fixed service (FS).

Similarly, propagation impairments on slant paths from satellites are addressed in prediction procedures to quantify the relevant effects and provide an assessment of overall propagation loss, fading behaviour or signal depolarization. WP 3M maintains Recommendations for the fixed-satellite service (FSS), the mobile-satellite service and the broadcasting-satellite service. Additional factors specific to the environment near the earth station are considered, such as shadowing and blockage by buildings. For mobile-satellite and non-GSO systems, the movement of the receiver or changes in the elevation angle are taken into account.

WP 3M is also studying propagation for optical communications on Earth-space and terrestrial paths, using information from WP 3J on atmospheric effects at optical frequencies.

To test its prediction procedures, WP 3M relies on databanks of measurement data. Databanksdatabanks are maintained for terrestrial and Earth-space paths, based on long-term measurements submitted by the membership, and assessed by Study Group 3 for accuracy and statistical validity.

A further major responsibility of WP 3M is the prediction of signals likely to cause interference. These signals, often propagating via short-term mechanisms such as ducting and rain scatter, can give rise to unacceptably high interference levels in shared frequency bands. Prediction methods are maintained to allow users to quantify the interference level, at a desired percentage of time, either from one point on the Earth’s surface to another, or between a space station and a point on Earth. In cooperation with WPs 3J and 3K, WP 3M is extending these interference prediction methods to account for the effect of building materials, to support sharing studies between indoor and outdoor radiocommunication systems.

WP 3M is also responsible for developing the propagation method for determining the Earth-station coordination area. This is an internationally accepted methodology – a used by administrations in their planning and deployment of terrestrial and earth stations (in the FS and FSS respectively) when sharing the same frequency band.

Handbooks

www.itu.int/pub/R-HDB

ITU-R Study Group 3 and its Working Parties developed a number of ITU-R Handbooks:

Handbook on ITU-R Propagation prediction methods for interference and sharing studies (www.itu.int/pub/R-HDB-58) provides technical information and guidance needed for sharing studies and interference assessments using selected ITU-R P-Series RF propagation models and prediction methods. The handbook is intended to be used in conjunction with ITU-R P-Series Recommendations to assist in performing interference analyses and prediction methods on radiocommunication service systems.

Handbook on Radiometeorology (www.itu.int/pub/R-HDB-26) provides general information on radiometeorology and covers the following topics: physical characteristics of the atmosphere, atmospheric refraction, particle scattering, atmospheric gaseous attenuation and dispersion, hydrometeor attenuation, radio emissivity, cross-polarization and anisotropy and statistical aspects of atmospheric processes.

Handbook on Curves for Radiowave Propagation over the Surface of the Earth (www.itu.int/pub/R-HDB-13)

Handbook on Terrestrial Land Mobile Radiowave Propagation in the VHF/UHF bands (www.itu.int/pub/R-HDB-44) gives the technical basis for predicting radiowave propagation in terrestrial point-to-point, point-to-area and point-to-multipoint mobile networks.

Handbook on the Ionosphere and its Effects on Radiowave Propagation (www.itu.int/pub/R-HDB-32) provides radioplanners and users with a guide on ionospheric properties and propagation effects in order to assist in the design of related radiocommunication systems.

Handbook on Radiowave Propagation Information for Predictions for Earth-to-Space Path Communications (www.itu.int/pub/R-HDB-27) supplies background and supplementary information on Earth-to-space propagation effects in order to assist in the design of different Earth-space communication systems.

Handbook on Radiowave propagation information for designing terrestrial point-to-point links (www.itu.int/pub/R-HDB-54) supplies background and supplementary information on radiowave propagation effects, and serves as a companion volume and guide to the ITU-R Recommendations that have been developed by Radiocommunication Study Group 3 to assist in the design of terrestrial communication systems.

Handbook on Ground wave propagation (http://www.itu.int/pub/R-HDB-59) is of special interest for communication, particularly broadcasting, at the lower frequencies where the mode has been in use for more than 90 years. It deals with fundamentals and theory, wide-scale considerations and prediction methods used for compatibility assessments and planning procedures. Smaller scale variability, which may be of major importance in assessing the quality of services, is also treated. The topics of measurements and phase are also covered.

Other deliverables from ITU-R Study Group 3

Study Group 3 and its Working Parties maintain a number of **Reports** (www.itu.int/pub/R-REP) relating to radiowave propagation and various field strength measurement aspects. It also maintains a number of datasets and software products in support of radiowave propagation models from several **ITU-R Recommendations** (www.itu.int/pub/R-REC) and the development of new and improvement of existing radiowave propagation models.

Study Group 4

Satellite services

www.itu.int/go/itu-r/sg4

Scope

Systems and networks for the fixed-satellite service, mobile-satellite service, broadcasting-satellite service and radiodetermination-satellite service.

Structure

Three Working Parties (WPs) carry out studies on Questions assigned to Study Group (SG) 4:

WP 4A	Efficient orbit/spectrum utilization for the fixed-satellite service(FSS) and broadcasting-satellite service (BSS)
WP 4B	Systems, air interfaces, performance and availability objectives for the fixed-satellite service (FSS), broadcasting-satellite service (BSS) and mobile-satellite service (MSS), including IP-based applications and satellite news gathering (SNG)
WP 4C	Efficient orbit/spectrum utilization for the mobile-satellite service (MSS) and the radiodetermination-satellite service (RDSS).[1]

[1] WP 4C also deals with the performance issues related to RDSS

ITU-R Working Party 4A – Efficient orbit/spectrum utilization for the fixed-satellite service (FSS) and broadcasting-satellite service (BSS)

The major study areas of Working Party 4A are orbit/spectrum efficiency, interference and coordination and related aspects for FSS and BSS. Its work has significant relevance to the preparatory work for World Radiocommunication Conferences.

Current study topics include:

- Technical and operational characteristics of Unmanned Aircraft Control and Non-Payload satellite communication links operated in certain frequency bands allocated to the fixed-satellite service not subject to RR Appendices 30, 30A and 30B.
- Guiding methodology for providing compatibility between ubiquitously deployed earth stations of the fixed-satellite service and stations of the fixed and/or mobile services in adjacent areas for the cases described in the Tables of Appendix 7 of the Radio Regulations.
- Guidelines to conduct bilateral coordination for explicit agreements, in the frequency band 14.5-14.75 GHz, for Regions 1 and 2 countries, or in the frequency band 14.5-14.8 GHz, for Region 3 countries, in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service, in order to protect all existing and planned services in all territories of those administrations engaging in such agreements.
- Maximum permissible levels of interference in a satellite network (GSO/FSS; non-GSO/FSS; non-GSO/MSS feeder links) in the fixed-satellite service caused by other co-directional FSS networks operating in frequency bands below 52.4 GHz.
- Uplink interference associated with closely separated GSO FSS VSAT networks in the 27.5-30 GHz frequency band.
- Technical and regulatory studies for 6/4 GHZ GSO/Non-GSO FSS sharing.
- Sharing between non-GSO FSS systems in the 6/4 GHz bands.
- Sharing between 50/40 GHz GSO and non-GSO systems.
- Protection of EESS (passive) and RAS systems from non-GSO satellite systems operating in the 37.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz frequency bands.
- Additional spectrum needs for development of the fixed-satellite service.
- Sharing with incumbent services in the 51.4-52.4 GHz band and adjacent and nearby bands.

