**Annex 5.1.**

**The international monitoring system**

1. **Introduction**

The monitoring of emissions is an essential component of the frequency spectrum management system. Each country should operate monitoring facilities as essential tools for ensuring efficient spectrum management at the national level. On the other hand, since aims of the ITU include ensuring efficient and economic use of the frequency spectrum and help towards the rapid elimination of harmful interference, administrations have decided to cooperate in the development and operation of an international monitoring system and to adopt appropriate regulatory provisions RR Article 16 contains the provisions governing the establishment and operation of the international monitoring system.

1. **Tasks and structure of the monitoring service**

The following monitoring service tasks are derived from the Radio Regulations (RR):

– monitoring emissions for compliance with frequency assignment conditions;

– frequency band observations and frequency channel occupancy measurements;

– investigating cases of interference;

– identifying and stopping unauthorized emissions.

Regularly monitoring national emissions for compliance with conditions and subsequently eliminating any non-compliance aims to prevent radio interference. Technical parameters such as frequency, bandwidth, frequency deviation and class of emission, and for certain radio communication services communication content needs to be monitored. For example by monitoring amateur radio communications care should be taken, that never broadcasts but regularly call signs are used.

Frequency band observations aim at determination of frequencies/channel occupation and user identification Channel occupancy measurements are undertaken to determine time and degree of frequencies usage – and to determine also unused frequencies – and to identify emissions and their basic characteristics. Knowledge of actual spectrum usage is essential for the frequency management aim ensuring efficient, interference-free frequency use and for the decision whether or not a certain frequency can be assigned to additional users. These data also form the basis for national and international frequency coordination.

The most important measurement tasks, which a monitoring station should at least be able to perform, are:

* frequency measurements,
* field strength and power-flux density measurements at fixed points,
* bandwidth measurements,
* modulation measurements,
* spectrum occupancy measurements,
* direction finding.
1. **FREQUENCY CHANNEL OCCUPANCY MEASUREMENTS**
	1. **Spectrum occupancy measurements - General observations**

 Spectrum occupancy measurements refer to the recording of emissions during a period of time. Out of the gathered raw data an almost unlimited number of plots, tables etc can be produced, e.g. the calculated occupancy per frequency band or per channel exceeding a threshold level. Questions concerning the identification of user, location and time and duration of radio frequency channel or band occupation are not part of spectrum occupancy but topic of § 4.8 (Signal analysis and transmitter identification).

For receiving equipment functions and characteristics of measuring receivers (narrow- or broadband) or spectrum analyser have to be in line with the relevant ITU-R Recommendations. .

For an excellent performance of spectrum occupancy measurements the ITU-R Recommendations mentioned in the bibliography should be taken into account.

Due to the increasing use of the radio frequency spectrum and demand for frequencies there is a need for the fulfilment of an efficient Spectrum Management by providing the radio spectrum planners with adequate reliable information about the actual usage of the spectrum by the Monitoring Service.

The results of Frequency Channel Occupancy Measurements will give information about the current use of frequencies, which is essential:

* to serve customers applying for new frequencies
* to verify complaints concerning channel blocking caused by co-channel users
* to verify the efficiency of spectrum usage .

pPresentations of frequency channel occupancy measurements should as a minimum contain the following information:

* location of monitoring;
* date and period of measurement;
* frequency;
* type of user(s);
* occupancy during busy hours.
	1. **Exchange of data**

Neighbouring of affected Administrations may be interested in exchanging occupancy data, especially concerning regions close to country borders, in order to get a basis for frequency assignments. In such cases it is important to use a unique and unambiguous format, that allows correct interpretation of the data, which cooperating parties exchange. .

 For example Recommendation ECC/REC(05)01 “Harmonisation of automatic measuring methods and data transfer for frequency band registrations” recommends to use the comma separated value (CSV) file format for this purpose. Most database and spreadsheet programs can read this format. A header section describes the location, from which the measurements are carried out, frequency range and a number of other technical parameters.

The header section is separated from the real measurement data by a blank line. Each line (scan) of the data section starts with the time followed by the level (or field strength) value for each frequency step, whichcan be typically 1ms . If the scan or sweep time is e.g. typically 10 s, the data file contains more than > 8 630 lines.(1000 \* 10 =10000?) almost 10000 lines.

