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PROPOSED DRAFT REVISION OF RECOMMENDATION ITU-R SM.1392-2

Essential requirements for a spectrum monitoring system for developing countries

Introductory remarks

Recommendation ITU-R SM.1392-2 was last revised in 2010. Since then a number of new ITU-R Recommendations and Reports have appeared on the subject area dealt with in Recommendation ITU-R SM.1392-2. More attention has begun to be paid to the area of planning and optimization of radio monitoring networks. TDOA and TDOA/AOA systems, which are not referred to at all in Recommendation ITU-R SM.1392-2, have begun to be introduced more widely. It would appear that Recommendation ITU-R SM.1392 should focus more attention on the issue of countries' participation in the international monitoring system.

All this confirms the need for the revision of Recommendation ITU-R SM.1392-2 set out below.

Proposal

A proposed draft revision of Recommendation ITU-R SM.1392-2 is reproduced in the attachment.

ATTACHMENT

DRAFT REVISION OF RECOMMENDATION ITU-R SM.1392-2

Essential requirements for a spectrum monitoring system for developing countries

(1999-2000-2010)

Scope

The specific situation in developing countries, particularly budget limitations, requires careful planning of a national spectrum monitoring system, including national, regional and local monitoring networks. This Recommendation provides some guidance in this regard.

The ITU Radiocommunication Assembly,

considering

- a) that the increasing use of radio services in the developing countries requires more efficient use of the radio-frequency spectrum;
- b) that spectrum monitoring is an important tool for frequency management in general, and for verification of efficient use of the radio-frequency spectrum in particular;
- c) that spectrum monitoring systems are often the most expensive part of a national spectrum management system whose optimal implementation, including the creation and/or optimization of national, regional and local monitoring networks, has a significant economic impact;
- d) that spectrum monitoring equipment becomes more and more sophisticated, providing more and more new functions, and its appropriate operation requires the availability of highly-professional and well-trained personnel, as well as the availability of the necessary infrastructure for testing, calibration and maintenance of the equipment, including antennas;
- e) that Recommendation ITU-R SM.1050 defines the tasks of a monitoring service, while Recommendation ITU-R SM.1139 contains provisions concerning participation in the international monitoring system;
- f) that it is necessary to specify minimum requirements for monitoring systems of developing countries, so that these systems may fulfil their tasks for national spectrum management, and can be part of the international monitoring system,

noting

the revision of the ITU Handbook on Spectrum Monitoring approved in 2010,

recommends

that monitoring systems and networks in developing countries should be designed to meet the requirements of Annex 1, in order to perform the tasks set out in Recommendation ITU-R SM.1050, but tailored to the national requirements.

Annex 1

1 Introduction

In principle, radio monitoring stations and networks of developing countries and developed countries have the same tasks, and hence the same requirements. The difference in terms of available budget and available manpower, however, might be substantial. Therefore, thorough planning and careful design of systems and networks are essential to minimise this difference.

The purpose of this Recommendation is to provide some guidance on how to establish a spectrum monitoring system and network within scarce available resources.

2 Tasks

2.1 General tasks

There are four main tasks of a radio monitoring service, which can be derived from the Radio Regulations (RR):

- monitoring of emissions for compliance with the provisions of the frequency assignment;
- frequency band observations and channel occupancy measurements;
- investigation of cases of harmful interference;
- identification and elimination of illegal emissions.

These are further specified in Recommendation ITU-R SM.1050.

Chapters 1 and 2 of the ITU Handbook on Spectrum Monitoring approved in 2010 (hereinafter “the Handbook”) list further tasks, such as the on-site inspection of radio stations, which may be assigned to a radio monitoring service.

2.2 Measurement tasks

Closer examination of these general tasks leads to specific measurement tasks which can be found in Recommendation ITU-R SM.1050 and Chapter 2 of the Handbook, e.g.:

- frequency measurements;
- field strength and power-flux density measurements;
- bandwidth measurements;
- modulation measurements;
- spectrum occupancy measurements;
- signal analysis and transmitter identification;
- direction finding and location determination.