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- Assessment on limitations mentioned in Annex 7 to RR Appendix 30 (Rev.WRC-12) in the 11.7-12.7 GHz band for the GSO broadcasting-satellite service in all Regions.
- Maximum permissible levels of off-axis e.i.r.p. density from non-axially symmetric earth station antennas transmitting to geostationary-satellite orbit networks operating in the fixed-satellite service in the 27.5-30 GHz frequency band.
- Operation of earth stations in motion (ESIM) communicating with geostationary space stations in the fixed-satellite service allocations at 17.7-19.7 GHz and 27.5-29.5 GHz.
- Airborne ESIM and the fixed service in the 27.5-29.5 GHz frequency band.
- Methodology to estimate the interference from land-based earth stations in motion (ESIMs) communicating with geostationary space stations in the fixed satellite service into fixed service stations operating in the 27.5-29.5 GHz frequency band.
- ITU SRS database analysis of stationary FSS earth station e.i.r.p. spectral density envelope in 27.5-29.5 GHz.
- ITU SRS database analysis of stationary FSS earth station characteristics in 17.7-19.7 GHz.
- Compatibility of International Mobile Telecommunications and broadcasting-satellite service (sound) in the frequency band 1 452-1 492 MHz in Regions 1 and 3.
- Treatment of frequency assignments with a bandwidth less than the stated averaging bandwidth.
- Range of notified characteristics of recorded frequency assignments of GSO satellite networks.
- Parameters for inter service sharing studies between FSS/BSS and other services.
- Application of coordination arc in the KA band, to determine coordination requirements between the FSS and other satellite services.
- Considerations on the content and application of Recommendation ITU-R S.1503-2.
- Bringing into use of frequency assignments to non-GSO FSS satellite networks/system.
- Modification (characteristics reduction) of a recorded assignment under RR Appendices 30 and 30A Regions 1 & 3 List.
- Discrepancy and / or inconsistency between the regulatory provisions dealing with any changes to the characteristics of an assignment.
- Identification of those specific satellite networks and systems with which coordination needs to be effected under RR Nos. 9.12, 9.12A and 9.13 or 9.21.
- Harmonization of RR Appendix 30B with RR Appendices 30 and 30A.

- Enhancement of the regulatory provisions of RR Appendix 30B to observe the principles based on which it was initially established.
- Updating the reference situation for networks under RR Appendices 30 and 30A when provisionally recorded assignments are converted into definitive recorded assignments.

Amongst those items on which Working Party 4A is engaged in preparation for WRC 19 are the studies on:

- Consideration of possible revision of Annex 7 to Appendix 30 of the Radio Regulations;
- Use of the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) by earth stations in motion communicating with geostationary space stations in the fixed-satellite service;
- Technical, operational issues and regulatory provisions for non-geostationary fixed-satellite service satellite systems in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space);
- Possible changes to the advance publication, coordination, notification and recording procedures for frequency assignments pertaining to satellite networks, in order to facilitate rational, efficient and economical use of radio frequencies and any associated orbits, including the geostationary-satellite orbit;
- Compatibility of International Mobile Telecommunications and broadcasting-satellite service (sound) in the frequency band 1 452-1 492 MHz in Regions 1 and 3;
- Technical and operational issues and regulatory provisions for new non-geostationary-satellite orbit systems in the 3 700-4 200 MHz, 4 500-4 800 MHz, 5 925-6 425 MHz and 6 725-7 025 MHz frequency bands allocated to the fixed-satellite service;
- Spectrum needs and possible allocation of the frequency band 51.4-52.4 GHz to the fixed-satellite service (Earth-to-space).

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ITU-R Working Party 4B – Systems, air interfaces, performance and availability objectives for the fixed-satellite service (FSS), broadcasting-satellite service (BSS) and mobile-satellite service (MSS), including IP-based applications and satellite news gathering (SNG)

Working Party 4B carries out studies on performance, availability, air interfaces and earth-station equipment of satellite systems in the FSS, BSS and MSS. This group has paid particular attention to the studies of Internet Protocol (IP)-related system aspects and performance and has developed new and revised Recommendations and Reports on IP over satellite to meet the growing need for satellite links to carry IP traffic. This group has close cooperation with the ITU Telecommunication Standardization Sector.

Working Party 4B is also developing new Recommendations and/or Reports on integrated systems and hybrid satellite-terrestrial networks.

Working Party 4B is the responsible group for all the studies related to the satellite component of IMT, including the development of new Recommendations and/or Reports on the satellite radio interface technologies.

This group also deals with SNG, which entails the use of transportable and portable earth stations for temporary and occasional transmission of video and/or sound signals, data and auxiliary signals from remote locations.

Current study topics include:

- Satellite transmission experiments for UHDTV satellite broadcasting.
- Scenarios and performance of an integrated MSS system operating in frequency bands below 3 GHz.
- MSS based broadband trunking communication system for disaster response and relief operations.
- Generic performance requirements for satellite systems operating above 15 GHz.
- Satellite aspects of improving reliability and security of telecommunications networks, including support of emergency services.
- Short-term error performance objectives.
- Performance requirements for digital television transmission schemes such as DVB and its variants for SNG usage.
- Implementations of adaptive coding and modulation.
- Key requirements for integration of satellite systems into IMT-2020 networks.

ITU-R Working Party 4C – Efficient orbit/spectrum utilization for the mobile-satellite service (MSS) and the radiodetermination-satellite service (RDSS) [2]

Studies conducted within Working Party 4C are aiming at a more efficient use of the orbit/spectrum resources by MSS and RDSS systems. This includes analyzing various interference situations between such systems but also with systems operating in other radiocommunication services, developing coordination methodologies, describing the potential use of MSS and RDSS systems for specific purposes like emergency situations, maritime or aeronautical telecommunications, time distribution, etc.

ITU-R Recommendations and Reports on these study items are elaborated and maintained by Working Party 4C, who also significantly contributes to the preparatory work for World Radiocommunication Conferences (WRCs).

Current study topics include:

- Use of existing mobile-satellite service systems for flight tracking.
- RNSS applications in the 1 164-1 215 MHz, 1 215-1 300 MHz, and 1 559-1 610 MHz frequency bands.
- Adjacent band compatibility studies of IMT-Advanced systems in the mobile service in the band below 1 518 MHz with respect to systems in the mobile-satellite service in the frequency band 1 518-1 525 MHz.
- Coexistence and compatibility study between mobile satellite systems and terrestrial IMT-Advanced systems in the IMT-2 GHz bands in different countries.
- Description of systems and networks in the radionavigation-satellite service (space-to-Earth and space-to-space) and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz.
- Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 215-1 300 MHz.
- Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) and receivers in the aeronautical radionavigation service operating in the band 1 559-1 610 MHz.
- Characteristics, performance requirements and protection criteria for receiving stations of the radionavigation-satellite service (space-to-space) operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz.

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2 WP 4C also deals with the performance issues related to RDSS

- Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 164-1 215 MHz.
- Guidance on ITU-R Recommendations related to systems and networks in the radionavigation-satellite service operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz.
- Protection of radionavigation-satellite service receiving earth stations operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz from unwanted emissions of IMT stations in the frequency bands below 3 GHz.
- Avionics and aviation communications systems.

Amongst those items on which Working Party 4C is engaged in preparation for WRC-19 are the studies on:

- Implementation of International Mobile Telecommunications in the frequency bands 1 885-2 025 MHz and 2 110-2 200 MHz;
- Consideration of regulatory provisions for updating and modernization of the Global Maritime Distress and Safety System;
- Spectrum needs and regulatory provisions for the introduction and use of the Global Aeronautical Distress and Safety System.

