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Radiocommunication Sector of ITU

Recommendation ITU-R SM.1723-2

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Mobile spectrum monitoring unit

SM Series

Spectrum management

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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.1723-2*

Mobile spectrum monitoring unit

(2005-2008-2011)

Scope

Following the approval of the ITU Handbook on Spectrum Monitoring (Edition 2011), it became apparent that Radiocommunication Study Group 1 should issue a Recommendation on the characteristics and functions of mobile spectrum monitoring covering the relevant information contained in the ITU Handbook on Spectrum Monitoring (Edition 2011), and ITU-R Recommendations. This Recommendation will facilitate the way in which administrations set up radio mobile monitoring systems on their national territories.

Keywords

Monitoring station, mobile station, spectrum monitoring

The ITU Radiocommunication Assembly,

considering

a) that mobile spectrum monitoring systems are available to support the administrative, frequency assignment and monitoring activities of spectrum administrators;

b) that the incorporation of mobile units into the monitoring and management system enables such a system to conduct measuring operations that cannot be effectively performed from fixed monitoring stations;

c) that mobile units have a vital role to play where low transmitter power levels, high antenna directivity and specific propagation characteristics preclude measurement by fixed monitoring stations;

d) that many administrations already have computerized systems from which information can be supplied to spectrum management and monitoring systems,

noting

a) Recommendation ITU-R SM.1537 – Automation and integration of spectrum monitoring systems with automated spectrum management;

b) the ITU-R Spectrum Monitoring Handbook, which provides guidelines on all aspects of radio emission monitoring;

c) that the measurement and direction-finding data collected by mobile units enable spectrum managers to perform their tasks throughout the country;

d) that the analysis of data from a mobile unit that has an automatic measurement and direction-finding system is vital to the proper operation of a national spectrum management system,

recommends

1 that administrations are encouraged, when procuring integrated and automated mobile units or multipurpose units that can be equipped according to the task to be performed, to use the information contained in Annex 1.

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* Radiocommunication Study Group 1 made editorial amendments to this Recommendation in the year 2019 in accordance with Resolution ITU-R 1.

Annex 1

Mobile spectrum monitoring unit

1 Context

Each administration intending to define and to purchase a spectrum monitoring system should take into consideration mobile monitoring unit. In addition of a fixed system, mobile units provide a flexible spectrum monitoring support which is particularly suited to carry out measurements close to emitters which are characterized for example by low power level and/or high frequency emissions.

The flexibility in terms of measurement is in accordance with:

– the type of vehicle;

– measuring equipments which are boarded in the vehicle;

– specific facilities fitted out in the vehicle.

Moreover, a monitoring system using fixed stations is not usually dimensioned to provide total coverage of a country's territory, but is mainly set up taken into account user density (urban or high radio-density areas). With computerized and radiocommunication network arrangements, the mobile unit could be integrated in a fixed monitoring system to be used as an additional fixed spectrum monitoring station to improve temporarily the coverage area of the global system. Thus, coupling with spectrum management and monitoring facilities, the mobile unit could automatically use the data collected by the monitoring system and the license information included in the management database in order to detect unlicensed emissions and licensing violations (see Recommendation ITU-R SM.1537). In many cases, only by using mobile monitoring units in addition to fixed stations the spectrum manager's tasks can be performed efficiently, either on account of the nature of the values to be measured or of difficulties arising from the topography or from the spectrum congestion.

Hence, depending on equipment boarded in the vehicle, a mobile unit shall carry out measurements prescribed by ITU. Mobile units might be incorporated into a national spectrum monitoring system at two levels:

1. by attaching the mobile unit to a monitoring centre having fixed monitoring stations;

2. autonomous operation.

This contribution intends to provide some guidelines about the technical and operational specifications to define requirements which could be helpful to define and to purchase mobile spectrum monitoring units.

2 Mobile unit and spectrum monitoring

2.1 General concept of mobile unit

The mobile monitoring stations supplement the network of fixed stations. Practically mobile unit may perform measurements as a fixed monitoring station and could be installed easily almost anywhere in the country.

A mobile unit consists of a vehicle that has been fitted out with a measurement and/or direction-finding system that can be used, in manual or automatic mode, to perform the following spectrum monitoring functions:

– measurement of the technical parameters of the signal;
– occupancy measurements coupled with direction-finding measurements;
– signal analysis;
– detection and location of transmitters including unidentified stations and transmitters producing interference;
– scheduling of measurement and direction-finding operations in real and deferred time;
– remote transmission of the data collected by the mobile unit to the spectrum monitoring centre(s);
– exchange technical information between the fixed and mobile spectrum monitoring units of the national spectrum monitoring system;
– on route mobile field strength/coverage measurements.