Chapter 4 of the Handbook provides detailed information on the measurements of these basic parameters, including measurements by monitoring systems based on a method involving measurements of the time difference of arrival (TDOA). Chapter 5 of the Handbook describes more specific monitoring systems and procedures relating to various radio services and their applications. Chapter 6 sets out fundamental principles of developing monitoring systems, including provisions on optimal planning and optimization of monitoring networks based on the angle of arrival method (AOA networks) from the perspective of ensuring appropriate monitoring coverage of the required territory; as well as basic supporting tools including maps, radiodetermination systems, Fast Fourier

Transform techniques, and so on. Annex 1 sets out recommendations on the planning of monitoring systems and networks from the viewpoint of equipment and conducting tender processes.

3 Scope of the radio monitoring system

Having limited budgets and certain requirements in mind, the scope of the radio monitoring system and network has to be restricted. For this purpose first some questions like the following ones have to be answered:

- What in detail is expected from the radio monitoring service?
- Which fields of activities are of great public, political or commercial interest?
- What is the frequency range of interest?
- Which radio services and their specific applications are essential to be monitored?
- Which regions of the country are essential to be provided by monitoring at the current stage of the country economics development and at what extent they should be covered by monitoring?
- What are the consequences of not covering a frequency range, a radio service or a task or a region of the territory?
- Can sufficient amount of highly professional and well trained operational staff be made available?
- Can the necessary infrastructure for testing, calibration and maintenance of the equipment including antennas be made available?
- Is there a need for data exchange between monitoring stations and monitoring centers and, if so, is the necessary infrastructure available?
- Is there any other institution available that could accomplish some of these tasks?

As these questions are interconnected and cannot be answered independently, they have to be considered in relation to operational issues. Resulting questions could be for example:

- Is there a need to monitor public mobile telephone networks and to measure their radio coverage or can this task be assigned to the network operator?
- Does the number of licenses issued for fixed links justify the procurement of special equipment for measurements up to 40 GHz or even higher?
- Which radiocommunication services and applications thereof are most affected by interference or by illegal operation and in which regions of the territory are they located?

4 Planning of a Radio Monitoring System

Upon answering the above mentioned questions, the required monitoring systems, specifically AOA and/or TDOA, as well as the necessary infrastructure can be determined on the basis of finance resources available. In this regard, special attention shall be given to the required number of monitoring stations, and the siting and remote control of monitoring stations.

Section 6.8 of the Handbook provides guidance on planning and optimisation of AOA spectrum monitoring networks in the context of monitoring coverage. More detailed planning and optimization procedures are set out in the Report ITU-R SM.2356. As regards TDOA systems, a number of guidelines on planning and optimization of such networks, including hybrid AOA/TDOA networks, are set out in § 4.7.3.2 of the Handbook and in the Reports ITU-R SM.2211 and ITU-R SM.2356.

Requirements on the siting and environmental protection of monitoring stations are presented in [Recommendation ITU-R SM.575](#) and in § 2.6 of the Handbook. It has to be understood that siting of monitoring station is a very important step as free and appropriate sites might not be found easily. [Detailed guidance on this subject is contained in Report ITU-R SM.2356.](#)

Section 2.5 of the Handbook provides details about the remote control of monitoring stations. The means of connection between different monitoring station sites, and also between these sites and the main control centre, has to be carefully considered.

Annex 1 of the Handbook gives guidance on monitoring system planning in relation to equipment and relevant tender process.

[Report ITU-R SM.2125 provides guidance on organization and technical/logistical aspects of monitoring during major events.](#)

[The role of radio monitoring in supporting inspections of radio facilities is set out in Reports ITU-R SM.2130 and ITU-R SM.2156.](#)

5 Equipment

Basically, all radio monitoring stations are composed of antennas, receivers or analyzers, direction finders and signal analysis and/or recording equipment. Modern equipment offers a high level of automation, and may accommodate several functions in one unit. For example, a receiver could include a DF function. Sometimes it is possible to upgrade such functions later.

Nevertheless, an external PC or laptop computer is required for automated or remote control of the equipment and for the documentation of the results.

5.1 Antennas

Suitable antennas are indispensable for all frequency ranges to be monitored. Antennas can be categorised in various ways, e.g.:

- passive/active antennas;
- low/high gain antennas;
- suitable for fixed/mobile/transportable use;
- directional/omnidirectional/direction-finding antennas.