Handbooks

www.itu.int/pub/R-HDB

ITU-R Study Group 4 and its Working Parties developed a number of ITU R Handbooks:

Handbook on Mobile-satellite service (MSS) (www.itu.int/pub/R-HDB-41) provides a brief survey and introduction to the field of MSS

Supplements No. 1, 2, 3 and 4 to Handbook on Mobile-satellite service (MSS) (www.itu.int/pub/R-HDB-51):

Supplement 1 - Systems aspects of digital mobile Earth Station

Supplement 2 - Methodology for the derivation of interference and sharing criteria for the Mobile-satellite services

Supplement 3 - Interference and noise problems for maritime mobile-satellite systems using frequencies in the region of 1.5 and 1,6 GHz

Supplement 4 - Technical aspects of coordination among mobile-satellite systems using the geostationary-satellite orbit

Handbook on Satellite Communications (FSS) (www.itu.int/pub/R-HDB-42) gives a comprehensive description of all issues relative to satellite communication systems operating in the fixed-satellite service (FSS)

DSB Handbook – Terrestrial and satellite digital sound broadcasting to vehicular, portable and fixed receivers in the VHF/UHF bands (www.itu.int/pub/R-HDB-20) describes the system and service requirements for digital sound broadcasting (DSB) to vehicular, portable and fixed receivers, the related propagation factors, the techniques employed in the digital sound broadcasting systems, and considers relevant planning parameters and sharing conditions.

ITU-R Special publication: Specifications of transmission systems for the broadcasting-satellite service (www.itu.int/pub/R-HDB-16)

Other deliverables from ITU-R Study Group 4

Study Group 4 and its Working Parties maintains a number of **Recommendations** (www.itu.int/pub/R-REC) and **Reports** (www.itu.int/pub/R-REP) relating to the fixed-satellite service, the broadcasting-satellite service, the mobile-satellite service and the radiodetermination-satellite service.

Study Group 5

Terrestrial services

www.itu.int/go/itu-r/sg5

Scope

Systems and networks for fixed, mobile, radiodetermination, amateur and amateur-satellite services.

Structure

Four Working Parties (WPs) carry out the studies on Questions assigned to Study Group (SG) 5 and one Task Group (TG) which conducts studies on WRC-19 Agenda item 1.131:

WP 5A	Land mobile service above 30MHz[3] (excluding IMT); wireless access in the fixed service; amateur and amateur-satellite services
WP 5B	Maritime mobile service including the Global Maritime Distress and Safety System (GMDSS); the aeronautical mobile service and the radiodetermination service
WP 5C	Fixed wireless systems; HF and other systems below 30 MHz in the fixed and land mobile services
WP 5D	IMT systems
TG 5/1	WRC-19 Agenda item 1.13 "to consider identification of frequency bands for the future development of International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 238 (WRC-15)";

[3] including the exact frequency of 30MHz

ITU-R Working Party 5A – Land mobile service excluding IMT; amateur and amateur-satellite service

WP 5A is responsible for studies related to the land mobile service, excluding IMT and including wireless access in the fixed service, and is also responsible for studies related to the amateur and amateur-satellite services.

Mobility is becoming an ever-increasing requirement and characteristic of today's communications. In addition to commercial wireless access systems, including radio local area networks (RLANs), specialized land mobile applications such as intelligent transport systems (ITS) are becoming essential in improving the safety and efficiency of our roads and highways.

A key objective of WP 5A is to facilitate, through appropriate studies, equitable access to the radio spectrum by the land mobile and the amateur services, providing benefits that are made possible by implementing radio solutions to the communication needs. WP 5A is also very active in the development and standardization of new technologies for land mobile systems.

The amateur services continue to provide an opportunity for approximately 3 million duly authorized persons throughout the world to use radiocommunications for personal applications without any pecuniary interest. Activities include technical experimentation and communications between licensed amateurs and disaster communications. There have been more than 40 amateur-constructed low-Earth orbit and highly elliptical orbit satellites launched in the amateur-satellite service. Studies carried out by WP 5A on the amateur services concern technical and operational characteristics, sharing studies and, when requested, preparation for World Radiocommunication Conference agenda items.

Another important effort undertaken within WP 5A is the production of a series of volumes for the Land Mobile Handbook. The Handbook covers all categories of land mobile applications such as cellular phone, broadband wireless access, fixed wireless access, dispatch and paging systems, and intelligent transport systems. Five volumes have already been published. The purpose of this Handbook is to assist the ITU membership in the decision-making process involving planning, engineering and deployment of land mobile systems around the world.

ITU-R Working Party 5B – Maritime mobile service including the Global Maritime Distress and Safety System (GMDSS); the aeronautical mobile service and the radiodetermination service

WP 5B is responsible for studies related to the maritime mobile service, including the Global Maritime Distress and Safety System (GMDSS), the aeronautical mobile service and the radiodetermination service, including both radiolocation and radionavigation services. It studies communication systems for the maritime mobile and aeronautical mobile services and radar and radiolocation systems for the radiodetermination service.

WP 5B is the lead group for developing and maintaining ITU-R Recommendations, Reports and Handbooks that enable effective operation and protection for different applications, including distress and safety applications of the above services, while permitting sharing of the limited spectrum resources with other services operating within the allocated bands.

The maritime mobile service, by the very nature of its remote operations, is critically dependent on radio spectrum for the conduct of its business activities, as well as providing a vital link to search and rescue authorities and ships and aircraft during distress incidents and other potentially dangerous conditions. In close cooperation with the International Maritime Organization (IMO), WP 5B also develops drafts of operational procedures for urgency, distress and safety communications and operation of systems belonging to the maritime mobile service, including the management of Maritime Mobile Service Identities (MMSI).

With respect to the aeronautical mobile service, the provision of air traffic control and other communications related to safety and regularity of flight are dependent on radio spectrum. Therefore, Recommendations relating to protection and sharing criteria are studied by WP 5B on a continuous basis, with respect to proposed new sharing scenarios and to take into account innovations in technology. In accordance with its mandate, Working Party 5B carries out studies and develops Recommendations related to new aeronautical applications such as unmanned aircraft systems.

Different aspects related to the development and operation of applications belonging to the radiodetermination service (including radiolocation and radionavigation) are also part of the WP 5B agenda. Systems belonging to the radiodetermination service are being employed not only by the aeronautical, maritime and meteorological industries but to an ever-increasing degree by other industries as well as the general public. While these systems operate within the current frequency allocations, proposals for sharing with new systems that require significant new spectrum allocations are being made in preparation for future World Radiocommunication Conferences. This requires the development of specific Recommendations addressing the characteristics of all known radar systems, potential enhancements made possible by the introduction of new technology and standardized measurement and mitigation techniques for each proposed new sharing scenario.

Taking into account the increasing importance of climate monitoring, WP 5B pays special attention to the development and maintenance of ITU-R Recommendations related to the operation of ground-based meteorological radars employed for weather, water and climate monitoring and prediction. These radars play a critical role in the immediate meteorological and hydrological alert processes and represent the last line of detection of weather that can cause loss of life and properties in flash flood or severe storm events.

Working Party 5B maintains strong cooperation with the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO) and the World Meteorological Organization (WMO).

Working Party 5C – Fixed wireless systems; HF systems in the fixed and land mobile services

WP 5C is responsible for studies related to fixed wireless systems and HF systems in the fixed and land mobile services. It studies performance and availability objectives, interference criteria, RF channel/block arrangements, system characteristics and sharing feasibility. (Note that for fixed wireless access (FWA) systems, work related to public access systems for potentially large deployment coverage is carried out in WP 5A.)

Performance and availability objectives for fixed wireless systems are established with the aim of integrating these systems in the public network. Close coordination with ITU-T on this issue is required for consistency with relevant ITU-T Recommendations.

Establishing interference criteria for FS systems due to various sources of interference is essential in the preparation of technical texts for future radiocommunication conference items on frequency sharing with other radio services.