Another mobile unit equipped with basic equipment like an antenna tower, cabling system, power supply and interface to the cars speed meter or cruise control to perform on route measurements, may be used for a general purpose.

The two main parameters to take into account to define mobile monitoring unit are:

– area of operation;
– tasks to be performed.

The first criterium may define the type of the vehicle which would be the best solution according to the area and the accessibility of a typical site of operation (Urban, suburban, rural environment or mountain land).

Representative examples of vehicles that can be used as mobile spectrum monitoring units are given below and are discussed in more detail and illustrated in the ITU-R Handbook on Spectrum Monitoring. Other types of vehicle may be selected on the basis of national requirements.

Type 1: These vehicles are passenger cars or estate wagons used to carry passengers, equipment and antennas. The antenna array used for DF and monitoring is mounted in an unobtrusive roof-top carrier mounted directly to the luggage rack on the roof of the car. The monitoring and DF equipment is mounted in the luggage area at the rear of the car, and the operator can be seated anywhere in the passenger area of the car and control the equipment from his laptop. This type of station can operate while in motion or stationary. Almost any passenger car or estate wagon can be used as a Type 1 vehicle, especially if it is factory equipped with a roof rack. Because they look like ordinary passenger cars and do not attract attention, these types of mobile stations are especially useful when searching for illegal transmitters.

Type 2: These are heavy duty 4x4 utility vehicles to be used on difficult road conditions where neither type 1 nor type 3 vehicles can go (desert areas, mountains, etc.). They contain equipment capable of both monitoring and direction finding while in motion or stationary. These vehicles are equipped with a telescopic mast compatible with the difficult road conditions the vehicle is used for and the compactness of the equipment compartment. With the mast down, this type of station can operate while in motion or stationary. This vehicle type is the standard vehicle for rural and mountain area operations where access would be difficult for passenger cars or large vans.

Type 3: These are heavy duty utility vans. They are intended for universal use and are therefore equipped with the same type of monitoring and direction-finding equipment as the Type 2 vehicles, including a mast which can be raised up to approximately 10 m above ground level. When the mast is not raised, the Type 3 vehicles can operate while in motion as a homing station. This vehicle can easily accommodate one passenger in the front and 2 or 3 operators in the back. This vehicle type is the standard vehicle of the monitoring service, primarily used for investigating interference. It may also accommodate transportable/portable equipment to perform monitoring and direction finding tasks equipment to be used outside the vehicle to reach an area inaccessible to vehicles.

These types and sizes are indicative and can be adapted to the availability or necessity to a particular administration.

The second criterium defines measuring equipment to install and facilities to fit out in the vehicle. In compliance with their functions, mobile monitoring subsystems (vehicle for interference investigation, coverage measurement, measurement of microwave networks...) include specialized measurement capabilities. Thus, 5 levels of fitting out could be highlighted:

Level 1: Not dedicated vehicle (general purpose with a basic outfit (only mast for example)).

Level 2: Dedicated vehicle for specific measurements (FM broadcasting measurement, GSM or UMTS coverage, Quality of service measurement...).

Level 3: Dedicated vehicle to frequency band (HF, V-UHF, SHF) measurement.

Level 4: Vehicle for general purpose (the difference with the type 1 is that the vehicle is fitted out with all facilities (mast, generator, mobile phone, workstations...) and minimum equipments (antenna, spectrum analyser, receiver, direction finder...)).

Level 5: Automated vehicle to ensure interconnection with fixed monitoring system, complete with all equipment and facilities necessary to make the required measurements.

On the one hand, the full-scale developed mobile stations, when each station has the same measurement capabilities can be more advantageous, consequently they can be used to perform many types of measurement tasks. The disadvantage of this building up is that many expensive instruments of the set are not always exploited.

On the other hand, it is more practical if special equipped, easily movable vehicles are at disposal.

Environment of operation and monitoring tasks to be performed should be well identified and highlighted to optimize the choice of the well-suited mobile monitoring unit.

2.2 Spectrum monitoring tasks

Main spectrum monitoring tasks performed with a mobile unit might be:

– Monitoring emission for compliance with frequency assignment conditions.
– Occupancy measurement.
– Interference measurement.
– Identification and localisation of unauthorised emissions.
– Direction finding and location measurement.
– Assistance on special events (sporting events, state visits...).
– Radio coverage measurements.
– Radio compatibility measurement.
– Technical and scientific studies (propagation measurement, quality of service...).