The various antenna types have different inherent advantages and disadvantages, depending on the individual application. For field strength measurements, the antenna's frequency-dependent antenna factor (*k*-factor) must be known.

Ample information on antennas can be found in Chapter 3 of the Handbook. Section 2.6 of the Handbook discusses site criteria and antenna protection measures.

5.2 Receivers and analyzers

Receivers and spectrum analyzers are indispensable tools of all radio monitoring services. The basic difference is that receivers normally provide pre-selection in the RF front-end and are designed for demodulation purposes, whereas spectrum analyzers are designed to display the spectral characteristics of the RF spectrum.

Measurements of analogue radio services, including measurements of frequency deviation and multiplex power of an FM broadcasting signal, for example, have to be performed with a receiver. Field strength measurements are also carried out using receivers. The measurement of parameters such as frequency and bandwidth can also be performed using a spectrum analyzer. They may also

be used for measurements of digitally modulated signals, or for the detection of unknown sources of interference.

Modern receivers may include some features which normally are expected from a spectrum analyzer. Conversely, a spectrum analyzer operated in zero-span mode may provide some receiver functions.

Meanwhile, FFT analysis in both receivers and spectrum analyzers has become affordable and should be preferred. This is not necessarily more costly than conventional sweeping analysis. Regarding receiver specifications, Chapter 3 of the Handbook and Recommendations ITU-R SM.1836, ITU-R SM.1837, ITU-R SM.1838, ITU-R SM.1839 and ITU-R SM.1840, and Reports ITU-R SM.2125 and SM.2080, may be consulted.

Recommendations ITU-R SM.377 and ITU-R SM.443 as well as §§ 4.2 and 4.5 of the Handbook describe the measurement of frequency and bandwidth in detail. [As the bandwidth of emissions from FM broadcasting transmitters is closely linked to frequency deviation, it is essential, when measuring the bandwidth of emissions from such transmitters, to bear in mind the provisions of Recommendation ITU-R SM.1268. Bandwidth limits for different classes of emissions are set out in Report ITU-R SM.2048.](#)

Details on field strength and power flux-density measurements can be found in Recommendation ITU-R SM.378 and in § 4.4 of the Handbook. Field-strength measurements along a route with geographical coordinate registrations, important for radiocommunication coverage area determination, are presented in Recommendations ITU-R SM.1447 and ITU-R SM.1875, and other considerations concerning coverage measurements are given in § 4.11 of the Handbook. Recommendation ITU-R SM.1708 details coverage measurements that apply to digital TV broadcasting.

[As regards measurement of radio noise, consideration must be given to Recommendation ITU-R SM.1753 and Report ITU-R SM.2055 and, as regards man-made noise, to Report ITU-R SM.2155.](#)

5.3 Direction finding and location determination

Direction finders (DF) are probably the most effective tools for the location of sources of harmful interference and for finding unauthorised transmitters. At the same time, they are often one of the most costly tools of a radio monitoring service.

Preserving budget requires careful planning of fixed DF sites in order to minimize their number while providing required location coverage and accuracy. Section 6.8 of the Handbook provides useful guidance on this topic. The temporary deployment of transportable DF stations may also be considered to extend coverage.

Planning fixed, mobile and transportable DF equipment requires prior consideration of the intended purpose. This has substantial influence on the specifications, e.g. the required frequency range and minimum signal duration. It should also be noted that mobile DFs are particularly useful for homing, whereas the determination of transmitter locations is the domain of fixed or transportable DF stations. For locating an interfering or illegal transmitter, a mobile monitoring station is necessary. One could also consider whether homing receivers might be helpful for some applications. Increased location reliability at frequencies above 30 MHz usually requires several DF stations for the triangulation process. For frequencies below 30 MHz, at least one single site location (SSL) station may be provided.

Example of DF limitation considerations: The occurrence of fixed links at 26 GHz and the appearance of high speed data applications, as such, would not justify the procurement of direction finders for that frequency band, or to specify very low minimum signal duration.

Section 4.7 of the Handbook, [Recommendations ITU-R SM.854 and ITU-R SM.1598](#), and [Reports ITU-R SM.2211 and ITU-R SM.2356](#) as regards TDOA DF systems, should carefully be studied before any decisions are made.