WP 5C also standardizes the RF arrangements (including those based on frequency blocks) in the various frequency bands allocated to the FS. These arrangements allow homogeneous patterns to be used, which is desirable for interconnecting systems on international circuits and to minimize mutual interference.

Fixed wireless system characteristics are also studied. Along with the interference criteria, knowledge of the system characteristics is vital for the work of WP 5C in assessing the impact of sharing with other services on a primary basis, in all the bands allocated to the FS.

The scope of WP 5C also covers use of frequency bands below 30 MHz by the fixed and land mobile services. Particular topics include adaptive HF systems, HF fixed service characteristics, including interference objectives and protection criteria, and interference evaluation in co-channel sharing feasibility studies.

ITU-R Working Party 5D – IMT Systems

WP 5D is responsible for the overall radio system aspects of the terrestrial component of International Mobile Telecommunications (IMT) systems, comprising the current IMT-2000, IMT-Advanced and IMT-2020.

For the last 20 years, ITU has been coordinating efforts of governments and the industry in the development of a global broadband multimedia international mobile telecommunications system, known as IMT. Since the year 2000, the world has seen the introduction of the first family of standards derived from the IMT concept: IMT-2000. There are currently several billions IMT subscribers in the world and these systems are continuing to expand and evolve.

IMT provides a global platform on which to build the next generations of mobile services – fast data access, unified messaging and broadband multimedia – in the form of exciting new interactive services.

Recommendation ITU-R M.2012 (www.itu.int/rec/R-REC-M.2012) provides detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced).

Recommendation ITU-R M.2083 (www.itu.int/rec/R-REC-M.2083) describes in detail the framework of the future development of IMT for 2020 and beyond, including a broad variety of capabilities associated with envisaged usage scenarios.

WP 5D has the prime responsibility within ITU-R for issues related to the terrestrial component of IMT, including technical, operational and spectrum-related issues to meet the objectives of future IMT systems and works closely with Working Parties 4B and 4C on issues related to the satellite component of IMT and with other Working Parties as necessary.

WP 5D is the lead group for the overall maintenance of existing, and the development of new, Recommendations on the terrestrial component of IMT. This activity also involves liaison with ITU-T on the network-related standardization activities of IMT and with ITU-D in relation to the application of IMT in developing countries. Strong cooperative efforts with external organizations and well-known standards development organizations are also maintained.

ITU-R Task Group 5/1 – WRC-19 Agenda item 1.13

Task Group 5/1 is responsible for the development of draft CPM text under WRC-19 Agenda item 1.13.

In developing sharing studies and draft CPM text, Task Group 5/1 is to consider, conduct and complete in time for WRC-19, in accordance with Resolution **238 (WRC-15)**, the results of appropriate studies from Working Party 5D on the spectrum needs, technical and operational characteristics including protection criteria, and deployment scenarios for the terrestrial component of IMT, as well as propagation models, technical characteristics including protection criteria for existing services allocated in, or adjacent to, the bands identified in *resolves to invite ITU-R 2* of Resolution **238 (WRC-15)**. Task Group 5/1 is also requested to conduct the appropriate sharing and compatibility studies, taking into account the protection of services to which the band is allocated on a primary basis.

Handbooks www.itu.int/pub/R-HDB

ITU-R Study Group 5 and its Working Parties developed a number of ITU R Handbooks:

Handbook on Amateur and Amateur-satellite services (www.itu.int/pub/R-HDB-52) provides general information about the amateur and amateur-satellite services. It also includes a compendium of existing ITU texts of relevance to the amateur and amateur-satellite services. This Handbook is intended to present, in one document, information about the amateur services for administrations and amateur radio organizations.

Handbook on Digital Radio-Relay Systems (www.itu.int/pub/R-HDB-24) represents a comprehensive summary of basic principles, design parameters and current practices for the design and engineering of digital radio-relay systems.

Handbook on Frequency adaptive communication systems and networks in the MF/HF bands (www.itu.int/pub/R-HDB-40) assists planners and decision-makers in the deployment of adaptive MF/HF systems in the fixed service, for both commercial and government users in developed and particularly developing countries. It provides material on current present technological capabilities in the field of adaptive MF/HF communications.

Handbook on Land Mobile (including Wireless Access) Volume 1: Fixed Wireless Access (www.itu.int/pub/R-HDB-25) assists in the decision making process involving planning, engineering and deployment of wireless access based land mobile systems, especially in the developing countries. It should also provide adequate information that will assist in training engineers and planners in regulating, planning, engineering, and deployment aspects of these systems.

Handbook on Land Mobile (including Wireless Access) Volume 2: Principles and Approaches on Evolution to IMT-2000/FPLMTS (www.itu.int/pub/R-HDB-30) provides an overview of principles and approaches to be considered in the evolution of existing and emerging systems towards IMT-2000. IMT-2000 are third generation mobile systems which are scheduled to start service around the year 2000, subject to market considerations.

Handbook on Land Mobile (including Wireless Access) – Volume 3: Dispatch and Advanced Messaging Systems (www.itu.int/pub/R-HDB-47) assists in the decision-making process involving planning, engineering and deployment of land mobile systems, especially in the developing countries. It should also provide adequate information to assist in training engineers and planners in regulating, planning, engineering and deployment aspects of these systems. Volume 3 on Dispatch and Advanced Messaging Systems provides information on state-of-the-art technology in terrestrial land mobile paging and advanced messaging and dispatch as well as descriptions of typical systems. The technical content is intended for use by administrations and operators in both developing and developed countries.

Handbook on Land Mobile Handbook (including Wireless Access) – Volume 4: Intelligent Transport Systems (www.itu.int/pub/R-HDB-49) provides a summary of the use of wireless communications in intelligent transport systems (ITS), current and under development, around the globe, including architecture, systems, and applications. This is a rapidly developing sector, which is still partly in its infancy.

Handbook on Land Mobile (including Wireless Access) – Volume 5: Deployment of Broadband Wireless Access Systems (www.itu.int/pub/R-HDB-57) overall purpose is to assist in the decision-making process involving planning, engineering and deployment of wireless-based land mobile systems, especially in developing countries. It also provides information that will assist in training engineers and planners in the regulating, planning, engineering and deployment aspects of these systems.

Handbook on Migration to IMT-2000 Systems – Supplement 1 (Revision 1) of the Handbook on Deployment of IMT-2000 Systems (www.itu.int/pub/R-HDB-46) expands on the first edition of the ITU Handbook - Deployment of IMT- 2000 Systems and updates much of the work that has occurred since the release of the Handbook. It addresses the subject of evolution and migration from current mobile systems towards IMT-2000. ITU-R has developed this work in response to ongoing liaison and interaction with the ITU-D and ITU-T Sectors and sees this material as the natural extension of the information presented in the Handbook.

