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**ITU-R**  
Radiocommunication Sector of ITU

**Recommendation ITU-R SM.1392-3**  
(02/2021)

**Essential requirements for a spectrum  
monitoring system for developing countries**

**SM Series**  
**Spectrum management**



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<b>SNG</b>	Satellite news gathering
<b>TF</b>	Time signals and frequency standards emissions
<b>V</b>	Vocabulary and related subjects

*Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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## RECOMMENDATION ITU-R SM.1392-3

**Essential requirements for a spectrum monitoring system  
for developing countries**

(1999-2000-2010-2021)

**Scope**

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

**Keywords**

Spectrum monitoring system and network, essential requirements, guidance, developing countries

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 of 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;
- 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 ITU Handbook on Spectrum Monitoring in its current edition and that the references applied in this Recommendation refer to the 2011 edition and the [ITU-D Report](#) on “Guidelines for the preparation of a tender to set up or update a spectrum monitoring network”,

*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, available manpower and existing infrastructure, however, might be substantial. Therefore, thorough planning and careful design of systems and networks is 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. 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 monitoring systems including optimal planning and optimization of monitoring networks, basic supporting tools like maps, Global Navigation Satellite Systems, Fast Fourier Transform techniques and so on.

### 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 centres and, if so, is the necessary infrastructure available?
- Is there any other institution available that could accomplish some of these tasks?
- Is there a suitable location available to build a fixed monitoring station?

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?
- Are there areas that should have fixed or mobile monitoring stations to enable fast actions taking into account the country infrastructure?

### 4 Planning of a radio monitoring system

Upon answering the above-mentioned questions, the required monitoring systems, specifically direction finding, 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.

Requirements on the siting and environmental protection of monitoring stations are presented in Recommendation ITU-R SM.575 and in section 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.2257 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 Report ITU-R SM.2156. Report ITU-R SM.2130 provides guidance about the inspection of radio stations.

## 5 Equipment

Basically, all radio monitoring stations are composed of antennas, receivers or analysers, 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 analysers

Receivers and spectrum analysers 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 analysers 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 analyser. 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 analyser. Conversely, a spectrum analyser operated in zero-span mode may provide some receiver functions.

Meanwhile, FFT analysis in both receivers and spectrum analysers 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, ITU-R SM.1840 and ITU-R SM.2080 and Report ITU-R SM.2125, may be consulted.

Recommendation ITU-R SM.377 as well as sections 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 section 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 section 4.11 of the Handbook. Recommendation ITU-R SM.1708 deals with field-strength measurements along a route with geographical coordinate registrations.

With regards to the measurement of radio noise, consideration must be given to Recommendation ITU-R SM.1753, Recommendation ITU-R P.372 and Report ITU-R SM.2055. For man-made noise in the HF range consideration must be given 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 or mobile 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, operation of a single site location (SSL) station may be considered.

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

Section 4.7 of the Handbook, Recommendation ITU-R SM.854 and Report ITU-R SM.2211 should carefully be studied before any decisions are made. Report ITU-R SM.2211 discusses the Time Difference of Arrival (TDOA) geolocation technique and a hybrid technique using both DF and TDOA for geolocation, and compares these with geolocation techniques based on using DF only.

### **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 analysers 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 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 analysers are required. Detailed information about modulation measurements can be found in section 4.6 of the Handbook.

### **5.6 Identification and decoding equipment**

The identification of a radio signal is one of the most difficult tasks of a radio monitoring service. 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 section 4.8 of the Handbook.

## **6 Fixed vs. mobile and transportable monitoring stations**

A radio monitoring service needs at least one building with offices, a storage room and a repair shop. Sometimes a few antennas can be installed on top of the roof. In the majority of cases, however, the use of separate antenna towers will be more appropriate.

Moreover, mobile and transportable monitoring stations are indispensable for monitoring tasks in the field, in particular for the identification of sources of harmful interference and unauthorised transmitters. Mobile monitoring stations are used for hunting and homing interferers. They can also be sent to places that are not covered by fixed monitoring stations and then serve as a temporarily fixed monitoring station. Transportable monitoring systems are usually used for the last few hundred meters hunting an interference source or an unauthorized transmitter.

Transportable monitoring stations might be used by carrying along in a vehicle where mobile monitoring stations are not available for whatever reason, and mobile monitoring stations might be used in areas that are not covered by a fixed monitoring station as already mentioned.

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 section 3.6.2 of the Handbook). Furthermore, it is very important that the radio monitoring service has access to the



complete license database via a suitable interface 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, staff training 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 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 applies for the necessary infrastructure for repairing, tuning, calibrating, testing and maintaining the equipment including antennas. For staff training, administrations of developing countries may consider the training conducted by the Human Resource Development Sector in the International Telecommunication Union (ITU-D) like the ITU Academy, and tuition-free training facilities available worldwide as listed in Chapter 2 of the Handbook.

As regards participation in the international monitoring system, consideration should be given to Recommendations ITU-R SM.1139, ITU-R SM.1393, ITU-R SM.1394 and ITU-R SM.1809, sections 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.

Administrations wishing to participate in the International Monitoring System as per Article **16** of the Radio Regulations (RR) may include their station in List of International Monitoring Stations (List VIII) which contains particulars of monitoring stations participating in international monitoring, together with the addresses of the centralizing offices. It includes information about the measurements that each monitoring station is able to perform.

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