All elementary measurements attached to general tasks described above are listed in the table below. However, not all measurements may be required for specific applications, and only those measurements that are needed to support the desired application should be specified.

Elementary tasks	Parameters to take into account to perform elementary task
Frequency measurement	– Range of frequencies, – Required accuracy in term of frequency.

Field strength, level and power-flux density measurement	– Required accuracy in term of level,
	– Frequency range,
	– Specific measurements:
	  – Coverage measurements (measurements along a road),
	  – Measurement of antenna patterns.

Spectrum occupancy including channel occupancy measurement and "on route" field strength/coverage measurements	– Radiocommunication standard, – Channel technical specifications: bandwidth, spacing, type of modulation, – Recording parameters, – Required scanning speed, – Additional information to be recorded (e.g. automated identification/decoding), – Number of measurements/meter distance based on gps or the number of pulses/meter provided by the interface to the speedometer or cruise control.
Occupied bandwidth measurement	– *B*/2 and/or *X*-dB method measurements using spectrum analyser or software or monitoring receivers, – Other methods.
Modulation measurement	– Type of modulation (analogue, digital).
Direction finding and location measurement	– Type of direction finders, – Class of accuracy, – Mapping, – Response time.
Identification measurement	– Classes of emission, – Call signs for selective calling, – Localization, – Emission mask (comparing with theoretical emission mask).

3 Mobile unit requirements

The vehicle should provide an appropriate working environment regarding both the operational aspect and of the comfort and safety of the operators. It usually has to accommodate two to three operators including the driver, and should be fitted out in such a way as to facilitate the measurement operations.

3.1 General requirements

On the one hand mobile monitoring unit may be designed and supplied housed in a vehicle and may be completely equipped with all necessary monitoring equipment, monitoring antennas, modem(s), communication antenna(s), GPS receiver and antenna, interconnecting cables, power supplies, cabinets, racks, mounting hardware, interface devices and terminal blocks to form a complete and

working stand alone system as well as a reliable component that is an integral part in the national spectrum monitoring system (refer to Recommendation ITU-R SM.1537).

On the other hand, the vehicle may also be empty and equipped with all necessary cabling systems and items that require a mechanical fix to the vehicle. This type of vehicle needs to be equipped with mounting posts and/or rails for all potential equipment to be used in the vehicle. The empty vehicle can be of any of the previous mentioned sizes/types and flexibly equipped with all equipment needed for the chosen task.

Taking into account these two alternatives, some general requirements might be recommended for mobile monitoring units:

a) The vehicles must be suitable to the national regulation about cars/vans/trucks and fulfil all the mandatory national recommendations and rules about fitting out and transformation.

b) If necessary, the mobile monitoring unit should be suitable and accommodating for off-road operations and local field conditions (4-wheel drive and/or air-conditioning for example).

c) Mobile monitoring unit should be equipped with auxiliary equipment according to the requirements listed below but not limited to:

   – all cable entry fixtures must be weatherproof;
   – the mast (if required), being automatically or manually erected, electrically or with compressed air, may optionally have a computer controlled powered rotator on top of the mast if directional antennas are required;
   – GPS receivers with reference oscillator signal (10 MHz) and associated antennas may be installed;
   – an electronic compass may be installed to get the north as a reference;
   – an electrical power source (auxiliary generator or vehicle-powered inverter), AC power transfer switch and distribution panel should be provided;
   – a working position for one operator might be fitted out with computer, keyboard, mouse/trackball, display unit, printer and writing area;
   – the chair for the operator might be securely fastened to the floor and shall be positioned ergonomically for easy operations;
   – the vehicle might contain a storage cabinet for cables, auxiliary tools, and other miscellaneous items;
   – the vehicle might be equipped with a wireless radiocommunication system (cellular or satellite) to allow data transmission and thus, to allow a direct interconnection with the control centre;
   – suitable protection devices should be installed to prevent operation of the electronic equipment if the internal temperature of the vehicle is outside the specified operating range of the equipment;
   – a warning device might be provided in order to clearly warn the driver when the mast is extended to avoid moving of the vehicle;
   – the vehicle must contain the number and type of fire extinguishers required by national regulation. It is advisable to have one extra extinguisher for electrical equipment usage.

d) Any adaptation and modifications that will be performed to the vehicle must comply with local rules and allow for vehicle registration by appropriate local authorities and issuing permission to circulate on public roads.