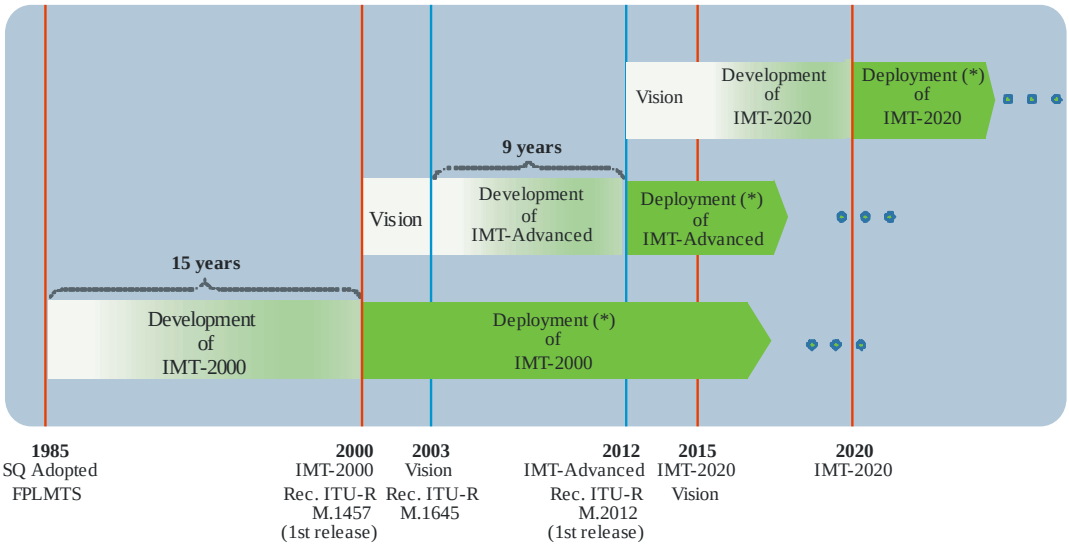
Handbook on IMT-2000: Special Edition on CD-ROM (www.itu.int/pub/R-HDB-37) is of particular interest to experts involved in IMT-2000 radio and network standards development and also to all those interested in a deeper understanding of the global scene of personal mobile communications. It contains a complete set of ITU texts on IMT-2000 and other related topics and includes Recommendation ITU-R M.1457 which describes the detailed specifications of the radio interfaces of IMT-2000.

Handbook on Global Trends in International Mobile Telecommunications (www.itu.int/pub/R-HDB-62) identifies International Mobile Telecommunications (IMT) and provides the general information such as service requirements, application trends, system characteristics, and substantive information on spectrum, regulatory issues, guideline for the evolution and migration, and core network evolution on IMT. The purpose of this Handbook is to provide general guidance to relevant parties on issues related to the deployment of IMT systems and to the introduction of their IMT 2000 and IMT Advanced networks.

Handbook on Guidance for bilateral/multilateral discussions on the use of frequency range 1 350 MHz - 43.5 GHz by fixed service systems (www.itu.int/pub/R-HDB-61) summarizes the existing technical approaches to resolve compatibility and sharing issues within fixed service stations. The objective is to provide a guide addressing best practices from those administrations already having knowledge and experience in developing such agreements. Examples are provided to facilitate the sharing of fixed service deployed in the neighbouring countries.

Other deliverables from ITU-R Study Group 5

Study Group 5 and its Working Parties maintains a number of **Recommendations** (www.itu.int/pub/R-REC) and **Reports** (www.itu.int/pub/R-REP) relating to the fixed, mobile, radiodetermination, amateur and amateur-satellite services.. Study Group 5 is also responsible of the development of IMT.



(*) Deployment timing may vary across countries.

M.2083-01

Development of International Mobile Telecommunications (IMT)

Study Group 6

Broadcasting service

www.itu.int/go/itu-r/sg6

Scope

Radiocommunication broadcasting, including vision, sound, multimedia and data services principally intended for delivery to the general public.

Broadcasting makes use of point-to-everywhere information delivery to widely available consumer receivers at home, in cars or in portable use. When return channel capacity is required (e.g. for access control, interactivity, etc.), broadcasting typically uses an asymmetrical distribution infrastructure that allows high-capacity information delivery to the public with lower capacity return link to the service provider (by using the so-called converged terminals). The work of the Study Group includes the production and distribution of programmes (vision, sound, multimedia, data, etc.) as well as contribution circuits among studios, information gathering circuits (ENG, requirements for SNG, etc.), primary distribution to delivery nodes, and secondary distribution to consumers.

The Study Group, recognizing that radiocommunication broadcasting extends from the production of programmes to their delivery to the general public, studies those aspects related to production and radiocommunication end-to-end, including the international exchange of programmes as well as the overall quality of service.

Structure

Three Working Parties (WPs) carry out studies on Questions assigned to Study Group (SG) 6:

WP 6A	Terrestrial broadcasting delivery
WP 6B	Broadcast service assembly and access
WP 6C	Programme production and quality assessment

ITU-R Working Party 6A – Terrestrial broadcasting delivery

WP 6A covers the activities in the area of terrestrial system characteristics, channel coding/decoding, modulation/demodulation, frequency planning and sharing for sound, video, multimedia and interactivity, characteristics of transmitting and receiving antennas and evaluation methods of service areas, transmitter and receiver reference performance requirements, requirements for source coding for terrestrial emission and requirements for metadata in terrestrial broadcasting.

WP 6A prepares handbooks and publications on terrestrial broadcasting that are useful to users in all parts of the world, including developing countries. A number of these handbooks have been prepared in the past such as the Handbook on Terrestrial and Satellite Digital Sound Broadcasting to Vehicular, Portable and Fixed Receivers in the VHF/UHF bands, a HF Broadcasting System Design Handbook, an LF/MF System Design Handbook and a Digital Terrestrial Television Broadcasting Handbook (www.itu.int/pub/R-HDB).

Current activities include principally work on planning criteria, including protection ratios, for 2nd generation digital terrestrial television services in the VHF/UHF bands; guidelines for assessment of interference into the broadcasting service from other services/applications; preparation of a Handbook on digital terrestrial television (DTTB) and multimedia implementation; guidelines on measurements for digital terrestrial television broadcasting systems; and contributions to the area of Green ICT and the effects of climate change with respect to terrestrial broadcasting.

ITU-R Working Party 6B – Broadcast service assembly and access

WP 6B covers the activities in the area of interfaces in the production chain and via/to the various delivery media (terrestrial, satellite, cable, internet, etc.), source coding and multiplexing/demultiplexing of content, metadata, middleware, service information, and access control, for all broadcasting services including multimedia/interactive and converged services, both fixed and mobile terminals. WP 6B is also responsible for requirements for ENG and broadcasting satellite services. In other words, WP 6B is responsible for any areas bridging programme production and broadcasting emission.

In a digital broadcast scenario, the content to be broadcast consists of audio, video, data and metadata. Each of these media types possesses its own characteristics that need to be taken into account in order to be able to achieve an optimum balance of technical and economic efficiency in their preparation for broadcast emission. Consideration needs to be given to the characteristics of different parts of the broadcast chain as well as of the delivery platform, while also taking account of user requirements.

Objectives of WP 6B are to study and seek harmonized systems for delivering programmes to receivers using terrestrial, satellite or Internet platforms. Moreover, WP 6B studies integrated broadcast-broadband systems (IBB) that combine services on broadcast and broadband networks, a specific example being access services for people with special needs.

WP 6B also maintains a watch on emerging digital broadcast technologies utilizing ICT and on the issues surrounding the rights management of digital broadcast content.

Current activities include work on a set of essential audio metadata and its association with audio essence for next generation immersive audio files, a serialized form of audio metadata, source coding and transport methods for new broadcasting systems, further harmonization of Integrated broadcast-broadband (IBB) systems, and study of a new global platform for the distribution of content produced by broadcasters using the large variety of distribution media now available to the public.

ITU-R Working Party 6C – Programme production and quality assessment

WP 6C studies issues and develops requirements associated with what can be called the "presentation layer" for radio and television broadcasting. This includes signal formats for the making and exchange of sound and television programmes, ways to evaluate sound and picture quality and guidance on the use of new technologies that are a critical elements in the choice of parameters for the end-to-end "presentation layer".

The ability to easily exchange programme material through common signal formats is vitally important for programme production, archiving, and for broadcasting itself. The use of efficient sound and vision formats for sound and television broadcasting means better use of radio spectrum and higher quality for the listener and the viewer.

A key objective of the working party is to continue to pioneer and develop standardized methodologies for evaluating sound and picture quality. These methods are used throughout the world's media community for all forms of media presentation.