5.4 Equipment for occupancy measurements and recording equipment

Channel occupancy, and band utilisation in general, are useful information for spectrum management. Specialized spectrum recorders facilitate simultaneous measurements of several bands, but require huge storage capacity. Sometimes the equipment requirements can be reduced, e.g. by reducing the recording time, by limiting the span to be observed or by increasing the necessary re-visit time of a frequency during measurement. Under these circumstances, the use of a modern FFT receiver facilitating spectrograms and occupancy measurements without additional equipment should be considered. In many cases, standard monitoring receivers or spectrum analyzers can also be used in conjunction with a computer running software that controls the equipment and stores the data. [Recommendation ITU-R SM.1880](#), [Reports ITU-R SM.2154, ITU-R SM.2256 and ITU-R SM.2270](#), and Section 4.10 of the Handbook, provide detailed information regarding ~~forms the basis for~~ the relevant measurements and visualization of the results obtained.

5.5 Equipment for modulation measurements

Standard monitoring receivers already provide some analogue and/or digital demodulation capabilities and an IF output for further analysis. It very much depends on the analysis according to § 2 above whether specific modulation analyzers are required. Detailed information about modulation measurements can be found in §§ 4.6 and 4.8 of the Handbook.

5.6 Identification and decoding equipment

The identification of a radio signal one of the most difficult tasks of a radio monitoring service. Recommendation ITU-R SM.1052 lists some requirements regarding the automatic identification of radio stations in the HF band. A more thorough discussion on signal analysis and transmitter identification can be found in [Recommendation ITU-R SM.1600](#), [Reports ITU-R SM.2258 and ITU-R SM.2304](#), as well as in § 4.8 of the Handbook.

6 Fixed vs. mobile and transportable monitoring stations

Mobile monitoring stations are indispensable for monitoring tasks in the field, in particular for the identification of sources of harmful interference and unauthorised transmitters. The number of vehicles may be limited by various factors. Budget is usually the most important one. This in turn requires the design and procurement of multipurpose monitoring vehicles instead of special vehicles where possible. However, limits of vehicle size and payload require compromises.

Monitoring using antenna heights above 10 m is difficult to accomplish in mobile stations, so fixed or transportable stations are usually used in that case. A radio monitoring service needs a building with offices, a storage room and a repair shop. Sometimes a few antennas can be installed on the roof. In the majority of cases, however, the use of separate antenna towers will be more appropriate.

Chapter 2 of the Handbook discusses various types of monitoring stations, including mobile stations. [Recommendation ITU-R SM.1723](#) concerns specifically mobile stations. [Report ITU-R SM.2356](#) considers the optimal ratios of fixed, transportable and mobile monitoring stations.

7 Software, interfaces

Besides standard office software comprising text processing and spreadsheet programs, a radio monitoring service needs additional software dedicated to the measurement equipment. This software automates routine and repetitive measurement processes, can inform or alert the operator

when specific criteria are met, and provides other features to aid the operator in understanding the kinds of signals and interference being monitored (examples are given in § 3.6.2 of the Handbook). Furthermore, it is very important that the radio monitoring service has access to the complete license database to allow comparison with monitoring results and to identify possible license violations and unlicensed transmitters.

Such an access allows automation and integration of spectrum monitoring systems with automated spectrum management (Recommendation ITU-R SM.1537).

8 Organisation and participation in the international monitoring system

Limited budgets normally go along with a lack of staff. This requires wide-ranging staff training and a flat hierarchy. In some administrations, the spectrum monitoring staff has to fulfil spectrum management and inspection tasks too. Several sections in Chapter 2 and Annex 1 of the Handbook deal with the structure and organisation of a radio monitoring service and with staff training, because these are essential elements affecting the efficiency of the whole system. The same concerns the necessary infrastructure for repairing, tuning, calibrating, testing and maintaining the equipment, including antennas.

As regards participation in the international monitoring system, consideration must be given to Recommendations ITU-R SM.1139, ITU-R SM.1393, ITU-R SM.1394 and ITU-R SM.1809, §§ 1.4 and 1.5 of the Handbook, and to Annex 1 to Chapter 1 of the Handbook. Consideration should also be given to the additional information on classes of emissions presented in Recommendation ITU-R SM.1270.