e) Suspensions of the vehicle must be sized to support the requested load consistent with the application and equipment fitted in the vehicle.

f) In the case of the power supply is provided by a generating unit, the receiving compartment of generating unit should be ventilated with fresh air from the outside, and a system to evacuate the exhaust gas should be planned. It should also be audio isolated.

g) In the case of the power supply is provided by additional batteries, the replacement of the alternator provided with the vehicle could be envisaged in order to take into account the recharge of several batteries.

h) "Shock absorber supports" may be used to limit vibration of measuring equipment.

i) To minimize the nonessential radio electric radiations, the following recommendations must be respected:

- A high performance EMI power filter should installed at the output of power supply just before the distribution to the plugs.
- Network wiring (RS232, Ethernet, IEEE 488) must be shielded (or use of optical fibre).
- The continuity of the ground of all the metal subsets must be ensured.
- Equipments (power generating unit, inverters, battery chargers, alarm vehicle...) must be protected to avoid electromagnetic disturbances.

j) At the delivery time of the finalized mobile monitoring unit, the Administration should obtain a list of all the furniture and their origins, plans of wiring (electricity and radio electricity), the study and the calculation of the gravity point in the fitted vehicle, the weight certificate, usages recommendation, all the administrative paper and check operations by a certified office to obtain the vehicle homologation.

3.2 Requirements based on safety and comfort of operators

An independent review organization could be required to carry out or to assess safety aspect of the fitting:

1. At the conception stage:

- the mass calculation;
- the gravity centre calculation with two persons on board and all the equipments;
- validating of the mass repartition;
- resistance test for the anchoring point.

Observations done by the independent review organization which are not compliant with the specifications done by the Administration or not compliant with local security rules of the country must be solved by the service provider.

2. At the realisation stage:

- control and validating of the quality of the fitting;
- control and validating of the compliance with specifications and with the security rules;
- control and validating on the electric system security.

If an independent review organization is requested, the organization is in charge of providing a report in order to fulfil all requirements described below:

a) The vehicle mustn't be overloaded. At the definition stage the total weight in load should be assessed by taking into account the weight of two persons with their luggage, the weight of the vehicle fully equipped and a reasonable margin.

b) The fitting out should be studied also with respect to a correct balance of weights in the vehicle.

c) Secure storages dedicated to antennas and to all measuring equipment must be planned to ensure best safety conditions while the vehicle is in motion.

d) For the comfort of operators, particular attention to good sound insulation, good thermal insulation, and heating and air conditioning facilities are required.

e) The mobile station unit must be equipped to operate safely under normal operating conditions.

f) Normal operating conditions should be defined by the provider. Restrictions and/or forbidden actions, in order to achieve the system performance must be specified.

g) The provider should describe in his proposal the vehicle's type and the dimensions (interior and exterior) and present colour pictures of the model recommended.

h) The vehicle must fulfil all the safety specifications enforced by national laws.

3.3 Measuring equipments

3.3.1 General requirements

a) The mobile monitoring unit may be equipped with all necessary monitoring and DF equipment, monitoring and DF antennas, modem(s) or communication devices, communication antenna(s), GPS, interconnecting cables, batteries and power supplies, meeting the requirements of the intended application, to form a complete and working stand alone system as well as a reliable component that is an integral part in the national spectrum monitoring system (refer to Recommendation ITU-R SM.1537).

b) In terms of equipments, monitoring tasks may be performed by receivers, direction finders, field-strength meters, frequency measuring equipment, bandwidth measurement, channel occupancy measurement, spectrum analyser, vector signal analyser, decoders, signal generators and recording equipment as required for the intended application.

c) All equipment above should be compliant with the guidance as given in the Spectrum Monitoring ITU-R Handbook.

3.3.2 Antenna

To determine the types and the number of antennas for each mobile monitoring unit the following parameters have to be considered:

– *Basic parameters*
  – Polarization and frequency ranges (sub-ranges).
  – Approximate distances from the region to be monitored (radius).
  – Radiation patterns and gains of the antennas.
  – Monitoring and direction finding capabilities.
  – Specialized antennas for specific applications (e.g., GPS, GSM, SHF, network communications, spacecraft emission ....).

a) The antennas must be designed to withstand the local environmental conditions.

b) Antennas should meet the following requirements:
  – A compact and lightweight design without any degradation of performance should be considered.
  – The antennas should be capable of operating in regions with special environment (for example: high atmospheric salt water content) depending of the operating environment.
  – The antenna should survive without any damage to wind speed of above 100 km/h, preferable above 120 km/h.

c) Complete drawings and pictures showing the physical layout for the antenna(s) configurations should be provided. If applicable, the drawings should show the antennas both in working (i.e. installed on the mast) and storage position (i.e. packed for transportation).

d) The mobile monitoring unit antennas are usually either installed permanently on the vehicle rooftop or mounted temporarily or permanently on a mast.

e) Additional antenna for the communications channel for data through GSM networks might be helpful and should be installed conveniently.