In response to the UN Convention on the Rights of Persons with Disabilities and ITU Resolution 175 (Guadalajara, 2010), the Working Party and the Study Group are actively working on improving accessibility to audiovisual media services (television, radio and Internet) for persons with hearing, sight or aging disabilities.

Current activities of the Working Party, come under four primary headings, *Video* including work on the parameters for high dynamic range television programme production and exchange, *Audio* including the multi-channel and object audio reproduction, *Quality* for both audio and video, including modernizing the internationally recognized ITU-R BT.500, methodologies for the measurement of the Quality of Experience and the requirements for assessing new audio systems and finally Reports giving guidance on the use of the Recommendations produced by the working party, which include high dynamic range, new colour schemes and quality assessment.

Other deliverables from ITU-R Study Group 6

Study Group 6 and its Working Parties maintain a number of **Recommendations** (www.itu.int/rec/R-REC-BT/en, www.itu.int/rec/R-REC-BS/en) and **Reports** (www.itu.int/pub/R-REP-BS/en, www.itu.int/pub/R-REP-BT/en) relating to the broadcasting service.

Two Recommendations in particular are now driving a revolution in the quality of experience that can be offered to audiences of broadcasting services around the world: BT.2020 has become the recognized basis of the next generation of ultra-high definition television systems, while BS.2051 is laying the foundation for a similar revolution in advanced sound.

Recently approved Recommendations, Reports and Handbook include:

Recommendation BS series

- BS.2094 Common definitions for the Audio Definition Model
- BS.2088 Long-form file format for the international exchange of audio programme materials with metadata
- BS.2076 Audio Definition Model
- BS.2051 Advanced sound system for programme production

Recommendation BT series

- BT.2100 Image parameter values for high dynamic range television for use in production and international programme exchange
- BT.2095 Subjective assessment of video quality using Expert Viewing Protocol
- BT.2087 Colour conversion from Recommendation ITU-R BT.709 to Recommendation ITU-R BT.2020
- BT.2077 Real-time serial digital interfaces for UHDTV signals
- BT.2075 Integrated broadcast-broadband system
- BT.2074 Service configuration, media transport protocol, and signalling information for MMT-based broadcasting systems
- BT.2073 Use of the high efficiency video coding (HEVC) standard for UHDTV and HDTV broadcasting
- BT.2072 Main functionalities of consumer receivers for worldwide broadcasting roaming

- BT.2020 Parameter values for ultra-high definition television systems for production and international programme exchange

Report BS series

- BS.2388 Usage guidelines for the audio definition model and multichannel audio files
- BS.2384 Implementation considerations for the introduction and transition to digital terrestrial sound and multimedia broadcasting

Report BT series

- BT.2390 High dynamic range television for production and international programme exchange
- BT.2389 Guidelines on measurements for digital terrestrial television broadcasting systems
- BT.2387 Spectrum/frequency requirements for bands allocated to broadcasting on a primary basis
- BT.2386 Digital terrestrial broadcasting: Design and implementation of single frequency networks (SFN)
- BT.2385 Reducing the environmental impact of terrestrial broadcasting systems
- BT.2383 Characteristics of digital terrestrial television broadcasting systems in the frequency band 470-862 MHz for frequency sharing/interference analyses
- BT.2382 Description of interference into a digital terrestrial television receiver
- BT.2381 Requirements for High Dynamic Range Television (HDR-TV) Systems
- BT.2380 Television colorimetry elements
- BT.2344 Information on technical parameters, operational characteristics and deployment scenarios of SAB/SAP as utilized in broadcasting
- BT.2343 Collection of field trials of UHDTV over DTT networks
- BT.2342 Production, emission and exchange of closed captions for all worldwide language character sets (latin and non-latin)

- Digital Terrestrial Television Broadcasting Networks and Systems Implementation (under publication)

  The Handbook is designed to provide assistance in technical and service issues such as networks and systems, audiovisual quality and quality of transmission as well as on other issues of interest for the introduction of digital terrestrial TV broadcasting (from multimedia systems to UHDTV) in different countries. The Handbook takes into account progress and convergence of technologies, different environments for production, primary and secondary distribution of broadcast programs as well as experiences in providing quality of service for DTTB.

www.itu.int/pub/R-HDB-03)

ITU-R Study Group 6 and its Working Parties have also developed a number of ITU-R Handbooks:

Handbook on Conclusions of the Extraordinary Meeting of Study Group 11 on High-Definition Television (www.itu.int/pub/R-HDB-11)

Handbook on Digital Television Signals: Coding and Interfacing within Studios (www.itu.int/pub/R-HDB-19) gives a summary of the background to what has been agreed so far in ITU-R, based largely on work already reported within Reports but also including references to published material outside of the ITU.

DTTB Handbook - Digital terrestrial television broadcasting in the VHF/UHF bands (www.itu.int/pub/R-HDB-39) provides guidance to engineers responsible for the implementation of digital terrestrial television broadcasting and combines material dealing with digital and analogue television systems and planning aspects of this new topic.

Handbook on HF Broadcasting System Design (www.itu.int/pub/R-HDB-33) provides practical and illustrative guidance (even to radio engineers not having been previously exposed to the specific task of HF broadcasting service planning). Considerable effort has been made to meet the expectations of HF broadcasting engineers from the developing world. This publication includes relevant texts from existing ITU-R Recommendations as well as advanced material.

Handbook on LF/MF system design (www.itu.int/pub/R-HDB-38) contains all the necessary information to carry out the planning and design of LF and MF broadcasting stations. Wide reference is made to relevant ITU-R Recommendations and ITU Frequency Plans. The Handbook is mainly addressed to engineers in developing countries to guide them in selecting the best approach.

Handbook on Subjective Assessment Methodology in Television (www.itu.int/pub/R-HDB-28). Part 1 describes the general methods of performing subjective assessments. Part 2 considers the application of specific elements. Three particular applications are given: digital coding systems, high-definition television and alpha-numeric and graphic systems evaluation.

Handbook on Technical Specifications of ITU-R Teletext Systems (www.itu.int/pub/R-HDB-34). Teletext systems provide the means to supplement an analogue television broadcast with digitally coded data signals carried in the vertical interval. The data signals can be displayed on the viewers receiver as printed text or diagrams, or possibly more elaborate multimedia. This Handbook currently in use worldwide as defined in ITU-R Recommendations. They are described in four Sections in a similar way, so that readers can understand the differences and similarities.

Handbook on Television Systems Used around the World (www.itu.int/pub/R-HDB-08) and **Reports** (www.itu.int/pub/R-REP)

Study Group 7

Science services

www.itu.int/go/itu-r/sg7

Scope

"Science services" refer to the standard frequency and time signal, space research (SRS), space operation, Earth exploration-satellite (EESS), meteorological-satellite (MetSat), meteorological aids (MetAids) and radio astronomy (RAS) services.

The systems linked with Study Group 7 are used in activities that are a critical part of our everyday life such as:

- global environment monitoring – atmosphere (including greenhouse gases emissions), oceans, land surface, biomass, etc.;
- weather forecasting and climate change monitoring and prediction;
- detection and tracking of many natural and man-made disasters (earthquakes, tsunamis, hurricanes, forest fires, oil leaks, etc);
- providing alerting/warning information;
- damage assessment and planning relief operations.

SG 7 also encompasses systems for the study of outer space:

- satellites for studying the sun, the magnetosphere and all the elements of our solar system;
- spacecraft for human and robotic exploration of extraterrestrial bodies;
- Earth and satellite-based radioastronomy to study the universe and its phenomena.