1. **Coverage measurements**

Monitoring services measure coverage of radio transmitters and networks for different purposes:

* to verify predictions of computerised tools used for the planning of the network.
* to verify compliance with license conditions on area or population coverage (in percentage) to verify the quality of service in a given area.
* to assess the receiving conditions at certain locations, where interference is reported.

Field strength measurments may be sufficient for analogue modulated systems. . Due to certain circumstances and inherent principles for the reception of digitally modulated systems, coverage for digital terrestrial networks has to be measured differently than for analogue terrestrial networks.

The follwoing chapters describe measurement principles, procedures and necessary equipment for fixed and mobile coverage measurements for radio transmitters and networks. However, it may be necessary to adapt the information provided to the requirements of the individual system or to the individual license conditions.

1. **Field strength measurements along a route with geographical coordinate registrations**

Influenced by the specific local receiving conditions, the real values of the field strength might significantly differ from predicted values. Therefore it is recommended to check radio field strength coverage of a large area by measurements.

Measurement results must be recorded along with their geographical co-ordinate data for mapping the results e.g. along accessible roads of the area in question.

For radio coverage evaluation the actual field strength corresponding to the output voltage of a receiving user antenna (the typical antenna for the service under investigation) has to be analysed.

Digital network systems (such as GSM, DCS1800 or DAB) are sensitive to effects of time delayed reflected reception. In this case besides measuring the signal level the reception quality measurement, done by bit-error ratio (BER) or channel impulse response (CIR) measurements, is also necessary for the system performance evaluation. Such evaluations can be done by automatically generated calls for operational digital networks without causing any negative system impact.

A continuous transmission is necessary for measurement purposes along a route. (See : ERC Recommendation (00)08)

1. **Determination of the radiated power by field strength measurements in the frequency range from 400 MHz to 6000 MHz**

Field strength measurements are one of the basic tasks of all radio monitoring services. It is feasible to measure the field strength at a single location in the electromagnetic field but due to reflections and other propagation effects, the measured values may change extremely even between measurement locations close to each other. The following measurement method describes, how these effects can be handled.

The measurement method relies on the correction of the influence of possible ground reflections from information gained through a height scan of the field strength at the location of reception, which allows estimating the effective reflection coefficient. This method is basically frequency independent. However, there are many cautions to take into account in order to reduce external influence factors, .

The suggested measurement method loses accuracy for frequencies below 400 MHz, because the height accessible by customary measurement antennas (10 m) will not be sufficient to capture both a maximum and a minimum of the field strength distribution.

Above about 3000 MHz the application of this method may be difficult, because the distance between maximum and the next minimum is very small due to the small wavelength of the signal.

Field strength measurements with relevance have to be performed in the far field. The transmission between near and far field is usually defined by D2/λ. D is the largest dimension of the transmitting antenna. For D=1 m (typical base station antenna) and λ=0.1 m (3 GHz) the measurement distance between the transmitter and the receiving antenna has to be at least 20 m.

 For different heights of the measurement antenna, the actual location, where the effective ground reflection takes place, is different.. A valid estimate of the reflection coefficient from a field strength height scan can thus be obtained under the assumption only, that locations of reflections for the “maximum” and the “minimum” reflection nearly coincide. This condition can be met easier for higher frequencies and closer measurement distances. This is in contrast to typical high power broadcast transmitters with large transmitting antenna heights.. In addition, the radiation is confined to a vertically narrow lobe which meets the ground at distances of several kilometres from the transmitter only. This brings the need of measurements to be done at large distances from the transmitter and locations of reflections may be 50 or 100 metres apart under these circumstances.

The measurement method assumes free space propagation, i.e. a 20 dB path loss per decade of distance. The accuracy of the method will not be guaranteed , if this condition e.g. at larger measurement distances is not fulfilled.,.

Finally it should be mentioned that measurement errors due to the aforementioned effects usually result in undervalued field strength or radiated power levels and not in increased levels.

**ITU-R Recommendations**

1. Recommendation ITU-R SM.182\* – Automatic monitoring of occupancy of the radio-frequency spectrum.
2. Recommendation ITU-R SM.1536\* – Frequency channel occupancy measurements.
3. Recommendation ITU-R SM.1753 – Method for measurements of radio noise.
4. Recommendation ITU-R SM.1793\* – Measuring frequency channel occupancy using the technique used for frequency band measurement.
5. Recommendation ITU-R SM.1809 – Standard data exchange format for frequency band registrations and measurements at monitoring stations.