3.3.3 Measurement accessories

a) A rotator may be installed on the top of the mast or a manual rotating mechanism should be installed, allowing rotation of directional antennas if directional antennas are required for the application:

- Include a control system to accurately establish the directional antenna(s) position along the axes of azimuth and elevation.
- The control system referred in item above should fully cover the possibility of rotation of 360° in azimuth and of 90° in elevation.
- The rotator both for azimuth and elevation should be operated and controlled electrically.

b) RF switches or distributors or other similar devices may be required to interface the antennas with the monitoring and direction-finding equipment. They should be computer controlled and allow for automatic configuration of the station, to the most possible extent, for the specific task to be executed.

c) If a Global Positioning System (GPS) is provided with or for the mobile unit it should be able to:

- Determine the position of the station (longitude, latitude, and altitude) with a sufficient accuracy.
- Provide standard date and time for the monitoring system.
- Provide a highly stabilized frequency reference signal of 10.0 MHz to referenced equipments boarded in mobile unit.

d) GPS should be compliant with parameters in the Table 1.

TABLE 1

Parameters required for GPS frequency reference

No.	Parameter	Required performance
1	Frequency reference stability (free running): Frequency accuracy:	Internal stability $\pm 1\times10^{-6}$
2	Frequency reference stability (disciplined): Frequency accuracy:	External GPS disciplined $\pm 1\times10^{-10}$
3	10 MHz output signal level	0 dBm sine wave or TTL level(1)
4	Phase noise @ 10 MHz	≤100 dBc/1Hz @ 10 Hz offset. ≤125 dBc/1 Hz @ 10 kHz offset.
5	Number of updates/seconds	10 (For measurement in motion)

(1) TTL: Transistor Transistor Logic 0–5 V.

e) In order to store/record monitoring data collected during mobile operations an appropriate Laptop might be included in the list of deliverables. This laptop might also accommodate spectrum monitoring and equipment control software.

f) Laptop characteristics should be appropriately sized and adapted to mobile operations. These characteristics should specify (but not limited to):

- CPU, RAM; Hard Disk Drive, Video, memory;
- Display size: 15" or better.

g) Mechanisms (hardware and software) should be proposed to transfer the data (commands, tasks, measurement results, etc.) between the mobile unit and the Control Centre in both directions.

h) At least two alternative communication links are advisable.

3.3.4 Optional portable equipments for spot monitoring

a) For some applications, lightweight and battery operation modes are two essential requirements for man-portable measurements. It might be helpful to consider in advance whether this might be necessary in the future or not.

b) If so, the monitoring receiver or spectrum analyser equipment (portable) should be easily transportable and have a flexible, configurable, modular and scalable architecture for adaptability to the various measurement applications that maybe required by the field investigations.

c) A separate set of omni-directional and directional antennas might be helpful to work with the rest of the equipment of the portable set.

d) For the portable operations a transportable power source might be included in the equipment set in order to supplement the operational time by battery pack.

e) The portable equipment set should include all needed adapters, probes, connectors, tripod(s) or stack mast, RF cables, power supply cables and any other cables required by the operations, as well as any additional device required to have a fully portable/transportable operation during spot monitoring.

f) Adequate carrying cases for the portable equipment should not be forgotten.

3.3.5 Interconnection of mobile monitoring units

a) It is preferable that the equipment and systems in the mobile unit have the capability for integrated operation of monitoring and/or DF operations from the mobile itself as well as integrated operation with external assets such as other mobiles and other fixed stations. The mobiles should be capable of being tasked to automatically perform monitoring and DF measurements and to provide results to both on-board workstations and relay appropriate data to external monitoring system assets.

b) It might be considered whether the mobile unit should be completely remote controlled as well. If so, the necessary communication links must be taken into account during the planning phase.

c) If the vehicle should be equipped with an interface to the speedometer or cruise control system, this interface should provide pulses or other stimuli depending on the distance driven. This would help to combine measured electrical and geographical data and to store them together.