Study Group 7 develops ITU-R Recommendations, Reports and handbooks that are used for development and ensuring non-interference operation of space operation, space research, Earth-exploration and meteorological systems (including the related use of links in the inter-satellite service), radio astronomy and radar astronomy, dissemination, reception and coordination of standard-frequency and time-signal services (including the application of satellite techniques) on a worldwide basis.

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Structure

Four Working Parties (WPs) carry out studies on Questions assigned to Study Group (SG) 7, and one Joint Task Group (JTG) conducts related studies on WRC-15 Agenda items 1.1 and 1.2

WP 7A	Time signals and frequency standard emissions: Systems and applications (terrestrial and satellite) for dissemination of standard time and frequency signals;
WP 7B	Space radiocommunication applications: Systems for transmission/ reception of telecommand, tracking and tele-metry data for space operations, space research, Earth exploration-satellite, and meteorological satellite services including the related use of links in the inter-satellite service;
WP 7C	Remote sensing systems: active and passive remote sensing applications in the Earth exploration-satellite service and systems of the MetAids service, as well as ground based passive sensors, space weather sensors and space research sensors, including planetary sensors;
WP 7D	Radio astronomy: radio astronomy and radar astronomy sensors, both Earth-based and space-based, including space very long baseline interferometry (VLBI).

ITU-R Working Party 7A – Time signals and frequency standard emissions

WP 7A covers standard frequency and time signal services, both terrestrial and satellite. Its scope includes the dissemination, reception and exchange of standard frequency and time signals and coordination of these services, including the application of satellite techniques on a worldwide basis.

The goals of WP 7A activities are to develop and maintain ITU-R Recommendations and Reports in the TF Series and Handbooks relevant to standard frequency and time-signal (SFTS) activities, covering the fundamentals of the SFTS generation, measurements and data processing. These ITU-R Recommendations are of paramount importance to telecommunication administrations and industry, to which they are first directed. They also have important consequences for other fields, such as radionavigation, electric power generation, space technology, scientific and meteorological activities and cover the following topics:

- Terrestrial SFTS transmissions (including HF, VHF, UHF broadcasts), television broadcasts, microwave link; coaxial and optical cables;
- Space-based SFTS transmissions/ (including navigation satellites) and communication satellites and meteorological satellites;
- Time and frequency technology, (including frequency standards and clocks), measurement systems, performance characterization, time scales and time codes.

ITU-R Working Party 7B – Space radiocommunications applications

WP 7B is responsible for the transmission and reception of telecommand, tracking and telemetry data for space operation, space research, Earth exploration-satellite, and meteorological satellite services. It studies communication systems for use with manned and unmanned spacecraft, communication links between planetary bodies and the use of data relay satellites.

WP 7B enables both scientific studies and technology programmes by intelligent use of the radio-frequency spectrum.

WP 7B develops and maintains the Recommendations to enable sharing of the limited orbital and spectrum resources. The technical and operational characteristics of spacecraft are also studied, defining the preferred frequency bands, bandwidths required, protection and sharing criteria for spacecraft, and orbital locations for data relay satellites. The resulting SA Series ITU-R Recommendations and Reports assist administrations, national space agencies and industry in the planning of systems that share frequency allocations used by space radio systems.

Space research, by the very nature of its remote operations, is critically dependent on the radio spectrum for the conduct of its activities.

Extreme distances characterize deep space activities, with some current missions in excess of 11 billion km from the Earth. These extraordinary distances require the use of sophisticated communication equipment and advanced technologies to achieve reliable communication links.

The expansion of radiocommunications using low-Earth orbit, coupled with the requirement for continuous communication, has led to the use of data relay satellites. Placed in geostationary orbit, a data relay satellite can provide continuous communication between a low-Earth orbiting spacecraft and a single earth station, and can support multiple spacecraft simultaneously with low to very high data rate requirements.

With respect to manned missions, the most challenging communication systems are those embedded in the space suits of astronauts engaged in space walks. The fact that the communication system must be integrated into the space suit severely limits the physical size and power consumption of such systems.

It is crucial for understanding the Earth and its natural phenomena, including climate change, that active and passive sensor data obtained from Earth exploration-satellites is disseminated, while the transmission of weather-related observations from meteorological satellites provides global or regional coverage for weather models, including cloud coverage, infrared, and water vapor images.

ITU-R Working Party 7C – Remote sensing systems

WP 7C covers remote sensing applications in the Earth exploration-satellite service (EESS), both active and passive, systems of the MetAids service, as well as ground based passive sensors, space weather sensors and space research sensors, including planetary sensors.

The objectives of WP 7C activities are to develop and maintain ITU-R Recommendations, Reports and handbooks relevant to remote sensing in Earth-exploration and meteorological activities. This includes the assessment of spectrum requirements and protection criteria for the above services and the establishment of sharing criteria with other services. The resulting RS Series ITU-R Recommendations are of paramount importance to administrations, international and national space agencies, as well as industry.

The Earth-exploration active sensors on-board satellites include systems such as altimeters, scatterometers and synthetic aperture radars to carry out:

- scientific and meteorological measurements of soil moisture, forest biomass, precipitation, surface winds, ocean topography, clouds structure, etc;
- measurements related to environmental protection and management of natural and man-made disaster situations (e.g. flooding, earthquakes, oil spills);

- Earth imaging at medium and high resolution for commercial and security applications.

The Earth-exploration passive sensors are used for a variety of terrestrial and atmospheric measurements, including important environmental data such as soil moisture, salinity, ocean surface temperature, water vapour profiles, temperature profiles, ocean ice, rain, snow, ice, winds, atmospheric chemicals, etc. Because of the required measurement accuracy down to fractions of one Kelvin, as well as the inability of the sensor to distinguish between natural and man-made radiation, a very high level of protection against interference from active services is necessary to obtain successful results.

The space research active and passive sensors are conceptually similar to the sensors used for Earth exploration, but are used either for the exploration of other planetary bodies of our solar system or for radio astronomical measurements from space.

The meteorological services comprise primarily the MetSat service and the MetAids service (the latter covering a variety of types of meteorological equipment), radiosondes, dropsondes and rocketsondes. MetAids are flown worldwide for the collection of upper atmosphere meteorological data for weather forecasts and severe storm prediction, collection of ozone level data, and measurement of atmospheric parameters for various applications.

WP 7C is also considering ground-based (incl. airborne) passive sensors, their technical and operational characteristics and corresponding protection requirements as they are becoming increasingly important in the observation and monitoring of the Earth environment and phenomena affecting it.

Furthermore, WP 7C is investigating about space weather observations with ground-based and/or space-based sensors in terms of the applicable radio services space weather observations would have to be categorized in, the corresponding frequency allocations and their technical and operational characteristics and protection requirements. According to the WMO definition, space weather encompasses the conditions and processes occurring in space, including on the sun, in the magnetosphere, ionosphere and thermosphere, which have the potential to affect the near-Earth environment”

ITU-R Working Party 7D – Radio astronomy

WP 7D covers the radio astronomy service. Its scope includes radio astronomy and radar astronomy sensors, both Earth-based and space-based, including space very long baseline interferometry (VLBI).

The goals of WP 7D activities are to develop and maintain the RA Series ITU-R Recommendations and Reports and Handbook relevant to radio and radar astronomy, covering their spectrum requirements, protection and sharing criteria. These Recommendations and Reports, as well as the Handbook on Radio Astronomy,are of paramount importance to administrations, national and international space agencies and industries, to which they are first directed.

Radio Astronomy observations involve the detection of extremely faint radio signals from the cosmos over the whole radio spectrum, and therefore require the most sensitive radio telescope systems. Such systems are very susceptible to radio frequency interference from other radio services and hence careful management of the radio spectrum is of extreme importance to radio astronomy.

The radio astronomy service uses very diverse instruments ranging from very large single-dish telescopes such as the new 500m diameter FAST telescope in China, to large distributed arrays such as the new Square Kilometer Array (SKA) now under construction in Australia and South Africa. These telescopes employ extremely sensitive cryogenically-cooled receivers and require advanced digital electronics and computer systems, often pioneering new technologies. WP 7D must develop the protection criteria for such services and work within the ITU to enable adequate protection for radio astronomy observations.

Handbooks

www.itu.int/pub/R-HDB

ITU-R Study Group 7 and its Working Parties developed a number of ITU R Handbooks:

ITU/WMO Handbook on the "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction (www.itu.int/pub/R-HDB-45) was developed in cooperation with the Steering Group on Radio Frequency Coordination of the World Meteorological Organization (WMO) and provides comprehensive technical information on the use of radio-based devices and systems, including meteorological and Earth exploration-satellites, radiosondes, weather radars, wind profiler radars, spaceborne remote sensing for weather and climate monitoring and forecasting.

Handbook on Earth-Exploration Satellite Service (www.itu.int/pub/R-HDB-56) describes the Earth exploration-satellite service (EESS), its technical characteristics, its applications, its spectrum requirements, as well as its benefits andprovides full and comprehensive information on the development of EESS systems. Specifically, it provides basic definitions, sheds light on the technical principles underlying the operation of systems and presents their main applications to assist administrations in the spectrum planning, engineering and deployment aspects of these systems.

Handbook on Radio Astronomy (www.itu.int/pub/R-HDB-22) is concerned with aspects of radio astronomy relevant to frequency coordination, i.e. the management of radio spectrum usage in order to minimize interference between radiocommunication services. It covers areas such as radio astronomy characteristics, preferred frequency bands, special radio astronomy applications, vulnerability to interference from other services, as well as issues associated with the sharing of radio spectrum with other services.

The search for extraterrestrial intelligence and ground-based radar astronomy are also considered in the Handbook.

Handbook on Selection and Use of Precise Frequency and Time Systems (www.itu.int/pub/R-HDB-31) describes basic concepts, frequency and time sources, measurement techniques, characteristics of various frequency standards, operational experience, problems and future prospects.

Handbook on Satellite Time and Frequency Transfer and Dissemination (www.itu.int/pub/R-HDB-55) provides detailed information on the applied methods, technologies, algorithms, data structure and practical use of frequency and timing signals provided by satellite systems.

Handbook on Space Research Communications (www.itu.int/pub/R-HDB-43), presents the basic technical and spectrum requirements for the many different space research programmes, missions and activities. It discusses space research functions and technical implementations, factors that govern frequency selection for space research missions, and space research protection and sharing considerations.

Other deliverables from ITU-R Study Group 7

Study Group 7 and its Working Parties maintains a number of **Recommendations** (www.itu.int/pub/R-REC) and **Reports** (www.itu.int/pub/R-REP) relating to relating to the science services. Recent developments include:

Recommendation ITU-R RS.1883 on **Use of remote sensing systems in the study of climate change and the effects thereof** (www.itu.int/rec/R-REC-RS.1883). This Recommendation encompasses guidelines on the provision of satellite-provided remote sensing data for studying climate change.

ITU-R Report RS. 2178 **The essential role and global importance of radio spectrum use for Earth observations and for related applications** (www.itu.int/pub/R-REP-RS.2178).

Coordination Committee for Vocabulary (CCV)

www.itu.int/itu-r/go/rccv/

Scope

Coordination and approval in close collaboration with the Radiocommunication Study Groups, the General Secretariat (Conferences and Publications Department) and other interested organizations (mainly the International Electrotechnical Commission (IEC)), concerning:

- vocabulary, including abbreviations and initials;
- related subjects (quantities and units, graphical and letter symbols).

The terminology managed by the Radiocommunication Sector, notably being completed and updated by the data supplied by the Radiocommunication Study Groups, is included in the database “ITU Terms and Definitions” (www.itu.int/ITU-R/go/terminology-database).

Conference Preparatory Meeting (CPM)

www.itu.int/go/itu-r/cpm

In accordance with Resolution ITU-R 2-7, the CPM will normally hold two sessions during the interval between WRCs.

The first session will be for the purpose of coordinating the work programmes of the relevant ITU-R Study Groups, and preparing a draft structure for the CPM Report, based on the agenda for the next two WRCs, and for taking into account any directives which may have come from the previous WRC.

The second session shall prepare a consolidated report to be used in support of the work of World Radiocommunication Conferences, based on:

- contributions from administrations, the Radiocommunication Study Groups (see also No. 156 of the ITU Convention) and other sources (see Article 19 of the ITU Convention) concerning the regulatory, technical, operational and procedural matters to be considered by such conferences;

- the inclusion, to the extent possible, of reconciled differences in approaches as contained in the source material, or, in the case where the approaches cannot be reconciled, the inclusion of the differing views and their justification.

Information from the responsible groups in charge of the ITU-R preparatory studies for WRC-19 and WRC-23 can be consulted online at: www.itu.int/go/rcpm-wrc-19-studies.

Publications

www.itu.int/publications

With over 4 000 published titles, ITU is the main publisher of texts dealing with telecommunication technology and regulation, providing also general information in that regard. ITU-R's publications constitute an essential reference source for all those wishing to remain abreast of the rapid and complex changes occurring in the world of international radiocommunications such as State entities, public and private telecommunication operators, manufacturers, scientific or industrial bodies, international organizations, consultancies, universities, technical institutions, etc.

The IAP Department edits and publishes regulatory texts such as the Radio Regulations, the Final Acts of World Radiocommunication Conferences and the Rules of Procedure, as well as ITU-R handbooks, Reports and Recommendations drawn up by the Radiocommunication Study Groups.

Publications are available in paper format, on CD-ROM or online, in six languages (Arabic, Chinese, English, French, Russian, Spanish) or can be ordered directly from the ITU website: www.itu.int/ITU-R/go/publications.

To obtain a full catalogue or place an order by telephone, please contact the ITU Sales Service on +41 22 730 6141.

Why become an ITU Member?

ITU Membership represents a cross-section of the telecommunications and information and communication technology (ICT) industry, from the world's largest manufacturers and carriers to small, innovative new players working in revolutionary or new fields such as wireless communications (e.g. IMT-Advanced), television digital broadcasting (e.g. 3DTV) or future satellite systems (e.g. for remote sensing, emergency communications or intelligent transport systems).

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ITU Sector Members may be involved with the organization and co-sponsorship of seminars and workshops, providing experts and lecturers, training facilities, etc.

Associates

Associate Members are entities or organizations who join a single ITU Sector, for example the ITU-R Sector, and take part in the work of a selected single ITU-R Study Group and its subordinate groups. Associates take part in the process of preparing ITU-R Recommendations (standards) before their eventual adoption.

Associates can have access to all related documentation in their chosen ITU-R Study Group, as well as to other Study Groups, as required by the work programme. Associates are not involved in voting for, or in the approval of Questions and Recommendations.

An ITU-R Associate Member may also serve as Rapporteur within the selected ITU-R Study Group, except for liaison activities, which are to be handled separately.

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- Access to publications, documents, information and statistics;
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- Discounts off the catalogue price for purchase of any ITU publication (except those available from the ITU Electronic Bookshop);
- Access to a large volume of restricted data such as draft documents, statistics, development plans, training modules, etc.

Academia

Academia, universities and associated research establishments concerned with the development of telecommunications/ICTs are also admitted to participate in the work of the three Sectors of ITU.

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www.itu.int/go/ITU-R/cvc/RSG and **www.itu.int/go/ITU-R/cvc/RAG**

ITU-R References

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